Productivity in the economies of Europe

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Quantitative sozialwissenschaftliche Analysen
von historischen und prozeß-produzierten Daten

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Preface

Conference papers normally emerge as the product of an idea and are usually focussed around a theme. The papers included in this volume were submitted for a meeting held at the Zentrum für Interdisziplinäre Forschung of Bielefeld University. That meeting was designed as a preparatory conference for a group of European economic historians who have informally engaged in discussions to write a new economic history of Western Europe.

Their plans have been stimulated by a shared dissatisfaction with the way economic history of Europe is now taught and written at universities throughout the continent and North America. They believe that the subject lacks a comparative perspective and a common method of approach which could supply coherence to the continued accumulation of data and historical narratives on a country by country basis. In brief they all feel it is time to break away from national history and the study of Europe's past economic development in terms of compartmentalized country studies and suggest that "European" economic history needs to be focussed on the measurement and explanation of differences in the levels of income and productivity attained by national economies for bench mark periods between the late eighteenth and the mid twentieth centuries.

Until such a statistical framework is established, many scholars who now research and teach in the expanding field of European economic history find it difficult to identify a central set of problems for their articles, books and lectures. Standard texts in the subject refer to "Europe", but they assemble together country studies which describe and analyse the process of economic development within a purely national context. They are cases which summarize and synthesize ongoing historical research state by state. Explicit comparisons across national frontiers constitute a rather limited part of the book and are often relegated to conclusions. For method, economic histories of Europe tend to rely upon preliminary chapters which guide students towards an understanding of the historical mechanisms through which such major inputs as capital, labour, technology, land, the widening of markets, demand and entrepreneurs, generated the observed growth of output for particular countries. And they depend for coherence upon a diffusion model which for the period before 1914 pushes enquiry towards an explanation for the British lead and continental lags in high rates of capital formation and the adoption of advanced industrial and agrarian technology. Objections to and dissatisfaction with recent attempts to write European economic history as technological diffusion or in terms of accelerated rates of investment are already well known. Nevertheless, typologies of development propounded by Rostow, Gerschenkron and Landes in the 1950s continue to dominate and to provide heuristic devices for the organization of runs of data and the plethora of scholarly country studies now available.

Many scholars in this field now expect that the elements of a new approach could emerge simply by bringing together the considerable but separated bodies of statistics we now possess for individual countries into a multinational frame of reference.

Perhaps the most obvious and urgent task of the discipline is to restructure and to reconstitute the economic data available into a form that will permit ready comparisons across the countries and across the regions of Europe. To advance further, European economic history should be firmly established on the basis of statistics which will command the respect of scholars throughout the continent. Such statistics would hopefully include the conventional kind of numbers readily accessible to economists and historians who are concerned with the development of Europe in the second half of the 20th century; for example, those familiar calculations of per capita incomes expressed in a common currency and numerous indicators of partial productivity for agriculture and industry which form the indispensable basis for analysis into contrasts in living standards and economic efficiency among the economies of Europe at the present time.

Certainly the amount of information available for earlier periods will be more limited. While the task of collating and structuring local and national statistics into a form which will allow historians to compare levels of welfare and productivity across national boundaries will require a sustained effort of research and co-operation from scholars in several European universities. There are, moreover, problems of method and definition to be solved before the search for data can begin. But the concepts connected with international comparisons of income and productivity have been extensively discussed by economists. And the voluminous research over the past three decades on the quantitative economic history of European countries indicates that a considerable volume of statistics are available to be collated into countrywide or regional averages and presented in form which would facilitate international comparisons.

When an acceptable body of data has been garnered (largely from published sources) and presented as sets of tables, the gaps in living standards among European populations can be located and quantified. Historians will be able to distinguish the share of the differential attributable to differences in the allocation of labour between industry and agriculture from the share attributable to national differences in the productivity of labour employed in industry and agriculture. Differentials in labour productivities can then be broken down between industries and sectors of agriculture. The productivity and role of the service sector can be fitted into the picture. Finally scholars could then proceed to analyse such differences in terms of capital-labour ratios, natural endowments, the diffusion of technology, variations in patterns of demand, the size of the market, etc. in different parts of Europe. At this stage (when salient differences between nations are clear and quantified) they can then begin to utilize, to modify and to construct models of economic growth to account for differences in their patterns and rates of growth over the long run.

All the scholars who met at Bielefeld believe that the statistical building blocks for an economic history of Europe must take the form of measures of the productivities of labour employed in producing the manifold commodities and services which make up the output of a given country. They recognized they could not hope to make productivity estimates for more than a selection of the principal commodities produced in the 19th and 20th centuries. But if the utility of the ideas is appreciated the example should stimulate further research by others along similar lines.

Meanwhile the production of estimates related to such obvious and major commodities as grain, meat, wine, coal, textiles, iron and steel, bricks, ships and railways

(just to take some obvious examples) should enable historians to begin to base Europe's economic history upon a valid body of statistics and focus it firmly upon an attempt to account for measured differences in levels of productivity over fairly long periods of time.

Statistics are only a preface to historical enquiry. But once they are collated into the required form, the analysis of contrasts and changes over the long run in labour productivity can begin and at that stage the relative significance of agriculture, food supplies, capital, the diffusion of advanced technology and other elements, which are the preoccupations of economic historians, can be appreciated and a European perspective brought to bear upon the national histories of its constituent states. At that point not only should a "real" economic history of Europe become possible but the finished study could exercise a real influence upon the teaching and writing of national economic history because the collection and proper arrangement of data on differences in productivity among European economies is probably indispensable for a deeper understanding of the long term economic evolution of individual states.

For its preparatory meeting at Bielefeld the group concentrated on three themes related to these broad ideas and objectives: first, the recent development and present state of European economic history (discussion was organized around the opening paper presented by Herman Van der Wee and Jos Delbeke and an address by Peter Mathias); secondly, a lively and protracted debate took place in several sessions concerned with the conceptual problems involved in the measurement and comparisons of income and productivity across countries (papers by Richard Tilly, Patrick O'Brien and Gianni Toniolo raised most of the theoretical issues which could arise); thirdly, our deliberations became more concrete when the conference turned to consider papers by Maurice Lévy-Leboyer, Angus Maddison, Juan Guispado and Rainer Metz designed to measure growth and fluctuations in productivity over time and even more specific when we considered two exercises in econometrics comparing the relative efficiency of European iron and steel industries, 1820–1914 by Rainer Fremdling and Robert Allen.

Interchanges between historians and economists from several national and intellectual traditions generated lively and constructive argument. Despite reservations expressed by many scholars about the conceptual and empirical difficulties of comparing trends in income and productivity across Western Europe, they remained convinced that a new economic history of the region could only be based on carefully collected and properly calibrated sets of statistics.

All those who attended the Bielefeld meeting on European Productivity, 1789–1950, from 25th–26th April, 1981, wished to extend their warm thanks to their academic host, Sidney Pollard, to the Directorial Board of the Zentrum für Interdisziplinäre Forschung (including its helpful executive staff) for financing and managing a conference on this important topic. They would also like to express their gratitude to the editors of Quantum for help in publishing most of the papers submitted or solicited for the Bielefeld, Conference.

Autumn 1981

Rainer Fremdling
Patrick K. O'Brien

Part 1: Concepts

Jos Delbeke, Herman Van der Wee

Quantitative Research in Economic History in Europe after 1945*

The study of quantitative economic history, building on the substantial base that was laid by economic historians such as Simiand and Labrousse in the 1930's, greatly expanded after 1945. The most important contributory factor for this phenomenon was undoubtedly the increasing interest of economists for the empirical testing of their theories, which, since the methodological conflicts of the 1880's, had been largely based on an ahistorical, deductive method. Then, too, more tools became available for the conduct of such research: more and more statistical techniques were developed that could be applied directly to economic research, and the evolution of computer sciences made their application practicable. Finally, the general expansion of the science of economy began to attract attention from other disciplines. Among those who felt this attraction were historians.

Our purpose here is to present the major trends of this intensified European research in economic history. We will concentrate on the fields of research that have occupied the attentions of the majority of the economic historians in specific periods. However, since complete bibliographies are readily available, we will make no attempt to provide an exhaustive list of the relevant publications.

The interest of economic historians has closely paralleled the contemporary problems confronting the science of economics. Between the two World Wars and shortly after World War II, economic movements attracted a great deal of attention. The great economic crises of the thirties end their aftermath were decisive. Historians set out to determine whether economic fluctuations had occurred in the past and, if so, in what manner. In so doing, they laid the foundations for the present quantitative economic history.

In the 1950's and 1960's, interest shifted more and more toward sectoral and macro-economic growth and toward the institutional factors associated with this growth. This was a period of decolonization, and the problem of development loomed large for the new nations though not less for the "old" nations. And with the ongoing crisis of the 1970's, the problem of discordant and unbalanced economic growth again came to the fore.

* We want to express our sincere thanks to Drs. E. Aerts for his valuable remarks.

Thus, our concern here is with the major trends in quantitative economic history as manifested in the work of European economic historians from 1945–1980. In addition, we will only treat the 1945–1980 period insofar as it is part of a larger whole. One final restriction: we will be interpreting this historical work in the strict economic sense: studies dealing primarily with demographical, social, political, and other analogous variables will not be taken into consideration. For them, we would refer the reader to more broadly conceived works.[1]

I. The Study of Economic Movements

The world depression of the 1930's stimulated economists and historians to take up the study of the fluctuations in economic development and of business cycles. This interest led to the establishment of the "International Scientifical Committee on Price History" in 1931 under the chairmanship of Lord Beveridge. This association provided the first significant impulse to quantitative economic historical research in Europe. The interest was primarily on fluctuations in prices and wages, and numerous studies appeared in France,[2] Germany,[3] Austria,[4] the United Kingdom,[5] Italy,[6] Poland,[7] and Spain.[8]

1. Baudet, H., Van Der Meulen, H., (eds.), *Kernproblemen der economische geschiedenis,* Groningen 1978.
   Bläsing, J. F. E., *Inleiding tot de elementaire economische geschiedenis,* Groningen 1980.
   Kula, W., *Problemi e metodi di storia economica,* Milano 1972.
   Geurts, P. A. M., Messing, F. A. M., *Theoretische en methodologische aspecten van de economische en sociale geschiedenis,* in: Geschiedenis in veelvoud 7/8, Den Haag 1979.
   Marczewski, J., *Introduction à l'histoire quantitative,* Genève 1965.
   Slicher van Bath, B. H., *Theorie en Praktijk in de economische en sociale geschiedenis,* in: A. A. G. Bijdragen, nr. 14, Wageningen 1967, pp. 105–228.
   Van der Wee, H., Klep, P. M. M., *Quantitative economic history in Europe since the Second World War: Survey, Evaluation and Prospects,* in: Recherches Economiques de Louvain, 41 (1975), pp. 195–218.
2. Hauser, H., *Recherches et documents sur l'histoire des prix en France de 1500 à 1800,* Paris 1933.
   Labrousse, C. E., *Esquisse du mouvement des prix et des revenus en France au XVIIIe siècle,* Paris 1933.
3. Elsas, M. J., *Umriss einer geschichte der Preise und Löhne in Deutschland,* Leiden 1936–49.
   Jacobs, A., Richter, H., *Die Großhandelspreise in Deutschland von 1792 bis 1934,* Berlin 1935.
4. Pribram, A. F., *Materialen zur Geschichte der Preise und Löhne in Oesterreich,* XV–XVIII Jahrhundert, Vienna 1938.
5. Beveridge, W., *Prices and Wages from the Twelfth to the Nineteenth Century. Vol. 1. Price Tables: Mercantile Era,* London 1939.
   Gilboy, E. W., *Wages in Eighteenth Century England,* London 1934.
6. Parenti, G., *Prime richerche sulla Rivoluzione dei prezzi in Firenze,* Florence 1939.
   Fanfani, A., *Indagini sulla "Rivoluzione dei prezzi",* Milano 1940.
   Parenti, G., *Prezzi e mercato del grano a Siena, 1546–1756,* Florence 1942.
7. Several price publications appeared in the series "Badania z Dziejow Spoznyck i Gospodarczyck" pod redahcja Prof. Fr. Bujak. The editors were Adamczyck, A., Furtak, T., Gorkiewicz, M., Hoszowski, S., Mika, M., Pelc, J., Siegel, S., Tomaszewski, E.

This trend continued after World War II, and new research projects were set up in various countries. Under the impetus provided by E. Labrousse and J. Meuvret in France, an enormous project was begun with the objective of editing and publishing official French price lists from the 16th century on.[9] Similar work was commenced in almost every European country: Italy,[10] the Netherlands,[11] Belgium (where the "Interuniversity Centre for the History of Prices and Wages" was established in 1953),[12]

8. Hamilton, E. J., *American Treasure and the Price Revolution in Spain, 1501–1650,* Cambridge, Mass. 1934.
Hamilton, E. J., *Money, Prices and Wages in Valencia, Aragon and Navarra, 1351–1500,* Cambridge, Mass. 1936.
Hamilton, E. J., *War and Prices in Spain, 1651–1800,* Cambridge, Mass. 1947.
9. Baulant, M., Meuvret, J., *Prix des céréales extraits de la mercuriale de Paris, 1520–1698,* Paris 1960.
Baulant, M., *Le prix du blé à Paris, 1450–1789,* in: Annales E. S. C., 23(1968), pp. 520–540.
Baulant, M., *Le salaire des ouvriers du bâtiment à Paris de 1400 à 1726,* in: Annales E. S. C., 26(1971), pp. 436–483.
Romano, R., *Commerce et prix du blé à Marseille au XVIIIe siècle,* Paris 1956.
Frêche, G. & G., *Les prix des grains, des vins et des légumes à Toulouse, 1486–1868,* Paris 1967.
Labrousse, E., Romano, R., Dreyfus, F. G., *Le prix du froment en France au temps de la monnaie stable, 1726–1913,* Paris 1930.
Dupaquier, J., Lachiver, M., Meuvret, J., *Mercuriales du pays de France et du Vexin français, 1640–1792,* Paris 1968.
10. De Maddalena, A., *Prezzi e aspetti di mercato in Milano durante il secolo XVII,* Milano 1950.
Romano, R., *Prezzi, salari e servizi a Napoli nel secolo XVIII, 1734–1806,* Milano 1965.
De Maddalena, A., *Prezzi e mercedi a Milano dal 1701 al 1860,* Milano, 1974.
Also several publications in: Cipolla, C. M., (ed.), *Archivio Economico dell' Unificazione Italiana,* 1956.
Sella, D., *Salari e lavoro nell edifizia lombarda durante il secolo XVII,* Pavia 1968.
Basini, G. L., *L'uomo e il pane. Ricorse, consumi e carenze della populazione modenese nel Cinque e Seicento,* Milano 1970.
Vigo, G., *Real Wages of the Working Class in Italy: Building Workers' Wages, fourteenth to eighteenth century,* in: The Journal of European Economic History, 3(1974), pp. 378–399.
11. Posthumus, N. W., *Nederlandsche Prijsgeschiedenis,* Leiden 1943.
Posthumus, N. W., Ketner, F., *Nederlandsche Prijsgeschiedenis,* Leiden 1964.
12. Verlinden, C., a. o., *Dokumenten voor de geschiedenis van prijzen en lonen in Vlaanderen en Brabant,* Bruges 1959–'73.
Van der Wee, H., *The Growth of the Antwerp Market and the European Economy, fourteenth-sixteenth centuries,* vol. 1: Statistics, The Hague 1963.
Ruwet, J., Hélin, E., Ladrier, F., Van Buyten, L., *Marché des céréales à Ruremonde, Luxembourg, Namur et Diest aux 17e et 18e siècles,* Louvain 1966.
Génicot, L., Bouchat-Dupont, M. S., Delvaux, B., *La crise agricole du Bas Moyen Age dans le Namurois,* Louvain 1970.
Fanchamps, M. L., *Recherches statistiques sur le problème annonaire dans la principauté de Liège de 1475 à la fin du 16e siècle,* Liège 1970.
Tits-Dieuaide, M. J., *La formation des prix céréaliers: l'exemple flamand et brabançon au 15e siècle,* Brussels 1975.
Several articles are published in the "Bijdragen tot de Prijsgeschiedenis/Contributions à l'histoire des prix".
In the 1970s, a series "Lonen en Prijzen", is being published under the direction of E. Scholliers (Brussels).

Denmark,[13] the United Kingdom,[14] Portugal,[15] Sweden,[16] the USSR,[17] Poland,[18] Spain,[19] West Germany,[20] and Turkey and the Middle East.[21]

These price and wage studies primarily constituted the first phase of quantitative economic historical research: the construction of a data bank. The data were very

13. Friis, A., Glamann, Kr., *A History of Prices and Wages in Denmark, 1660–1800,* London 1958.
14. Postan, M. M., Titow, J., *Heriots and Prices on Winchester Manors,* in: The Economic History Review, 11(1958–'59), pp. 392–417.
Farmer, D. L., *Some Grain Price Movements in Thirteenth-Century England,* in: The Economic History Review, 10(1957–'58), pp. 207–220.
Farmer, D. L., *Some Livestock Price Movements in Thirteenth Century England,* in: The Economic History Review, 22(1969–'70), pp. 1–16.
Brenner, Y. S., *The Inflation of Prices in Early Sixteenth Century England,* in: The Economic History Review, 14(1960–'61), pp. 225–239.
Brenner, Y. S., *The Inflation of Prices in England, 1551–1650,* in: The Economic History Review, 15(1962–'63), pp. 266–284.
Bowden, P., *Agricultural Prices, Farm Profits and Rents,* in: J. Thirsk (ed.), The Agrarian History of England and Wales, vol. IV: 1500–1640, Cambridge 1967, pp. 593–695.
Hoskins, W. G., *Harvest Fluctuations and English Economic History, 1480–1619,* in: Agricultural History Review, 12(1964), pp. 18–46.
Hoskins, W. G., *Harvest Fluctuations and English Economic History, 1620–1759,* in: Agricultural History Review, 16(1968), pp. 15–31.
Chapman, A., Knight, R., *Wages and Salaries in the United Kingdom, 1920–1938,* London 1953.
15. Magelhaes Godinho, V., *Prix et Monnaies au Portugal, 1750–1850,* Paris 1955.
16. Hammarström, I., *The Price Revolution of the Sixteenth Century: Some Swedish Evidence,* in: The Scandinavian Economic History Review, 5(1957), pp. 118–154.
Jörberg, L., *The Development of Real Wages for Agricultural Workers in Sweden During the Eighteenth and Nineteenth Centuries,* in: Economy and Theory, 15(1972), pp. 41–57.
17. Mankov, A. G., *Le mouvement des prix dans l'état russe du 16e siècle,* Paris 1957.
18. Hoszowski, St., *Les prix à Lwow, 16e–17e siècles,* Paris 1954.
19. Eiras Roel, A., Uzero Gonzales, R., *Los Précios de los granes de Santiago de Compostella: siglo 18,* in: Jornadas de Metodologia aplicada de las Ciencas Historicas, 24–27 Abril 1973, Ponencias y Communicaciones, vol. 2, pp. 20.
Garcia Lombardero, J., *Analisis estadistico de los precios de los productos agricolas en la Galicia del siglo 18,* in: Jornadas de metodologia aplicada de las Ciencas Historicas, 24–27 Abril 1973, Ponencias y Communicaciones, vol. 2, pp. 12.
20. Abel, W., *Agrarkrisen und Agrarkonjunktur. Eine Geschichte der Land- und Ernährungswirtschaft Mitteleuropas seit dem hohen Mittelalter,* Hamburg, Berlin 1935.
Abel, W., *Massenarmut und Hungerkrisen im vorindustriellen Europa,* Hamburg, Berlin 1974.
Achilles, W., *Getreidepreise und Getreidehandelsbeziehungen europäischer Räume im 16. und 17. Jahrhundert,* in: Zeitschrift für Agrargeschichte und Agrarsoziologie, 7(1959), pp. 32–55.
Schmidt, H. J., *Faktoren der Preisbildung für Getreide und Wein in der Zeit von 800 bis 1350,* Stuttgart 1968.
21. Barkan, O., *XV. asrin sonunda bazi büyük schirlerde esya ve yiyecik fiyatlari,* Istanbul 1942.
Barkan, O., *Les mouvements des prix en Turquie entre 1490 et 1655,* in: Mélanges en l'honneur de F. Braudel, Vol I.: Histoire économique du monde méditerranéen, 1450–1650, Toulouse 1973, pp. 65–79.
Ashtor, E., *Histoire des prix et des salaires dans l'Orient Mediéval,* Paris 1969.

precisely classified and made homogeneous, but very few statistical analyses were carried out. The publication of primary sources continues unabated today, which is necessary for further research. Now, however, most publications include more extensive statistical analyses.

Also during the 1930's, some economists became fascinated by the successive periods of growth and decline that seemed to occur in the various economic sectors, and they began to subject these phenomena to detailed historical and statistical analysis, which the increasing availability of numerical material made possible.

The Russian economist, N. D. Kondratieff, was the first to test and integrate the existing speculative theories on the long waves scientifically.[22] The influence of his work was great, and, together with the outbreak of the Great Depression, it inspired a number of important studies that often extended into the pre-industrial period: in France by F. Simiand and E. Labrousse,[23] in Belgium by L. H. Dupriez and his colleagues,[24] and in the Netherlands by S. De Wolff.[25] In Germany, numerous interesting studies were published.[26] After World War II, the study

22. The idea of long waves was first suggested in 1913 by the Dutch economist Van Gelderen, who wrote under the name of J. Fedder. In the twenties, Kondratieff developed the notion of long waves systematically.
Kondratieff, N. D., *Die langen Wellen der Konjunktur,* in: Archiv für Sozialwissenschaft und Sozialpolitik, 56(1926), pp. 573–609.
Kondratieff, N. D., *Die Preisdynamik der industriellen und landwirtschaftlichen Waren,* in: Archiv für Sozialwissenschaft und Sozialpolitik 60(1929), pp. 1–85.

23. Simiand, Fr., *Le salaire, l'évolution sociale et la monnaie. Essai de théorie expérimentale du salaire,* Paris 1932.
Simiand, Fr., *Recherches anciennes et nouvelles sur le mouvement général des prix du 16e au 19e siècle,* Paris 1932.
Simiand, Fr., *Inflations et stabilizations alternées: le développement économique des Etats-Unis,* Paris 1934.
Labrousse, C. E., *Esquisse du mouvement des prix et des revenus en France au 18e siècle,* Paris 1932.
Labrousse, C. E., *La crise de l'économie française à la fin de l'Ancien Régime et au début de la Révolution,* Paris 1944.

24. Duprièz, L. H., *Einwirkungen der langen Wellen auf die Entwicklung der Wirtschaft seit 1800,* in: Weltwirtschaftliches Archiv, 37(1935), pp. 1–12.
Dupriez, L. H., *Des mouvements économiques généraux,* Louvain 1947.
Dupriez, L. H., *Philosophie des conjonctures économiques,* Louvain 1959. The very interesting sectoral research of Dupriez and his colleagues was published in Recherches Economiques de Louvain, formerly Bulletin de l'Institut des Sciences Economiques, founded in 1929.

25. de Wolff, S., *Prosperitäts- und Depressionsperioden,* in: Der lebendige Marxismus. Festgabe zum 70. Geburtstag von K. Kautsky, Jena 1924.
de Wolff, S., *Het Economisch Getij,* Amsterdam 1929.
As noticed in footnote 22, Van Gelderen (pen-named J. Fedder) first suggested the idea of the long wave, already before the first world war.
Van Gelderen, J., *Springvloed: beschouwingen over industriële ontwikkeling en prijsbeweging,* in: De Nieuwe Tijd, 1913, pp. 253–277, 369–384, 445–464.

26. Abel, W., *Agrarkrisen und Agrarkonjunktur. Eine Geschichte der Land- und Ernährungswirtschaft Mitteleuropas seit dem hohen Mittelalter,* Hamburg, Berlin 1935.
Cassel, G., *Theoretische Sozialökonomie,* Leipzig 1932.

of the long waves was enriched by the integration of the study of short-term fluctuations.[27]

The most influential of the authors who dealt with long wave theories was undoubtedly J. A. Schumpeter.[28] His works are milestones in economic historiography, and they continue to exercise much influence on economic thought. The dating of his analytical schema was carried out by Simon Kuznets.[29]

Notwithstanding the interest in the long waves, research concerning short-term fluctuations continued to be very active. In France, these studies were dominated by Labrousse's concept of "crise d'ancien type" or "crise de subsistance".[30] The interest in England was focused more on the business cycles in the 18th and 19th centuries. Some of these studies were the result of broad and fruitful Anglo-American cooperation,[31] and others were published as shorter monographs[32] or as articles.[33]

II. The Study of Economic Growth

In the postwar period, the successes achieved in the reconstruction of wage and price data were rapidly extended to the areas of agrarian, industrial, commercial, and monetary statistics. Indeed, the economic movement theories had shown how usefully diverse quantitative information could be combined in such a way that more profound analyses could be carried out than were possible using traditional qualitative historiography.

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von Ciriacy-Wantrup, S., *Agrarkrisen und Stockungsspannen zur Frage der langen Wellen in der wirtschaftlichen Entwicklung,* Berlin 1936.
Däbritz, W., *Die typischen Bewegungen im Konjunkturverlauf,* Leipzig 1929.
Wagemann, E., *Struktur und Rhythmus der Weltwirtschaft,* Berlin 1931.
Wagemann, E., *Menschenzahl und Völkerschicksal,* Berlin 1948.
Woytinski-Lorenz, W., *Das Rätsel der langen Wellen,* in: Schmoller's Jahrbuch (1931), pp. 1-42.

27. Akerman, J., *Structures et Cycles Economiques,* Paris 1957.
Imbert, G., *Des mouvements de lonque durée Kondratieff,* Aix-en-Provence 1959.
Parry Lewis, J., *Building Cycles and Economic Growth,* London 1965.
Thomas, B., *Migration and Economic Growth,* Combridge 1954.
Weinstock, U., *Das Problem der Kondratieff-zyklen,* Berlin, München 1964.
For the pre-industrial period can also be mentioned:
Braudel, F., Spooner, F. C., *Prices in Europe from 1450 to 1750,* in: The Cambridge Economic History of Europe, vol. IV, Cambridge 1957, pp. 374-486.
Van der Wee, H., *Typologie des crises et changements de structures au Pays-Bas, 15e-16e siècles,* in: Annales E.S.C., 18(1963), pp. 209-225.
28. Schumpeter, J. A., *Business-Cycles. A theoretical, historical and statistical analysis of the capitalist process,* New York 1939.
29. Kuznets, S., *Schumpeter's Business Cycles,* in: Economic Change, New York 1953.
30. Meuvret, J., *Etudes d'histoire économique. Recueil d'articles,* Paris 1971.
Chabert, A., *Essai sur le mouvement des revenus et de l'activité économique en France de 1798 à 1820,* Paris 1945-'49.
31. Gayer, A., Rostow, W. W., Schwartz, A. J., *The Growth and Fluctuations of the British Economy, 1790-1850,* Oxford 1953.
32. Ashton, T. S., *Economic Fluctuations in England, 1700-1800,* Oxford 1958.
33. Phelps-Brown, E. H., Handfield-Jones, S. J., *The Climacteric of the 1890's: A study in the Expanding Economy,* in: Oxford Economic Papers, 4 (1952) pp. 266-307.

Initially, the major effort was devoted to the construction of reliable data bases, and statistical analyses were limited. The researchers evidently hoped that more integrated analyses could be performed afterwards, and as time went by they tried more and more to test the existing theories for their truth value.

The most significant analyses, nevertheless, were those that provided fundamental contributions to the formulation of new economic theories on the basis of history. The long-wave theoreticians and historians had been the pioneers in this regard because they had illustrated how fruitful a laboratory history could be for the human sciences, to which economics continues to belong in spite of its use of methods derived from the positive sciences.

And in the 1950's and 1960's, there was a great need for new theory formation. Many economists, confronted with the problems of the developing countries and the questions concerning further progress in a world that had recovered from the war, felt the limitations of the ahistorical marginalist approach. Therefore, they took up the study of history from their own scientific points of view in order to analyze the variables of economic development, which had been considered externally up till then. The pioneers of this evolution were Kuznets, Gerschenkron, and Rostow in the United States, Lewis in the United Kingdom, and Perroux in France.[34] More and more historians joined this evolution and schooled themselves in economic theories and quantitative analysis, instruments that had matured in the science of economics. These historians fruitfully emphasized the social changes that economic growth seemed to imply.

Interest in commercial statistics had long been keen, doubtless because of the emphasis that classic economic theory had placed on commercial liberalization for the development of the capitalist world economy. Several important publications were devoted to maritime statistics. N. Ellinger Bang published the *Sont* registers, that is, statistical material on the Baltic and North Sea trade. These data were computerized by Johansson.[35] P. Chaunu and H. Chaunu compiled the first statistics concerning the trade between Europe and the West Indies.[36] For England, global statistics on the overseas trade were assembled with a high degree of reliability and "cover", that is, for the Middle Ages,[37] the 17th century,[38] and for the later period.[39] For the other

34. Kuznets, S., *Modern Economic Growth: Rate, Structure and Spread*, New Haven, Conn. 1966.
Gerschenkron, A., *Continuity in History and other Essays*, Cambridge, Mass. 1968.
Rostow, W. W., *The Stages of Economic Growth*, Cambridge, Mass. 1966.
Lewis, W. A., *Economic Development with unlimited Supplies of Labour*, in: Manchester School of Economic and Social Studies, 12(1954).
Perroux, F., *La coexistence pacifique*, Paris 1958.
35. Ellinger Bang, N., Korst, Kn., *Tabeller over Skibsfart og Varetransport gennen Øresund, 1497–1660*, Copenhagen 1906–1923.
Ellinger Bang, N., Korst, Kn., *Tabeller over Skibsfart og Varetransport gennen Øresund, 1661–1783 og gennem Storebaelt, 1701–1748*, Copenhagen 1930–1953.
36. Chaunu, P. & H., *Séville et l'Atlantique, 1504–1650. Statistique du traffic entre l'Espagne et le Nouveau Monde*, Paris 1953–1960.
37. Carus-Wilson, E. M., Coleman, O., *England's Export Trade, 1275–1547*, Oxford 1963.
38. Davis, R., *English Overseas Trade, 1500–1700*, London 1973.
39. Schumpeter, E. B., *English Overseas Trade Statistics, 1697–1808*, Oxford 1960.
Schlote, W., *British Overseas Trade from 1700 to the 1930's*, Oxford 1952.

European countries, analogous global or national statistical information concerning the Ancien Régime was not available, although several studies appeared with more specific commercial statistics concerning particular harbors, forms of trade, or toll revenues.

The innovational works began increasingly to apply the international trade theories to the historical data that had become available: F. Mauro developed a model for the European colonial expansion of the Modern Period;[40] H. Van der Wee proposed a dual development model as the explanation of the trend in European trade in the late Middle Ages and in the Modern Period;[41] K. Veraghtert applied advanced statistical techniques to new sources concerning the Port of Antwerp in the 19th century;[42] and other European economic historians studied the role of international trade in industrial development (see below). Thus, C. Wilson investigated the relationship between the growth of British overseas trade and the development of European industry,[43] and P. Bairoch contributed to the comparison of foreign trade and economic development in Europe during the 19th and 20th centuries.[44]

Most economic historians seem to have been fascinated primarily by the study of macro-economic growth, and major works were published on this subject, though many of them were still descriptive in nature. Regional studies, mainly on the Ancien Régime, were very popular on the continent. The general influence of the French "Annales" school and the specific influence of F. Braudel's geo-history and his "Longue Durée" are obvious.[45] For France, it is possible to point to an entire series of important regional studies for the period from the Late Middle Ages to the 19th century.[46] Outside of France, the influence of the "Annales" school was strongly felt in Italy, Spain, Belgium, and the Netherlands.[47]

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40. Mauro, F., *Towards an Intercontinental Model: European Overseas Expansion between 1500 and 1800,* in: The Economic History Review, 15(1961), pp. 1-17.
41. Van der Wee, H., Peeters, Th., *Un modèle dynamique de croissance interseculaire du commerce mondiale, 12e-18e siècles,* in: Annales E.S.C., 25(1970), pp. 100-126.
42. Veraghtert, K., *De havenbeweging te Antwerpen tijdens de 19e eeuw. Een kwantitatieve benadering,* Leuven 1977.
43. Wilson, Ch., *The Growth of Overseas Commerce and European Manufacture,* in: New Cambridge Modern History, 1957.
44. Bairoch, P., *Commerce internationale et genèse de la révolution industrielle anglaise,* in: Annales E.S.C., 28(1973), pp. 541-571.
    Bairoch, P., *European Foreign Trade in the XIXth Century. The Development of the Value and Volume of Exports,* in: The Journal of European Economic History, 2(1973), pp. 3-56.
    Bairoch, P., *Geographical Structure and Trade Balance of European Foreign Trade from 1800 to 1970,* in: The Journal of European Economic History, 3(1974), pp. 557-608.
45. Braudel, F., *La Méditerranée et le monde méditerranéen à l'époque de Philippe II,* Paris 1949.
46. Le Roy Ladurie, E., *Les Paysans de Languedoc,* Paris 1966.
    Goubert, P., *Beauvais et le Beauvaisis de 1600 à 1730,* Paris 1960.
    Léon, P., *La naissance de la grande industrie en Dauphiné, fin du 17e siècle-1869,* Paris 1954.
    Baehrel, R., *Une croissance: la Basse-Provence rurale, fin du 16e siècle-1789,* Paris 1961.
    Neveux, H., *Les grains du Cambrésis, fin du 14e-début du 17e siècles. Vie et déclin d'une structure économique,* Lille 1974.
47. Vilar, P., *La Catalogne dans l'Espagne moderne,* Paris 1962.

In Great Britain, numerous major studies were published on the industrial revolution by such scholars as T. S. Ashton, P. Deane, R. M. Hartwell, P. Mathias, and P. Mantoux.[48] This research was soon followed on the continent by P. Lebrun and H. Van der Wee in Belgium, W. G. Hoffmann in Germany, J. A. De Jonghe and R. T. Griffiths in the Netherlands, and F. Crouzet, P. Léon, M. Lévy-Leboyer, and J. Marczewski in France.[49] The Take-Off and Great Spurt Hypotheses of W. W. Rostow and A. Gerschenkron, respectively, attracted a great deal of interest. Later on, however, more and more studies were devoted to the long-term development of industrial capitalism in Western Europe[50] for which extensive statistical material was assembled and made homogeneous.[51]

Van der Wee, H., *The Growth of the Antwerp Market and the European Economy, fourteenth-sixteenth centuries,* The Hague 1963.
Slicher van Bath, B. H., *Een samenleving onder spanning. Geschiedenis van het platteland in Overijssel,* Assen 1957.
Van der Woude, A. M., *Het Noorderkwartier. Een regionaal historisch onderzoek in de demografische en economische geschiedenis van westelijk Nederland van de late middeleeuwen tot het begin van de 19e eeuw,* in: A.A.G.-Bijdragen, nr. 16, Wageningen 1972.
Faber, J. A., *Drie eeuwen Friesland. Economische en sociale ontwikkelingen van 1500 tot 1800,* in: A.A.G.-Bijdragen, nr. 17, Wageningen 1972.

48. Ashton, T. S., *The Industrial Revolution, 1760–1830,* London 1948.
Deane, Ph., *The First Industrial Revolution,* Cambridge 1965.
Hartwell, R. M. (ed.), *The Causes of the Industrial Revolution in England,* London 1967.
Mathias, P., *The First Industrial Nation,* London 1969.
Mantoux, P., *La révolution industrielle au 18e siècle,* London 1960.

49. Lebrun, P., *La Revoluzione Industriale in Belgio. Strutturazione e destrutturazione delle economie regionale,* in: Studi Storici, 2(1961), pp. 448–558.
Lebrun, P., Bruwier, M., Dhondt, J., Hansotte, G., *Essai sur la révolution industrielle en Belgique, 1770–1847,* Brussel 1979.
Van der Wee, H., *De Belgische Industriële Revolutie,* in: Historische aspecten van de economische groei, Antwerpen 1972.
Hoffmann, W. G., *Das Wachstum der deutschen Wirtschaft seit der Mitte des 19. Jahrhunderts,* Berlin 1965.
De Jonghe, J. A., *De industrialisatie in Nederland tussen 1850 en 1914,* Amsterdam 1968.
Griffiths, R. T., *Industrial Retardation in the Netherlands, 1830–1850,* Den Haag 1979.
Crouzet, F., *Angleterre et France au 18e siècle. Essai d'analyse comparée de deux croissances économiques,* in: Annales E.S.C., 21(1966), pp. 254–291.
Léon, P., Crouzet, F., Gascon, R., *L'industrialisation en Europe au 19e siècle. Cartographie et Typologie, Lyon 7–10 Octobre 1970,* Paris 1972.
Lévy-Leboyer, M., *Les banques européennes et l'industrialisation internationale dans la première moitié du 19e siècle,* Paris 1964.
Marczewski, J., *The take-off hypothesis and French experience,* in: Rostow, W. W., The economics of take-off into sustained Growth, London 1963, pp. 119–139.

50. Deane, P., Cole, W. A., *British Economic Growth, 1688–1959. Trends and Structure,* Cambridge 1962.
Landes, D. S., *The Unbound Prometheus. Technological Change and Industrial Development from 1750 to the present,* Cambridge 1969.
Milward, A. S., Saul, S. B., *The Economic Development of Continental Europe, 1780–1870,* London 1973.
Milward, A. S., Saul, S. B., *The Development of the Economies of Continental Europe, 1850–1914,* London 1977.

In the analysis of the determinants of economic growth, capital formation in Great Britain received considerable attention, particularly since the pioneering study of A. K. Cairncross.[52] On the continent, too, research in this area increased: in France under the direction of F. Crouzet and in the Scandanavian countries.[53]

Inspired by the New Economic History in the United States, the effect on economic growth of investment in the railroad sector attracted the attention of a number of scholars such as F. Caron in France, G. R. Hawke in England, and R. Fremdling in Germany.[54] Others studied more explicitly the role of technological innovations

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Pollard, S., *Peaceful Conquest: The Industrialisation of Europe, 1760–1970,* Oxford 1981.
Hoffmann, W. G., *British Industry, 1700–1950,* Oxford 1955.
Hoffmann, W. G., *Ein Index der industriellen Produktion für Grossbritannien seit dem 18. Jahrhundert,* in: Weltwirtschaftliches Archiv, 36(1934), p. 383.
Gadisseur, J., *Le produit physique de l'économie belge, 1831–1913. Présentation critique des données statistiques,* Liège 1980.
Perroux, Fr., *Prises de vue sur la croissance de l'économie française, 1780–1950,* in: Kuznets, S. (ed.), Income and Wealth, Series V, London 1955.
Hodne, F., *Growth in a Dual Economy: The Norwegian Experience, 1814–1914,* in: Economy and History, 16(1973), pp. 81–110.
Hausen, S. A., *Økonomisk Vaekst i Danmark, 1720–1970,* Copenhagen 1972.
Berend, I. T., Ranki, G., *Hungary. A Century of Economic Development,* New York 1974.
Nadal, J., *El Fracaso de la Revolucion industrial en Espana, 1814–1913,* Barcelona 1975.

51. Mitchell, B. R., Deane, P., *Abstract of British Historical Statistics,* Cambridge 1962.
Mitchell, B. R., *European Historical Statistics, 1750–1970,* London 1975.

52. Cairncross, A. K., *Home and Foreign Investment, 1870–1913,* Cambridge 1953.
Chapman, S. D., *Fixed Capital Formation in the British Cotton Industry, 1770–1815,* in: The Economic History Review, 23(1970), pp. 235–266.
Deane, Ph., *Capital Formation in Britain before the Railway Age,* in: Economic Development and Cultural Change, 11(1961), pp. 352–368.
Feinstein, C. H., *Home and Foreign Investment: Some Aspects of Capital Formation and Finance in the United Kingdom, 1870–1913,* Cambridge 1959.
Feinstein, C. H., *Capital Formation in the United Kingdom, 1920–1938,* Cambridge 1965.
Hawke, G. R., Reed, M. C., *Railway Capital in the United Kingdom in the Nineteenth Century,* in: The Economic History Review, 22(1969), pp. 269–286.
Higgens, J. P. P., Pollard, S., (eds.), *Aspects of Capital Investment in Great Britain, 1750–1850. A Preliminary Survey,* 1971.
Lenfant, J. H., *Great Britain's Capital Formation, 1865–1914,* in: Economica, 18(1951), pp. 151–168.
Pollard, S., *The Growth and Distribution of Capital in Great Britain, 1770–1870,* in: Third International Conference of Economic History, München 1965, vol. 1, 1968.

53. Crouzet, Fr. (ed.), *Capital Formation in the Industrial Revolution,* London 1972.
Lundberg, L., *Kapitalbildningen i Sverige, 1861–1965,* Upsala 1969.
Martinus, S., *Agrar Kapitalbildnung och finansiering, 1833–1892,* Göthenborg 1970.
Krust, O. A., Bjerke, J., *Real Capital and Economic Growth in Norway, 1900–1956,* in: Income and Wealth, Series 8, London, 1959.

54. Caron, Fr., *Histoire de l'exploitation d'un grand réseau: la Compagnie du Chemie de Fer du Nord, 1846–1937,* Paris 1973.
Hawke, G. R., *Railways and Economic Growth in England and Wales, 1840–1870,* Oxford 1970.
Mitchell, B. R., *The Coming of the Railway Age and United Kingdom Economic Growth,* in: Journal of Economic History, 24(1964), pp. 315–336.

and their diffusion. The research of H. J. Habakkuk was very significant in this area.[55] In Britain, several studies were undertaken in order to measure labor and capital productivity on the national, regional, and sectoral levels. A. Maddison, P. O'Brien, and others compared the evolution of labor productivity internationally.[56] In this connection, the brilliant study of E. H. Phelps-Brown and M. H. Browne, "A Century of Pay", must also be mentioned here.[57]

In France, Germany, and Belgium, particular attention was devoted to the influence of financial intermediation on economic development.[58] A more recent de-

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Vamplew, W., *Railways and the Transformation in the Scottish Economy,* in: The Economic History Review, 24(1971), pp. 37–54.
Vamplew, W., *Railways and the Iron Industry in Scotland,* in: Reed, M. C. (ed.), Railways in the Victorian Economy, Newton Abbot 1969.
Fremdling, R., *Eisenbahnen und deutsches Wirtschaftswachstum, 1840–1879. Ein Beitrag zur Entwicklungstheorie und zur Theorie des Infrastruktur,* Dortmund 1975.
Fenoaltea, S., *Railroads and Italian Industrial Growth, 1861–1913,* in: Explorations in Economic History, 9(1972), pp. 325–352.

55. Habakkuk, H. J., *American and British Technology in the 19th Century: the Search for Labour-Saving Inventions,* Cambridge 1962.
56. Maddison, A., *Economic Growth in the West: Comparative Experience in Europe and North America,* New York 1964.
O'Brien, P. K., Keyder, C., *Economic Growth in Britain and France, 1780–1914: Two Paths to the 20th Century,* London 1978.
Blaug, M., *The Productivity of Capital in the Lancashire Cotton Industry during the Nineteenth Century,* in: The Economic History Review, 13(1960–1961), pp. 358–381.
Floud, R., *Changes in the Productivity of Labour in the British Machine Tool Industry, 1856–1900,* in: McCloskey, D. N. (ed.), Essays on a Mature Economy, Princeton 1971, pp. 313–337.
Hunt, E. H., *Labour Productivity in English Agriculture, 1850–1914,* in: The Economic History Review, 20(1967), pp. 281–292.
Kennedy, W. P., *Foreign Investment, Trade and Growth in the United Kingdom, 1870–1913,* in: Explorations in Economic History, 9(1973–1974), pp. 415–444.
Lomax, K. S., *Production and Productivity Movements in the United Kingdom since 1900,* in: Journal of the Royal Statistical Society (1959).
Rostas, L., *Comparative Productivity in British and American Industry,* Cambridge 1948.
Saul, S. B. (ed.), *Technological Change: the United States and Britain in the Nineteenth Century,* London 1970.
Tann, J., *Fuel Savings in the Process Industries during the Industrial Revolution: A Study in Technological Diffusion,* in: Business History, 15(1973), pp. 149–159.
Taylor, A. J., *Labour Productivity and Technological Innovation in the British Coal Industry, 1850–1914,* in: The Economic History Review, 16(1961–1962), pp. 48–70.
Walters, R., *Labour Productivity in the South Wales Steam-Coal Industry, 1870–1914,* in: The Economic History Review, 28(1975), pp. 280–303.
57. Phelps Brown, E. H., Browne, M. H., *A Century of Pay. The Course of Pay and Production in France, Germany, Sweden, the United Kingdom and the United States of America, 1860–1960,* London, New York 1968.
58. Bouvier, J., *Le Crédit Lyonnais de 1863 à 1882. Les années de la formation d'une banque de dépôts,* Paris 1961.
Bouvier, J., *Les Rothschild,* Paris 1967.
Lévy-Leboyer, M., *Les banques européennes et l'industrialisation internationale dans la première moitié du 19e siècle,* Paris 1964.

velopment in Europe is the application of quantitative methods in business history. In 1970, during the first Anglo-American MSSB conference at Harvard, K. Trace and P. H. Lindert used cost-benefit analysis in order to estimate the effect of entrepreneurial decision making in the chemical industry on the Victorian economy.[59] Both J. Kocka and R. Tilly have conducted quantitative studies on the relation between industrialization, bureaucratization, and the capital markets in Germany during the second half of the 19th century.[60] Both of these German studies, however, were more statistical than econometrical history. More econometrical was H. Deams' research on the strategy of the large Belgian holding companies. This study developed a mathematical theory of corporate control, measured the impact of the financial institution on Belgian economic growth, and estimated the financial performance.[61]

A true macro-economic approach was applied in the massive effort to reconstruct the national accounts. The greatest influence in this regard came undoubtedly from Simon Kuznets and from the International Association for Research in Income and Wealth, which not only renovated the research in the field but also supported it financially.[62] In England, the National Institute of Economic and Social Research and the Department of Applied Economics of Cambridge University were very active; in France the Institut des Sciences Economiques Appliquées (ISEA); and in Germany the Institut für Weltwirtschaft in Kiel and the Deutsche Forschungsgemeinschaft. The first useable results became available in the 1960's published under the direction of P. Deane and W. A. Cole in Great Britain, J. Marczewski in France, and W. Hoffman in Germany.[63]

Eistert, E., *Die Beeinflussung des Wirtschaftswachstums in Deutschland von 1883 bis 1913 durch das Bankensystem*, Berlin 1970.

59. Lindert, P. H., Trace, K., *Yardsticks for Victorian Entrepreneurs*, in: McCloskey, D. N. (ed.), Essays on a Mature Economy, Princeton 1971, pp. 239–274.
See also: Buxton, N. K., *Entrepreneurial Efficiency in the British Coal Industry between the Wars*, in: The Economic History Review, 23(1971), pp. 476–497.

60. Kocka, J., *Unternehmungsverwaltung und Angestelltenschaft am Beispiel Siemens, 1847–1914. Zum Verhältnis von Kapitalismus und Bürokratie in der deutschen Industrialisierung*, Stuttgart 1969.
Tilly, R., *Zur Entwicklung des Kapitalmarktes und Industrialisierung im 19. Jahrhundert unter besonderer Berücksichtigung Deutschlands*, in: Vierteljahrschrift für Sozial- und Wirtschaftsgeschichte, 60(1973), pp. 145–165.

61. Daems, H., *The Holding Company and Corporate Control*, Leiden, Boston 1978.

62. The first results of this research project were published in Kuznets, S. (ed.), *Income and Wealth*, vol. 2, 3, and 5, London, 1952, 1953 and 1955.
Summaries by Kuznets, S., *Quantitative Aspects of the Economic Growth of Nations*, in: Economic Development and Cultural Change, 1956 and following years.

63. Deane, P., Cole, W. A., *British Economic Growth, 1688–1959. Trends and Structure*, Cambridge 1969.
Jeffreys, J. B., Walters, D., *National Income and Expenditure of the United Kingdom, 1870–1952*, in: Income and Wealth, Series V, London, 1956.
Mitchell, B. R., Deane, P., *Abstract of British Historical Statistics*, Cambridge 1962.
O'Brien, P. K., *British Income and Property in the Early Nineteenth Century*, in: The Economic History Review, 12(1959–1960), pp. 255–267.

The publication of these national accounts was not very well received by most economic historians.[64] Indeed, the authors of these studies were severely criticized by their fellow historians for relying uncritically on the historical sources, for unwisely inter- and extrapolating to fill up data gaps, and for ignoring significant cycles by using decennial averages. Some experts in more traditional historiography such as P. Chaunu completely denounced the idea of aggregation and fiercely argued for the "histoire sérielle".[65] Other historians, however, accepted the principle of aggregation but called for more careful application of this principle and for special attention to the reliability of the historical source while calculating time series. Adopting this more careful approach, F. Crouzet and M. Lévy-Leboyer recalculated French annual industrial production and annual agrarian income during the 19th century.[66] Under the direction of P. Léon in Lyons, new calculations were made on a regional basis with the objective of constructing more homogeneous regional amalgamations.[67] P. Deane and C. H. Feinstein also recalculated the series for Great Britain.[68]

Earlier publications were:
Prest, A. R., *National Income of the United Kingdom, 1870–1946,* in: The Economic Journal, 58(1948), pp. 31–62.
Wright, J. F., *An Index of the Output of British Industry since 1700,* in: Journal of Economic History, 16(1956), pp. 356–364.
Marczewski, J., (ed.), *Histoire quantitative de l'économie française,* in: Cahiers de l'I.S.E.A., Paris 1961–1969, 11 vol. Most of the research has been done and published by T. J. Markovitch and J. Toutain.
Hoffmann, W. G., *Das Wachstum der deutschen Wirtschaft seit der Mitte des 19. Jahrhunderts,* Berlin 1965.

64. For a survey of this criticism:
Crouzet, Fr., Chaloner, W. H., Stern, W. M., (eds.), *Essays in European Economic History, 1789–1914,* London 1969.
Richet, D., *Historia Kwantytatywna zcy ekonometria retrospekywna? Proba bilansu,* in: Leskiewicz, J., Kowalska-Glikman, S., (eds.), Historia i Nowoczesnosc, Warsaw 1974, pp. 107–120.
The review on Hoffmann's book in: Journal of Economic History, 26(1966), p. 256.
Le Roy Ladurie, E., *Les comptes fantastiques de Gregory King,* in: Annales E.S.C., 23(1968), pp. 1086–1102.
65. Chaunu, P., *Histoire quantitative ou histoire sérielle,* in: Cahiers Vilfredo Pareto, 3(1964), pp. 165–176.
Chaunu, P., *L'histoire sérièlle. Bilan et perspectives,* in: Revue Historique, 494(1970), pp. 297–320.
66. Lévy-Leboyer, M., *La croissance économique en France au 19e siècle. Résultats préliminaires,* in: Annales E.S.C., 23(1968), pp. 788–807.
Crouzet, Fr., *Essai de construction d'un indice annuel de la production industrielle française au 19e siècle,* in: Annales E.S.C., 25(1970), pp. 56–99.
67. Léon, P., *The Study of Economy and Society at the Centre d'Histoire Economique et Sociale de la Région Lyonnaise,* in: The Journal of European Economic History, 3(1974), pp. 485–491.
68. Deane, Ph., *New Estimates of Gross National Product for the United Kingdom, 1830–1914,* in: Kuznets, S. (ed.), Income and Wealth, 1968.
Feinstein, C. H., National Income, Expenditures and Output in the United Kingdom, 1855–1965, Cambridge 1972.

In spite of the climate of distrust toward the construction of aggregated economic series, scholars began to reconstruct series of national accounts in several other European nations, including Norway, Denmark, Finland, Sweden, Italy, the Netherlands, Hungary, Poland, and Belgium.[69] In general, the scholars in these countries tried to avoid the drawbacks found in the pioneering work in the United Kingdom, France, and Germany. Most of the attention went to the construction of reliable series of agrarian and industrial production, foreign trade, and investment in infrastructure. An interesting example of this concern for statistical reliability may be found in P. Lebrun and J. Gadisseur's research on the Belgian economy in the 19th century.[70]

The macro-approach became more and more geographically restricted as regional growth disparities drew more attention. C. H. Lee and E. H. Hunt contributed much to a better understanding of regional development in the U. K.[71] L. H. Klaassen, P. W. Klein, and J. H. Paelinck of the Netherlands proposed a model for the very long term evolution of a system of regions at the Copenhagen Conference in 1974.[72]

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69. Bjerke, J., *Langtidslinger i Norsk Økonomi, 1865-1960,* Oslo 1966.
Bjerke, J., *The National Product of Denmark, 1870-1952,* in: Income and Wealth, Series V, London 1955.
Pikkala, E., *Finland's Foreign Trade, 1860-1917,* Helsinki 1969.
Johansson, Ö., *The Gross Domestic Product of Sweden and its Composition,* 1861-1955, 1967.
Fridlizins, S., *Sweden's Exports, 1850-1960. A study in perspective,* in: Economy and History, 6(1963), pp. 3-10.
A good survey of historical statistics on the Scandinavian countries in:
Schiller, B., Öden, B., *Statistik für Historiker,* Stockholm 1970, pp. 231-300.
Fua, G., (ed.), *Lo svillupo economico in Italia. Storia dell'economia italiana negli ultimi cento anno,* Milan 1969.
Caracciòlo, A., (ed.), *La formazione dell'Italia industriale,* Bari 1969.
Teyl, J., *Nationaal inkomen van Nederland in de periode 1850-1900,* in: Economisch-Historisch Jaarboek, 34(1971), pp. 234-262.
Eckstein, A., *National Income and Capital Formation in Hongary, 1900-1950,* in: Income and Wealth, Series V, London 1956.
Lukasiewicz, J., *Indeks produkcji przemyslowej na ziemiach polskich w latach, 1870-1913,* in: Leskiewicz, J., Kowalska-Glikman S., (eds.), Historia i Nowoczesnosc, Warsaw 1974, pp. 277-290.
Lebrun, P., Gadisseur, J., Pirard, J., Degrève, D., Desama, Cl., *L'industrialisation en Belgique au 19e siècle. Première approche et premiers résultats,* in: Léon, P., Crouzet, Fr., Gascon, R., (eds.), L'industrialisation en Europe au 19e siècle. Cartographie et Typologie, Lyon, 7-10 oct. 1970, Paris 1972, pp. 141-186.
Gadisseur, J., *Le produit physique de l'économie belge. Présentation critique des annees statistiques, 1831-1913,* Liège 1980.
70. Gadisseur, J., *La production industrielle au 19e siècle de Belgique: construction de l'indice,* in: Archief- en Bibliotheekwezen in België, 10(1973), pp. 79-96.
71. Lee, C. H., *Regional Economic Growth in the United Kingdom since the 1880s,* London 1971.
Hunt, E. H., *Regional Wage Variations in England and Wales,* 1974.
72. Klaassen, L. A., Klein, P. W., Paelinck, J. H. P., *Very long Term Evolution of a System of Regions,* in: Glamann, Kr., a. o. (eds.), Sixth International Congress on Economic History, Copenhagen 1974, pp. 93-108.

This model, however, has yet to be adequately tested. G. De Brabander has investigated the regional and sectoral specialization in Belgium and has tested the effect of this specialization on regional growth disparities.[73]

Even though the vast majority of economic historians seemed to prefer the industrial sector and the macro-economic approach, considerable interest continued for the agricultural sector.[74] This may be explained partially because such study could contribute to the macro-approach, and partially because of the success of Malthusian development theories, which strongly stressed the importance of the agrarian sector. In the 1970's, more attention was paid to the shift from the agrarian to the industrial economy and particularly to the stage of development between the two, namely, proto-industrialization.[75] In Belgium, P. Klep developed a two-sector model, analyzing this transition and the dual character of the Brabantine economy in the 18th and 19th centuries.[76]

As a conclusion for the period during which economic growth was the major topic of research in Western Europe, we may state that the American New Economic His-

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73. De Brabander, G. L., *Regional Specialization, Employment and Economic Growth in Belgium between 1846 and 1970,* New York 1981.

74. Goy, J., Le Roy Ladurie, E., (eds.), *Les Fluctuations du produit de la dîme. Conjoncture décimale et domaniale de la fin du Moyen Age au 18e siècle,* Paris, The Hague 1972.
Kakh, J., Milov, L., Selunskaya, N., Tarvel, E., *Quantitative Methods of the Inner structure of the Peasant and Landbord Household in Russia in the Period from the 17th to the Beginning of the 20th Century,* in: Sixth International Congress on Economic History, Copenhagen, 12–23 August, 1974.
Kakh, J., Ligi, H., Tarvel, E., *Beiträge zur Marxistischen Agrargeschichte Estlands der Feudalzeit,* Tallinn 1974.
Kula, W., *Théorie économique du système féodal. Pour un modèle de l'économie polonaise, 16e–18e siècles,* Paris, The Hague 1970.
Lunden, K., *Some Causes of Change in a Peasant Economy: Interactions between Cultivated Area, Farming Population, Climate, Taxation and Technology. A Theoretical Analysis of the Norwegian Peasant Economy, c. 800–1600,* in: The Scandinavian Economic History Review, 22(1974), pp. 117–135.
O'Grada, C., *Supply Responsiveness in Irish Agriculture during the Nineteenth Century,* in: The Economic History Review, 28(1975), pp. 312–317.
Slicher van Bath, B. H., *Yield Ratios, 1810–1820,* in: A.A.G.-Bijdragen nr. 10, Wageningen 1963.
Wyczanski, A., Topolski, J., *Peasant Economy before and during the First Stage of Industrialisation. General Report,* in: Glamann, Kr., a.o. (ed.) Sixth International Congress on Economic History: 5 Themes, Copenhagen 1974, pp. 11–31.

75. Mendels, F. F., *Protoindustrialisation: The First Phase of the Industrialisation Process,* in: Journal of Economic History, 32(1972), pp. 241–261.
Kriedte, P., Medick, H., Schlumbohm, J., *Industrialisierung vor der Industrialisierung. Gewerbliche Warenproduktion auf dem Land in der Formationsperiode des Kapitalismus,* Göttingen 1977. This work is translated by Shempp, B., *Industrialisation before Industrialisation. Rural Industry in the Genesis of Capitalism,* Cambridge 1981.
Very interesting articles on protoindustrialisation can also be found in two special issues of Revue du Nord, 61, 240(1979) and 63, 248(1981).

76. Klep, P. M. M., *Bevolking en Arbeid in transformatie: Brabant, 1700–1900. Een analyse van ongelijktijdige ontwikkelingen in een maatschappij op weg naar moderne economische groei,* Leuven 1978.

tory had an important but not overwhelming influence, and that thereby the depth of economic-historical analyses clearly increased. Not being bound to the neoclassical paradigm seems to have left room for the testing of, and contributing to, economic theory. This approach, which was paired with more precise data reconstruction, seems to have augmented significantly the scientific character of the study of economic growth.

III. Again Crisis Concepts

Since the middle of the 1970's, after decades of intensive research on economic growth, a clear shift has been perceptible in economic historical research, particularly with regard to the contemporary period. The reason for this was the realization that the ongoing economic crisis of the 1970's and early 1980's was not so much conjunctural as structural. This crisis has shocked the Keynesian optimism with regard to the avoidance of economic regression and the neoclassical faith in steady real growth. Economic historians started again to study the industrial crises of the 19th and 20th centuries and began to see unbalanced growth as the rule instead of balanced growth. The long wave theories were again studied intensively and brought up-to-date. Significant in this regard were the empirical testing of Schumpeter's innovation theory by G. Mensch and W. W. Rostow's book, *The World Economy.*[77]

Primarily in Europe, long wave research was progressing well by the end of the 1970's. J. J. Van Duijn of the Netherlands took up the old tradition of his country, and an interdisciplinary working group has been established in Amsterdam by G. Van Roon for the study of the long wave theory.[78] Two significant congresses have been held in Bochum (BRD), and an interesting long wave reader with contributions from all over Europe is being published.[79] In Britain, C. Freeman has dedicated a thematic number of the futurological journal, *Futures,* to innovation and long waves.[80] In Belgium, L. H. Dupriez has actualized his theory, while E. Mandel has developed a Marxian scheme in which the rate of profit is the crucial variable.[81] In Leuven, J. Delbeke is developing model based on a revised long wave concept integrating the real, monetary and financial sectors of the economy.[82] And at the economic history congress to be held in Budapest in 1982, a B-section, under the direction of J. Bouvier, has been set aside for the study of long waves.

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77. Mensch, G., *Das technologische Patt: Innovationen überwinden die Depression,* Frankfurt a/Main 1975.
Rostow, W. W., *The World Economy. History and Prospect,* New York 1978.
78. Van Duijn, J. J., *De lange golf in de economie,* Assen 1979.
Van Duijn, J. J., *The long wave in economic life,* in: De Economist, 125(1977), pp. 544–576.
Interfacultaire Werkgroep "Lange Golven", *Interim-rapport 1980,* Amsterdam 1980.
79. Petzina, D., Van Roon, G., (eds.), *Konjunktur, Krise, Gesellschaft. Wirtschaftliche Wechsellagen und soziale Entwicklung im 19. und 20. Jahrhundert,* Stuttgart 1981.
80. Freeman, C. (ed.), *Technical Innovation and Long Waves in World Economic Development,* in: Futures, 13(1981), 238–338.
81. Dupriez, L. H., *De actuele betekenis van de lange golfbeweging,* in: Tijdschrift voor Economie en Management, 23(1978), pp. 21–29.
Mandel, E., *Het laatkapitalisme,* Amsterdam, 1970.
82. Delbeke, J., *Recent Long Wave Theories: A Critical Survey,* in: Futures, 13(1981), pp. 246–257.

The increased interest in the long waves, however, seems to have proceeded in a rather confused manner. On the theoretical level, many researchers tend to ascribe to monocausal explanations, which was the case with the majority of the analyses of the 1930's and 1940's. The renewal, however, seems to lie more on the integrative level. Furthermore, the importance of social and institutional changes has also been largely underestimated.[83] On the empirical level, the number of publications appearing is increasing rapidly. After an abundant presentation of long-term series in which movements can be distinguished, model-oriented approaches have also been undertaken.[84] Nevertheless, in our opinion, the solution lies more in the use of basic statistical techniques rather than in empirical model construction, because long wave research presumes fundamental "variable parameters".

Moreover, we are convinced that a purely macro approach is not correct. New entreprenurial activity and technological and institutional innovations seem to be crucial, but their origins can only be studied on a very disaggregated level. Therefore, long wave research has to be performed on the macro, the meso, and the micro level.

It must be admitted, however, that the quantitative material is scarce. Within the context of modern industrial civilization, we have only had three and a half long waves. Therefore, it is not clear whether the past experiences, i.e. the periods of up- and downswing, will repeat themselves in the future. Forrester and other futurologists claim that we are entering a post-industrial society.[85] Others, such as Van Duijn, Kleinknecht, Mensch, and Rostow, are more convinced of the repetitive nature of the long wave.[86] It seems to be an open question whether the uneven growth of the past centuries has to be described as a long "cycle" (i.e. a regular and continued upward and downward movement) or as a long "wave", which does not involve such narrow constraints. Given the widespread skepticism vis-à-vis the existence of a long wave

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83. Akerman, J., *Structures et Cycles Economiques*, Paris 1957.
Chandler, A. D., *The Beginnings of Big Business in American Industry*, in: Business History Review, 33(1959), pp. 1-31.

84. Broersma, T., *De lange golf in het economisch leven: empirische en theoretische onderzoekingen*, Groningen 1978.
Metz, R., *Theoretische Aspekte der statistischen Analyse langfristiger Konjunkturschwankungen*, in: Petzina, D., Van Roon, G., (eds.), Konjunktur, Krise, Gesellschaft. Stuttgart 1981.
Schulte, H., *Ein neuer statistischer Ansatz zur Identifizierung von Wellenbewegungen in der langfristigen Wirtschaftsentwicklung*, in: Petzina, D., Van Roon, G., (eds.), Konjunktur, Krise, Gesellschaft. Stuttgart 1981.
Stier, W., *Zur Rolle und Funktion statistischer Verfahren in der empirischen Wirtschaftsforschung und der Wirtschaftsgeschichte*, in: Petzina, D., Van Roon, G., (eds.), Konjunktur, Krise, Gesellschaft. Stuttgart 1981.

85. Forrester, J. W., *Business Structure, Economic Cycles and National Policy*, in: Futures, 8(1976), pp. 195-214.
Forrester, J. W., *Growth Cycles*, in: De Economist, 125(1977), pp. 525-543.

86. Van Duijn, J. J., *De lange golf in de economie*, Assen 1979.
Kleinknecht, A., *Basisinnovationen und Wachstumsschübe: das Beispiel der westdeutschen Industrie*, in: Konjunkturpolitik, 25(1979), pp. 320-343.
Mensch, G., *Das technologische Patt: Innovationen überwinden die Depression*, Frankfurt a/Main 1975.
Rostow, W. W., *The World Economy. History and Prospect*, New York 1978.

regularity, which has been interpreted by R. Spree, we think that the fundamental question of this research is whether or not our industrial society is behaving along a life cycle.[87] The answer to this question is crucial enough to give the research the importance it needs.

Conclusion

The interests of Western European economic historians have flexibly adapted in response to the economic problems of their time. First, interest shifted to the study of economic growth after having been concentrated on economic movements. At the end of the euphoric 1960's, the stress shifted back again to the study of long waves.

While a large part of the quantitative economic research was concentrated on the formation of a data base, important empirical studies have been undertaken that have had repercussions on economic theory. The New Economic History, an American phenomenon, thus has not had too large an effect in Europe, the reasons for which have been thoroughly analyzed elsewhere.

Nevertheless, another and more important observation must be made. The Western European economic historians not only constructed more accurate data bases, they also brought about significant changes in economic theory. It is in these changes that their value must be sought. They have had the virtue of not being compelled to force each economic historical phenomenon into a neoclassical strait jacket. It is to be expected that, with more extensive use of statistical economic methods, they will proceed further in this direction.

In addition, it can also be stated that the national accounts that were constructed will have to be thoroughly revised, even though they were milestones in postwar research. The constant growth averages that appear in them will have to be amended.

Finally, we think that the productivity project that is now being conducted can play an important role from both the empirical and the theoretical viewpoints. We are convinced that more attention in long wave research must be given to the crucial components of economic progress, namely, the process of factor substitution and factor use, and to comparisons between countries and sectors, the objective being to discover specific leads and lags.

The discussions of this symposium promise to be particularly useful in this regard.

87. Spree, R., *Wachstumstrends und Konjunkturzyklen in der deutschen Wirtschaft von 1820 bis 1913*, Göttingen 1978.

Zusammenfassung:
Der Stand der europäischen Wirtschaftshistoriographie nach 1945

Das Forschungsinteresse westeuropäischer Wirtschaftshistoriker hat sich den jeweiligen ökonomischen Problemen der Zeit flexibel angepaßt. Nachdem es sich zunächst auf die Wirtschaftskonjunkturen gerichtet hatte, verlagerte es sich auf das Wirtschaftswachstum. Gegen Ende der euphorischen 1960er Jahre widmete man sich allerdings erneut der Untersuchung langer Wellen.

Zu einem großen Teil befaßte sich die quantitative Wirtschaftsgeschichte mit der Erstellung einer Datenbasis. Daneben gab es bedeutende empirische Untersuchungen, die Auswirkungen auf die Wirtschaftstheorie ausübten. Die aus Amerika stammende New Economic History School zeigte keine allzu lang anhaltende Wirkung in Westeuropa. Gründe dafür wurden ausführlich an anderer Stelle dargelegt.

Wichtiger ist allerdings wohl, daß westeuropäische Wirtschaftshistoriker neben dem Aufbau stärker abgesicherter Datensammlungen bedeutsame Änderungen in der Wirtschaftstheorie herbeiführten. Mit diesen wichtigen Änderungen der Theorie ist der Historiker aus der Zwangslage befreit, nun jedes wirtschaftshistorische Phänomen dem neoklassischen Rahmen einfügen zu müssen. Bei stärkerem Einsatz statistisch-ökonomischer Methoden werden die Wirtschaftshistoriker noch weiteren Einfluß auf die Wirtschaftstheorie nehmen können.

So müßten die volkswirtschaftlichen Gesamtrechnungen, die bisher aufgestellt wurden, gründlich überprüft werden, selbst wenn sie einst in der Nachkriegszeit einen Meilenstein der Forschung darstellten. Die konstanten durchschnittlichen Wachstumsraten, die in diese volkswirtschaftlichen Gesamtrechnungen eingingen, müssen abgeändert werden.

Man kann erwarten, daß das Forschungsprojekt zur Produktivitätsentwicklung, an dem jetzt gearbeitet wird, einen wichtigen Beitrag sowohl zu empirischen als auch zu theoretischen Aspekten zu leisten vermag. Bei der Forschung über die langen Wellen muß sicher mehr Gewicht auf die entscheidenden Komponenten des wirtschaftlichen Fortschritts gelegt werden, nämlich auf Vorgänge der Faktorsubstitution und der Faktorverwendung. Größere Aufmerksamkeit sollte auch den Länder- und Sektorenvergleichen zukommen, mit denen man jeweils ein Führen oder Nachhinken ("leads" und "lags") aufspüren könnte.

Richard Tilly

Per Capita Income and Productivity as Indices of Development and Welfare. Some Comments on Kuznetsian Economic History

1. The Growth Paradigm

The point of departure of this paper is that a close connection exists between the use of the national income accounts in economic history and the importance for that discipline of what one might call the "Growth paradigm".[1] Insofar as the long run growth of the Wealth of Nations is the concern of economic historians, there is no better frame of reference available for their work than the income accounts. Indeed, I doubt whether meaningful research into the comparative history of economic growth can be done without reference to those accounts (or to some surrogate based on the same principles). Nevertheless, this perspective has limitations—of which two are worth mentioning here. First, it imposes a modern set of values on the past. In Kuznets' words, "the accepted definitions and measures of national product reflect the broad features of modern societies dominated by the ideas of secularism, egalitarianism, and nationlism". These imply that "if we want to contrast modern economic growth with earlier periods and patterns of growth, we must evaluate and appraise the earlier periods also in modern terms in full knowledge that part of the difference would be due to the fact that societies of the earlier times did not share many of the notions of means, ends, and values that constitute impulses to growth is modern times."[2] The cost of this perspective is our inability to focus on the older values, institutions and activities which may have had to be transformed or eliminated before modern economic growth could begin. Second, the growth paradigm and its accounting complement (national income) implies the primacy of consumption of goods and services as the aim of economic activity and subordinates all other processes—of government, capital accumulation, or even production—to that end. Economic history of this genre is a drama featuring man's conquest of nature for man's material enjoyment. It is a fascinating drama and well worth our attention. However, there are plausible alternatives—for example, the Marxist drama featuring class conflicts and

1. Cf. Tilly, R., *Das Wachstumsparadigma und die europäische Industrialisierungsgeschichte,* in: Geschichte und Gesellschaft, 3 (1977); also Parker, W., *Economic History seen through the Income Accounts,* in: Zeitschrift für die gesamte Staatswissenschaft, 124 (1968). This volume was also a Festschrift for Walther Hoffmann edited by Giersch H., and Sauermann H., (Quantitative Aspekte der Wirtschaftsgeschichte).
2. Kuznets, S., *Modern Economic Growth. Rate, Structure and Spread,* New Haven 1966.

treating economic growth as a largely unintended consequence of those conflicts.[3] For those of us who opt for the growth paradigm, of course, there is need for neither self-congratulation nor apology, only for recognition of a conscious choice and, if possible, acceptance of its limiting implications.

2. *An Analogy*

The argument of much of the paper is based on a general behavioral assumption and an analogy. The behavioral assumption is that people generally act as if they would rather be rich than poor. The analogy is between individuals and economies. Just as I believe that individuals prefer wealth to poverty, so too do I believe that poor countries strive to become rich ones. And in both cases I believe the relationship to be non-reversible. Rich people and countries do not strive to become poor ones. This non-symmetrical relationship is important for the rest of the argument of the paper, for it serves as a justification for comparing rich and poor countries using the standards (or price weights) of the richer country as a measuring rod. Comparing conditions in this manner is to state how far along a given poor country is on its way to attaining the position occupied by a richer one. And to complete the analogy, we base our comparisons of rich and poor countries on the standard of *per capita* income—which means that we work with the individualistic notion of the representative consumer and make national economic welfare a function of individual welfare.[4] Countries—or regions—are thus seen as discrete bundles of individuals, a decisive number of which are striving for higher incomes. Were this not the case, the long debate on economic growth of the past three or four decades, it seems to me, would make little sense.

3. *Per Capita Income as Welfare Index*

Using per capita income as a comparative index of economic welfare implies, then, a unity of opinion about the individualistic ends and the means of economic activity. Kuznets has written: "There is, after all, a strong element of community of human wants and needs, translatable in the modern economic epoch into a set of widely prevalent notions of means, ends, and values of economic activity".[5] The sad truth, however, is that such unity of opinion in societies over time and space is extremely hard, if not possible, to document empirically. Significant criticism of per capita income as

3. In this sense W. W. Rostow's *The Stages of Economic Growth,* Cambridge 1960, was, in fact, a kind of non-Communist Manifesto, for it did see consumption and technology as the master processes of economic history, if not history *in totum.*
4. On an empirical level, per capita income appears to be much more closely related to a number of important aggregate structural features of developing economies—e. g. the share of total employment and product originating in the agricultural sector, the share of total income spent on foodstuffs and the share of income saved—than is total income. That makes per capita income a more useful instrument for comparative analysis. See esp. Chenery, H., *Structural Change and Development Policy,* Oxford 1979 or Chenery H., and Sirquin M., *Patterns of Development,* Oxford 1975. On the analogy between individual and national per capita income see also Usher, D., *The Measurement of Economic Growth,* Oxford 1980.
5. Kuznets, *Modern Economic Growth,* p. 24.

a welfare index stems, ultimately, from doubts concerning that unity. For the purposes of this paper, this criticism may be devided into five points:
(1) the problem of non-material or non-economic welfare;
(2) the exclusion of non-market activities;
(3) the definition of final (or intermediate) goods;
(4) the assumption of constancy of preferences and production possibilities; and
(5) the problem of income distribution and community welfare.

a) Non-material Welfare
The first criticism is that improvements in economic welfare which rising per capita incomes could conceivably reflect say nothing about non-material or non-economic welfare. Non-materialist ends might have priority over material ones in certain societies and, theoretically, satisfaction of the former could deteriorate as a result of improvements in respect to the latter.[6] This possibility is discussed below in connection with "social indicators", but in the absence of clear evidence to the contrary, we can only assume that changes in economic welfare are not systematically (and negatively) related to changes in non-material wellbeing.

b) Non-market Activities
The second and third criticisms really turn on the proper definitions of the ends of economic activity and the resultant definition of the final products going into national income calculations. National income is a flow statistic reflecting market transactions over a given period. For some countries and periods we have imputations for the value of non-marketed goods and services such as rental income from owner-occupied housing and farm-consumed agricultural products, but, on the whole, market transactions are disproportionately represented. This means that, on the one hand, comparisons of per capita income between developed market economies and societies in which specialization of economic activity and 'hence' market relationships are only weakly developed, could be biased against the latter unless corrections are made for their relatively significant non-market activity. On the other hand, there are some offsetting biases against modern economies for which imputations might well be in order, e.g., the productive work of housewives (as substitutes for domestic servants), time spent in educational institutions, or the value of leisure time generally. Thus, Nordhaus and Tobin have estimated the value of non-market activity in the U.S. in the 20th century at between 40 and 50 percent of GNP while Kuznets has suggested an upward adjustment for the leisure in the same country of as much as 40 percent of the estimated national product.[7] My impression is that the bias against underdeveloped countries will be strongest for comparisions covering the transitional or "take-off" phase of industrialization, subsequently turning the other way. For western European countries, I suppose, the shift in bias for intertemporal

6. See Gould, J. D., *Economic Growth in History,* London 1972, pp. 5–6.
7. See Nordhaus W., and Tobin J., Is Growth obsolete? in: Moss M. (Ed.), The Measurement of Economic and Social Performance. (Studies in Income and Wealth, vol. 38) N. B. E. R., N. Y. 1973, and Kuznets, *Modern Economic Growth,* pp. 220–34 and esp. p. 221. Also Kendrick J., *Economic Accounts and their Uses,* N. Y. 1972. For a brief discussion of this question as applied to American economic history see. Davis L., et al., *American Economic Growth. An Economist's History of the United States.* N. Y. 1972, pp. 42–50. Cf. also Section 5 below.

comparisons would come around 1900. This is a matter which only further research can clarify.

c) Intermediate and final Products

The distinction between inputs, intermediate and final products lies behind a further set of possible biases. National income, as indicated, is conventionally defined as a net flow of final goods and services over time. To avoid double-counting, the value of products used in the production of other final products must be deducted from the value of total output—as in the classic textbook case of the flour used in the production of bakery goods. Problems arise when goods and services satisfy intermediate *and* final demands and convention assigns them exclusively to *one* of those two classes, or where such conventions vary across time and countries. Per capita income comparisons are biased upward in favour of the more industrialized countries where goods and services such as vehicles, transportation, water supply, sanitation and policing—which are in part costs of urbanization and industrialization and hence akin to intermediate products—are treated as part of final products. This amounts to double counting insofar as other final products embody these costs.[8] The bias is easy to conceptualize, but in practice, it is virtually impossible to distinguish the part of the total product which is intermediate from that which represents final consumption. Some urban amenities, after all, do (or could) reflect increased consumer utility. Economic historians working in this area will have to decide for each country and period under investigation, (a) which items are ambiguous and (b) how to allocate them.

A similar difficulty relates to the role of capital formation. Net capital formation is commonly regarded as part of final product—on the convincing grounds that it forms the basis of long-run and future consumption. It is difficult to identify, however, because (a) some activities or commodities can be defined as either capital formation *or* intermediate product and because (b) the flow or capital goods over time is a gross figure and will include the production of replacements for capital used up over a period, i.e. capital consumption allowances, whereas there is no clear rule for estimating the latter. Intercountry and intertemporal comparisons of per capita income obviously will be biased against those economies which work with the narrowest definition of capital formation and/or make the largest deductions for depreciation. Typical problem topics are the treatment of government expenditure on social overheads or infra-structure as intermediate products, the treatment of current spending by integrated business firms on construction of new plant and equipment as intermediate output, or the maintenance of standard deductions on a capital stock of rising durability.[9] This should be, I suggest, an important target area for historical work on comparative real incomes.

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8. Kuznets, *Modern Economic Growth*, pp. 225-27. Intersocietal and intertemporal comparison will reveal some of these "intermediate" goods to be only present in the moré developed economy, thus posing, in addition, a weighting problem. More on this below. See also on all of these problems Ruggles N. and R., *The Design of Economic Accounts*, N.Y. 1970, esp. pp. 38-48. For Germany, Stobbe A., Volkswirtschaftliche Gesamtrechnung, in: Handwörterbuch der Wirtschaftswissenschaft. Vol. 8, Stuttgart and N.Y. 1980.
9. Capital formation raises problems of theory into which the discussion above does not go. See Usher, *Measurement*, esp. Chapter 5. On the measuring problems also Kuznets, *Modern Economic Growth*, Chapter 5.

d) The Assumption of Constant Preferences

Intersocietal comparisons of per capita income levels are dogged by the necessity of the unrealistic assumption of constant preferences and production possibilities. Much scattered evidence exists on the variability and mutability of tastes through history, for example, in the discussion of protoindustrialization or of the economics of peasant society, and who could deny that the emergence of new products and product quality changes are an important part of the history of economic development?[10] Strictly speaking, absolute, incontrovertible proof of vast differences in preferences across countries or time should rule out income comparisons *qua* welfare

Table 1: Illustration of Real Income Measurement over Two Periods under Different Assumptions

	Period 1				
	Qo	Po	Qo Po		
Good A	20	2	40		
Good B	50	1	50		
Income			90		
	Period 2			(a)	(b)
	Q1	P1	Q1 P1	Qo P1	Q1 Po
Good A	40	4	160	80	80
Good B	100	2	200	100	100
Income			360	180	180
	Period 3			(a)	(b)
	Q2	P2	Q2 P2	Q2 P1	Q1 P2
Good A	160	2	320	640	80
Good B	200	2	400	400	200
Income			720	1040	280

Index I : Σ Q1 P1 / Σ Qo Po = 400

" IIa : Σ Q1 P1 / Σ Qo P1 = 200 (Paasche Index)

" IIb : Σ Q1 Po / Σ Qo Po = 200 (Laspeyres ")

" IIIa : Σ Q2 P2 / Σ Q1 P2 = 257 (Paasche ")

" IIIb : Σ Q2 P1 / Σ Q1 P1 = 289 (Laspeyres ")

10. For the general problem, see Gould, *Economic Growth*, pp. 7-9; for "protoindustrialization" and consumer preferences see. Kriedte P., et al., *Industrialisierung vor der Industrialisierung. Gewerbliche Warenproduktion auf dem Lande in der Formationsperiode des Kapitalismus*, Göttingen 1977, esp. Chapter 2 pp. 138-54; on "peasant economics" see Chayanov A. V., *On the Theory of the Peasant Economy*, Edited by Thorner D., *et al.*, Homewood 1966; Mathias P., has raised almost the same question in "Adam's Burden: Historical diagnoses of poverty", *The Transformation of England*, London 1979.

comparisons. Such proof, however, is not generally available for the period of modern economic growth (since around 1750) and so we follow Kuznets and others in *assuming* the broad community of wants and needs across countries and time that the income comparisons require.[11] In so doing, to be sure, we are not free to do as we please and are obligated to be as specific as we can about possible distortions (or biases) in the comparisons executed. In this connection we tread the ground well known to economists as the "index number problem"—the essence of which is the difficulty of comparing magnitudes which cannot be compared. For comparisons of real income—be they intertemporal or intersocietal—are only meaningful insofar as they involve indexes of prices and quantities of goods and services having a common denominator, and choosing the latter invariably involves creation of biases. To make this point clearer, a brief digression on price index comparisons follows here.

For illustration purposes, take the example of a simple economy producing two final commodities A and B and compare two periods. Table 1 below depicts the two situations (with Q representing quantity purchased and P the price per unit of commodity). Three important, if banal, conclusions can be drawn from the illustration. First, comparing the products of price and quantity of different periods is not a meaningful comparison of welfare if prices *and* quantities change, for price changes alone do not represent changes in well-being and must be eliminated by deflation. This we may do by multiplying the quantities in both periods by the prices of period 1 (Laspeyres Index) or of period 2 (Paasche Index). Either of these exercises will produce the required common denominator and desired *real* income comparison.[12] Second, the choice of deflator, i.e., the period prices used as common denominator, will have no effect on the welfare comparison only if either quantities of both goods or prices of both goods change at the same rate as between two periods (as between period 1 and 2 in our table). Third, if relative prices and quantities change (and that is what we speak of when changes are not equiproportional) and quantities are rising, then the choice of first period prices will generally produce, *ceteris paribus*, a higher rate of change between periods than the use of end-period prices (in the comparison between period 2 and 3 of our example, e.g. 189 compared to 157 percent). This makes sense in terms of the theory of demand, for that postulates a generally negative relationship between price and quantity demanded and using the higher first period prices to value the larger end-period quantities sets aside that "law of demand" for the end period, so to speak, thus "permitting" consumers to buy as much at higher relative prices as they did when those prices were lower. Just the opposite applies to the use of end-period prices as weights (These yield a lower rate of real in-

11. J. Mokyr's brief survey of demand as a factor in the Industrial Revolution does not explore the possibility of preference shifts except in connection with a presumed trade-off between leisure and money income. He concludes that autonomous demand shifts were of little demonstrable importance for industrialization and pleads for supply-oriented analysis. If his survey is representative, there are few data available on this question. See Mokyr J., *Demand vs. Supply in the Industrial Revolution*, in: Journal of *Economic History*, 37 (1977). Cf. also Mathias P., "Leisure and Wages in Theory and Practice, *The Transformation*, who identifies some possible data sources but on the whole concurs with Mokyr's judgement.

12. In terms of our table Index I has no relevance. For completeness' sake it may be pointed out that price indexes bearing the names Laspeyres and Paasche have the opposite constructions, with the Laspeyres = $\Sigma p_1 q_0 / \Sigma p_0 q_0$ and the Paasche = $\Sigma p_1 q_1 / \Sigma p_0 q_1$.

come change than the "law of demand" would seem to warrant). It is in this sense that we may speak of a "bias" in estimates of *real* income based on the deflators or price weights used.

Turning back to the historical problem of real income estimates, we may ask whether the empirical record confirms such theoretical expectations. The answer is rather ambivalent. There is some seeming confirmation, both for intertemporal and cross-country comparisons. It is believed, for example, that the rate of growth of real incomes in the U.S., 1840–1900, is higher when 1860 prices are used as deflators than when 1900 prices are so employed.[13] And estimates of the GNP growth of the Soviet Union, 1928–37, employing 1928 price weights are nearly 100 percent larger than estimates using 1937 ones (11.9 percent per annum instead of 6.2. percent!). Sectoral time series studies support this argument.[14] On the other hand, there are exceptions, demonstrated, for example, in a careful study of Swedish income growth by Krantz and Nilsson. In part, this reflects differing levels of aggregation: the broader the categories aggregated, the weaker the substitution effect. In any case, the exceptions remind us that even a theoretical discussion of index number bias in growth measurement must make provision for the possibility of demand shifts (caused either by shifts in tastes or income elasticities of demand.[15] In fact, on theoretical grounds alone, with income effects compensating substitution effects, we can expect index number bias to be negligible.

However, no discussion of the historical use of price indexes will be complete without a few words on the conceptually trivial, but practically significant, question of data comparability. In a strict sense, the world of economic theory with its prices and quantities of individual commodities has no counterpart in reality, and both economic historians and national income accountants have to make do with improvisations and analogies. National income statistics reflect average prices and quantities, but it is apparent that such averages reflect both different data processing operations and different types of transactions. Take the average price of a ton of Ruhr coal in 1855 and 1900: the estimated difference of 21 Pfennige (8,53 (1900) and 8,32 (1855)) or two percent, seems small, but it refers to two quite different commodities: anthracite or hard coal in the first year, and bituminous of soft coal in the second.[16] Now

13 See Davis, *American Economic Growth,* p. 49.

14. Gould, *Economic Growth,* pp. 18–20, discusses this point, citing Moorsteen R., and Powell R., *The Soviet Capital Stock, 1928–1962,* Homewood 1966 and also Gerschenkron A., *A Dollar Index of Soviet Machinery Output, 1927–28 to 1937,* Santa Monica 1951. Gerschenkron has elsewhere discussed this phenomenon of a Laspeyres vs. Paasche "bias" as an essential part of growth, so that the phenomenon itself has been dubbed the "Gerschenkron Effect." See Gerschenkron A., *Economic Backwardness in Historical Perspective,* Cambridge 1962, Chapter 8 and 9, where the difference between the two prices indexes is seen as a measure of structural change.

15. Krantz O., and Nilsson C.-A., *Swedish National Product, 1861–1970,* Lund 1975, deal explicitly with the "Gerschenkron Effect" and attribute its virtual absence in Sweden to significant demand shifts (Ibid., 196–202). See also Solow R., and Temin P., *Introduction: The Inputs for Growth,* in: Cambridge Economic History of Europe, Vol. 8, Edited by Mathias P., and Postan M., Cambridge 1978, p. 6.

16. Cf. Holtfrerich C.-L., *Quantitative Wirtschaftsgeschichte des Ruhrkohlenbergbaus im 19. Jahrhundert,* Dortmund 1973, p. 18.

coal probably represents a resolvable problem, but what about iron or steel? Here it is not merely a matter of specifications of physical properties of the commodity, e.g., its subdivision into components such as bars, plates and rails and standardized weight measures, but also of knowing whether the prices averaged reflect a standard procedure for estimating transportation cost from plant to representative consumer, discounts for volume and cash purchases, etc. etc.[17]

Then there is the question of uncertainties in the estimation of quantity data. For example, for the Prussian and German *agricultural* sector, the choice of period, the treatment of intermediate products, and assumptions about slaughter rates and weights are much more important determinants of the measured rate of growth of output than are the choice of price weights. This can be demonstrated by means of the following estimates:[18]

Aggregate	Output,	Prussia,	1816–49	(vF) 2,1% p.a
Aggregate	Output,	Prussia,	1816–49	(GH) 2,2% p.a
Net	Output,	Prussia,	1816–49	(RT) 2,6% p.a
Net	Output,	Prussia,	1816–52	(RT) 2,1% p.a
Net	Output,	Germany 1846/49–1910/13		(L) = 1,46; (P) = 1,40 p.a
Net	Output,	Germany 1850/54–1910/13		(L) = 1,85; (P) = 1,83 p.a

Index number problems are not a negligible factor and warrant further consideration in connection with productivity measurement. But the point is, historians of 19th century productivity may face more dangerous enemies.

We have already called attention to the symmetry of time series and cross-sectional comparison. We thus expect the estimated income differences between rich and poor countries to be larger using the latter's prices as weights. Patel's experiments with Indian and American data for 1959 showed a difference of 100 percent, i.e., India's per capita output was more than twice as high in U.S. dollars when measured in U.S.

17. Morgenstern O., *On the Accuracy of Economic Observations*, 2d Ed., Princeton 1965, esp. Chapter 10. It should be pointed out that inferences about costs on the basis of price data depend on assumptions about competition which require investigation. They can be critical, as the discussion of British, German and American productivity in the steel industry seems to indicate. See, e.g. Allen R. C., *International Competition in Iron and Steel, 1850–1913*, in: Journal of Economic History, 39 (1979), esp. pp. 933–37, where a debate with the study of McCloskey D., *Economic Maturity and Entrepreneurial Decline*, Cambridge 1974, is joined. See also Webb S., *Tariffs, Cartels, Technology and Growth in the German Steel Industry, 1879 to 1914*, in: Journal of Economic History, 40 (1980), esp. pp. 321–23.

18. von Finckenstein, Graf M. W., *Die Entwicklung der Landwirtschaft in Preußen und Deutschland, 1801–1930*, Würzburg 1960, Helling G., *Berechnung eines Index der Agrarproduktion in Deutschland im 19. Jahrhundert*, in: Jahrbuch für Wirtschaftsgeschichte, 4 (1965); Tilly R., *Capital Formation in Germany in the Nineteenth Century*, in: Mathias P., and Postan M., (eds.), Cambridge Economic History of Europe, vol. 7, Cambridge, 1978; Jacobs A., and Richter H., *Die Großhandelspreise in Deutschland von 1792 bis 1934, Sonderheft des Instituts für Konjunkturforschung*, Berlin 1935. The abbreviations vF, GH and RT in the text refer to the sources von Finckenstein, Gerhard Helling and R. Tilly, respectively. 'L' to Laspeyres price weights and 'P' to Paasche ones.

prices as when measured in Indian prices and much closer to American levels.[19] A less extreme but nevertheless significant difference was produced by Gilbert and Kravis—by somewhat different methods—in their classic study of purchasing power parity exchange rates between European countries and the U.S. in the early postwar period.[20] Table 2 summarizes their findings.

Table 2: Income per capita in Different Countries According to Exchange Rates and Purchasing Power Parities, 1950 (U.S. per capita Income = 100)

Country	Exchange Rate	U.S. Prices	European Prices
U.S.A.	100	100	100
U.K.	37	63	53
France	35	53	42
Germany	26	43	33
Italy	16	30	22

Source: M. Gilbert and I. Kravis, An International Comparison of National Products and the Purchasing Power of Currencies (Paris, n.d.)

Last but not least I should mention here O'Brien and Keyder's study comparing Great Britain and France as one of the first significant attempts to extend this kind of analysis to 19th-century economic history.[21] In this case, however, the fact that French per capita incomes seem relatively higher with French price weights than with British ones is not unambigously interpretable in terms of our rich country—

19. Patel S., *The Economic Distance Between Nations: Its Origin, Measurement and Outlook,* in: Economic Journal, (1964). See also Kuznets, *Modern Economic Growth,* pp. 374–84.
20. Gilbert M., and Kravis I., *An International Comparison of National Products and the Purchasing Power of Currencies. A Study of the U.S., the U.K., France, Germany and Italy,* Paris n.d.
21. O'Brien P., and Keyder C., *Economic Growth in Britain and France, 1780–1914. Two Paths to the 20th Century,* London 1978. It is useful to note, however, that in this comparison, differing national output structures are used to weight two national consumption "baskets" (including items common to both countries) which, by means of substitution of each country's prices into the other country's "basket", yield two "exchange rates". These are then applied to the money income of one country to permit one-currency income comparisons. That is, p_0q_0/p_1q_0 or p_1q_1/p_0q_1 where 0 = Great Britain and 1 = France. Their exercise involves only conversion of French incomes into Sterling or: French income/p_0q_0/p_1q_0 and French income/p_1q_1/p_0q_1.

poor country dichotomy; for the country differences may have been small. In discussing how this method gets around some of the difficulties of using official exchange rates for a cross-country income comparison, O'Brien and Keyder suggest calculating *two* rates of exchange for every two-country comparison: the purchasing power parity of sterling in terms of francs (or the number of francs needed to purchase a basket of goods representative of British consumption patterns costing 1 £ in Britain) and the purchasing power parity of francs in terms of sterling. This suggestion correctly emphasizes that (a) the rate reflecting one country's price weights, say, Britain's, permits conceptualizing how well off an average inhabitant of that country would be in Britain with the average income of inhabitants of another country—in this case, France; that (b) the same experiment with the other country's price weights permits the opposite comparison, (c) that both rates are equally "valid", and (d) that the difference between the incomes so converted reflects differences in preference patterns but also gives us an idea of the maximum and minimum size of real income differentials. Like all such explicit comparisons it is an exercise in hypothetical history. This particular case, to be sure, is a double exercise.

These observations return us to Kuznets' interpretation of real income comparisons across time and space as being products of a point of view rather than reflections of universally objective measuments. The point is well taken, but we should not forget that Kuznets also suggested that in long-run historical comparisons, some points of view may be more valid than others. Where income gaps between countries are large, he recommended use of the preference and production patterns, i.e., the price weights, of the more advanced, high-income country for comparative purposes on the grounds that poorer countries strive to become richer but not vice-versa.[22]

This brings us full circle and back to the remarks about the universal community of wants and needs and the analogy between rich and poor persons with which this section began. It amounts to an endorsement of the use of per capita income as an index of economic development, though the endorsement is a qualified one. In the next section, we must conclude our discussion of that index by examining what is perhaps the single most important qualification—the unresolved problem of distribution.

e) Income Distribution and Community Welfare

An increase in a country's per capita real income could mean an increase in its economic welfare in the sense of increased satisfaction of material wants, but such an increase will reflect the distribution of income, since, obviously, only those wants backed up by income can be made effective. One could take the position that every society gets the income distribution it deserves and regard per capita income as ever-optimally distributed—be it in a social-democratic, welfare-state economy, a laissez-faire liberal one, or a totalitarian communist dictatorship. But this would be panglossian. Alternatively, one can impose modern distributional "welfare functions" on the historical situation investigated. On only moderately egalitarian assumptions about the utility of income to different classes of individuals in society, we have to recognize, it seems to me, that increases in per capita income might not reflect increases in aggregate welfare at all, for example, if they were accompanied by a sharp

22. Kuznets, *Modern Economic Growth*, pp. 23, 484–85.

redistribution of income in favour of the wealthiest members of the community and/or against a great majority of low-income receivers.[23]

Given the fact of distributional inequality and the practical impossibility of assigning generally accepted utility weights to different income groups, quite a few scholars have chosen not to interpret real income per capita as an index of welfare at all, but rather as an index of productive capacity, as an index of *potential* welfare, so to speak. According to Harvey Leibenstein, for instance, increasing per capita income represents increasing "possible achievement" i.e., a larger sum available for potential redistribution, should that be found desirable.[24] I disagree with the notion of "potential welfare"[25] and wish to return to the related interpretation of real income per capita as productive capacity shortly; but for the moment, let us note that such a reaction depends on one's ideas about the behavior of income distribution. In the face of compelling evidence confirming the stability of income distribution across time and countries, most economists and economic historians, I suspect, would find it difficult not to interpret increases in per capita real income as improvements in community welfare. And evidence showing non-negligible increases in the inequality of income distribution, it follows, could be seen as reductions in community welfare, deductible, as it were, from any increases in per capita real income.

In any case, that is the sensible approach followed in a number of important treatises on economic development, notably those by H. Chenery and his collaborators.[26] The schemes devised in these studies weight income growth in the different income classes by the number of persons in them. Given the disproportionately large share of population in the lowest groups, this amounts to assigning utility points to increases in the share of income *increases* going to the lowest income groups of a given country. The logic of this procedure derives from its frequently practiced opposite: to view aggregate per capita real income growth as welfare growth is, in fact, to weight increases in the average income of the wealthy, say, the top 20 percent of income re-

23. Usher, *Measurement,* Chapter 3, lists identical tastes, equal shares in ownership of the factors of production and/or unitary income elasticities of demand for all goods as the conditions for interpreting real income estimates based on observed prices and quantities as a community welfare index.

24. Cf., e.g., Leibenstein H., *Economic Backwardness and Economic Growth,* N.Y. 1963, Chapter 2; also Viner J., *International Trade and Economic Development,* Oxford 1953, Chapter 6.

25. The problem with "potential welfare" is that it is misleading, for a situation with more potential welfare can quite easily be a situation with less actual welfare if the contingent redistribution does not take place. The notion of "potential welfare" thus settles nothing. On this and other related matters, see. Sen A., *The Welfare Basis of Real Income Comparisons: A Survey,* in: Journal of Economic Literature, 17 (1979). Sen, in fact, proposes some measures of inequality of income distribution which are worth considering, but he appears, in general, to take the position that a country's economic welfare is not measurable in terms of its per capita income. I have a less rigorous understanding of economic welfare than Sen and persist, in this paper, in associating it with per capita income—subject to one qualification to be mentioned shortly. See also Usher, D., *The Welfare Basis of Real Income Comparisons: A Comment,* in: Journal of Economic Literature, 18 (1980).

26. Chenery, H., et al., *Redistribution with Growth,* Oxford 1974; Chenery H., *Structural Change and Development Policy,* Oxford 1979; Chenery H., *Armut und Fortschritt—Alternative für die Dritte Welt,* in: Finanzierung und Entwicklung, 17 (1980); also Sen, *Welfare Basis,* pp. 30–31, and some of the literature cited there.

ceivers—who typically obtain 50 percent of a given income increase in poor countries—about 10 times higher than the income gains of the representative poor—whose aggregate increment typically accounts for five percent of the total.[27] Alternatively, weights can be assigned to increases in the share of the population living above some materially defined standard of poverty. The importance of such possible adjustments lies in the fact that growth of per capita incomes has not automatically contributed to alleviation of poverty in poor countries in recent years. Indeed, according to Chenery, in some places and times income growth has achieved less than specific distributional policies have done. In this connection we are invited to compare the experience of slow growers such as Cuba or Sri Lanka with fast growers such as Brazil.[28] Historical extensions of the argument readily suggest themselves. They run from the famous "Standard of living" debate concerning British workers during the Industrial Revolution, through S. Kuznets' well-known thesis on the inverted U-curve of income inequality during economic development (e.g., increasing inequality in the early stages) to more recent work on Britain and the United States by J. Williamson, P. Lindert and others.[29] I have no wish to review this literature here and only mention it as a way of suggesting that the distribution of income may represent an important modification of per capita as a long-run development welfare index.

However, the word "may" in the previous sentence was used advisedly, for certain problems emerge with this use of distributional considerations that have not yet been satisfactorily resolved. Their mention therefore concludes this section of the paper. The relevance of distribution for welfare interpretations of per capita income growth will depend on answers to three questions: (1) to what extent are we free or obligated to impose our presumably modern welfare standards on the past—even in the face of evidence on the prevalence of wholly different welfare notions among the populations being investigated. Put in a comparative context: do we impose one standard on two societies and will there be "bias" as a consequence? (2) To what extent does a distributional correction of per capita income indexes imply recourse to a standard of individual aspirations which, strictly speaking, requires additional correction, e.g., for average age and life cycle experience of the population? (3) The evidence cited above to the contrary notwithstanding, is a distributional correction necessary? Or rather: what is the long-run relationship between income growth and the equality of its distribution? I submit that if our answer to the last question is "positive"[30] we can

27. Chenery suggests (in *Redistribution with Growth*) the following measure of development as welfare: $G = w_1g_1 + w_2g_2 + w_3g_3 + w_4g_4 + w_5g_5$ where g = the mean income of each quintile of the population of income recipients and w = the population weight of each quintile.
28. Cf. esp. Chenery, *Armut und Fortschritt*, p. 13; also Chenery et al., *Redistribution*.
29. Cf. Taylor A., (Ed.), *The Standard of Living in Britain in the Industrial Revolution*, London 1975; Kuznets S., *Economic Growth and Income Inequality*, American Economic Review, 45 (1955); J. Williamson, *Earnings Inequality in Nineteenth-Century Britain*, in: Journal of Economic History, 40 (1980); Williamson J., *The Sources of American Inequality, 1896–1948*, in: Review of Economics and Statistics, 58 (1976); and the interesting observations on links between inequality and cost of living indexes by David P., and Solar P., A Bicentenary Contribution to the History of the Cost of Living in America, in: Uselding P., (Ed.), Research in Economic History, Greenwich 1977.
30. Some evidence points in this direction. See e.g. Chenery, *Structural Change*, Chapter 8.

avoid some very difficult conceptual and empirical problems, though that will not obviate the necessity of mobilizing the distribution data themselves. They remain as significant desiderata of the comparative history of income growth.

4. Social Indicators and the Income Concept

Dissatisfaction with per capita income as a development and welfare measure produced in the 1960's the so-called "social indicators movement". It represents the search for quantitative indicators reflecting dimensions of social experience presumed not to be covered by the national income accounts. Before taking up the social indicators, however, I would like to make a few comments on some extensions of the concept of national income which are closer to its original meaning and were mentioned briefly earlier under the heading of "imputations". In the early 1970's, W. Nordhaus and J. Tobin offered one of the most comprehensive suggestion for extensions in the form of a "Measure of Economic Welfare" (M.E.W.). As the name suggests, their concern was with developing a more consistent measure of *welfare* than GNP or income per capita were believed to provide. Welfare is defined as the consumption of final goods and services including an allowance for leisure and a deduction for environmental deterioration *plus* the investment expenditures neccessary to insure maintenance of the current rate of productivity growth into the future. Their calculation thus (1) divides government expenditures into final consumption and intermediate goods and services ("regrettables" such as defense and other "inputs" to other sectors); (2) divides household expenditures into consumption and investment and intermediate activities (such as expenditures for travelling to work); (3) expands the concept of capital formation to take account of consumer durables, education and health investment, as well as investment (already mentioned) needed to insure a given current rate of productivity advance; (4) expands the concept of final product to assign to leisure time activities consumption values (this is by far the largest modification, amounting to more than GNP for 1929, e.g.); and (5) makes a calculation of the social costs of growth especially, those related to environmental deterioration.

Table 3 suggests their 20th-century importance.[31]

I must confess to mixed feelings about suggestions such as these. On the one hand, we should think seriously about expanding historical national income statistics in a similar direction, for a good *a priori* case can be made for some of the extensions suggested and, in any case, we are faced with the need to estimate the value of historical transactions on the basis of evidence just as suspect and as indirect as that employed by modern "imputers".[32] On the other hand, a case can also be made—for some purposes such as the analysis of cycles—for reducing or limiting the measured product

31. This discussion is based on Nordhaus and Tobin, cited in note 6 and the discussion in that NBER volume, see also Usher, *Measurement Journal of Economic History*, Chapter 7, Kuznets, *Modern Economic Growth*, pp. 220-34, and Kendrick J., *Economic Accounts and their Uses*.

32. For example, agricultural income is derived from crop and animal output estimates applying market prices to *non*-market production, and much of non-agricultural income also must be imputed, e.g., that of self-employed artisans.

Table 3: Gross National Product and M.E.W. in the U.S.A., 1929–65 (billions of dollars, 1958 prices)

	1929	1935	1954	1965
1. Gross national product	203.6	169.5	407.0	617.8
2. Capital consumption NIPA	-20.0	-20.0	-32.5	-54.7
3. Net national product NIPA	183.6	149.5	374.5	563.1
4. NIPA final output reclassified as regrettables and intermediates				
a. Government	-6.7	-7.4	-57.8	-63.2
b. Private	-10.3	-9.2	-16.4	-30.9
5. Imputations for items not included in NIPA				
a. Leisure	339.5	401.3	533.2	626.9
b. Nonmarket activity	85.7	109.2	211.5	295.4
c. Disamenities	-12.5	-14.1	-24.3	-34.6
d. Services of public and private capital	29.7	24.2	48.9	78.9
6. Additional capital consumption	-19.3	-33.4	-35.2	-92.7
7. Growth requirement	-46.1	-46.7	-63.1	-101.8
8. Sustainable MEW	543.6	573.4	961.3	1.241.1

NIPA= national income and product accounts.
Source: Nordhaus and Tobin as cited in note 7.

to market or quasi-market transactions. This is owing to the absence of annual data for imputed items and the resultant necessity of extrapolating and interpolating for missing observations. If the trade-off between observable market activities and imputed non-market ones is subject to cyclical influences—modifications by means of trend relationships may produce a distorted view of economic growth patterns and also of welfare, as for example Nordhaus and Tobin's data do for the 1929–35 period of U.S. economic history (when much *involuntary* leisure time emerged). The point is, one's particular research interest may have to determine one's choice of definitions of national product.

Turning away from national income to the "social indicators movement", we should first note that in one sense this movement represents a step backwards: none

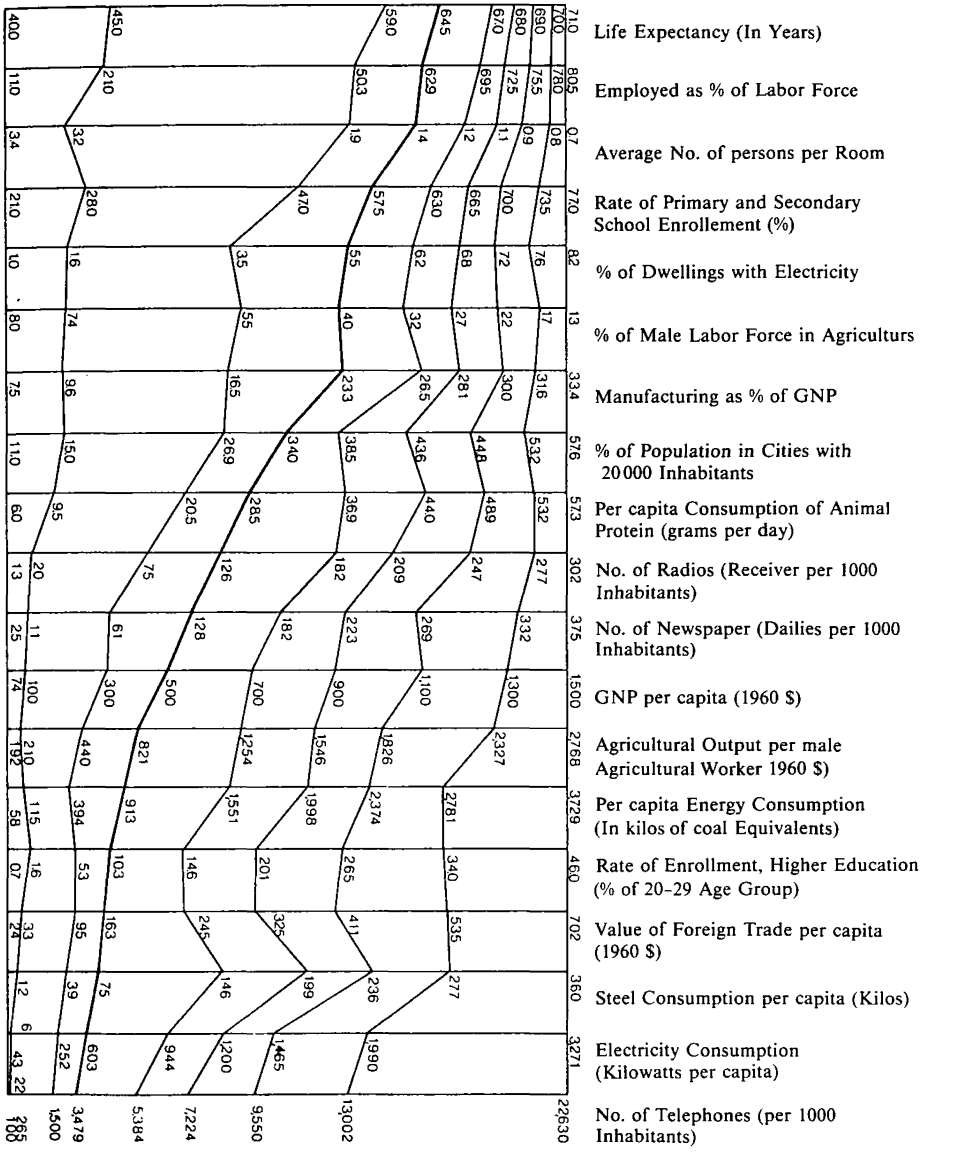
of the proposed indicators are themselves as comprehensive as the income accounts, and in contrast to the components of those accounts they cannot be added up to something comparable to GNP. However, for many of the experts working in this area of applied statistics the data requirements of GNP and its underlying assumptions seemed to go well beyond available knowledge, particularly where comparisons with less developed countries of the past and present were sought. One idea was to collect those concrete data which were believed to represent development indicators, were readily available, and posed no difficult valuation problems: for example, tons of wheat or steel production per annum, numbers of bicycles or radio sets per head of population, number of crude births per 1,000 inhabitants, and so on. Comparison, it was hoped, could thus be extended to countries having no national income statistics.[33] On the whole, however, this attempt has not been particularly successful, either because the indicators or their averages, taken by themselves, had no clear meaning, (either as welfare or capacity indicators) or because, where they were linked via correlation analysis to GNP, they became no more than rather poor proxies for the latter.

Table 4 illustrates the bind we are in. There is good correspondence in an ordinal ranking sense, but the scales of the variables are multi-dimensional and hence, quantitatively non-comparable. This means that for ranking purposes the indicators are superfluous—since we already have per capita income statistics—but for quantitative extensions into times and countries with deficient data, inadequate, especially when we note the irrelevance of some of the indicators for historical work on the 19th century (e.g., radios or electricity).

The "social indicators movement", however, aimed in two other directions as well. One of those reflects modern-day concern in industrial nations with the "costs of economic growth". It is in search of indicators of social and environmental change generally believed to affect social welfare. Here, the idea has been to develop an index of the "quality of life" which could be combined with GNP to help to decide whether economic change over a given period has been, on balance, socially beneficial or detrimental for the population affected. This effort is closely related to the extensions of the concept of real income discussed earlier (as "imputations"). It is much too early to say what will come out of this attempt, but two tentative observations seem relevant for our purposes. First, as in the correspondence "test" just displayed, most of the indicators of social well-being are positively associated with changes in GNP per capita. Given the widespread belief that the direction (or sign)

33. See on this, Gould, *Economic Growth,* pp. 11-14; Beckerman W., and Bacon R., *International Comparisons of Income Levels: A Suggested New Measure,* in: Economic Journal, 76 (1966); or the discussion of social and economic indicators developed by the UN in Nohlen D., and Nuscheler F., (Eds.), *Handbuch der Dritten Welt,* I, Hamburg 1974. It may be added that Gerschenkron's wellknown approach to European industrialization limited quantitative growth analysis to industrial production, for want of more comprehensive, yet reliable, data. Cf. Gerschenkron A., *The Approach of European Industrialization: A Postscript,* and *Problems of Measuring Long-Term Growth in Income and Wealth,* in: Economic Backwardness, esp. pp. 353-54; also Gerschenkron, *The Early Phase of Industrialization in Russia: Afterthoughts and Counterthoughts,* in Rostow W. W., (Ed.), The Economics of Take-Off into Sustained Growth, N.Y. 1963, esp. pp. 161-63.

Table 4: (GNP per capita and Corresponding Indicators)



Source: U.N. Research Institute for Social Development (Reprinted in D. Nohlen and F. Nuscheler (Eds.), *Handbuch der Dritten Welt*, I (Hamburg, 1974), p. 248.

of this correlational relationship is negative, that is an important result.[34] Second, the indicators are aggregative and say nothing about distributions and/or social inequality. If we wish to correct GNP for changes in the degree of economic inequality, an analogous correction for these indicators will also be in order.

A second prong of the "social indicators movement" has focused on the under-developed countries. Its proponents have interpreted economic growth as part of a broader cultural process embracing social and political change. Such an interpretation called for (a) data on social and political change and (b) analysis of the links between such data and more conventional indicators of economic development. I. Adelmann and C. T. Morris, in one of the more ambitious examples of this genre, have shown that the interdisciplinary data approach can enlighten.[35] Applying factor analysis to a cross-country array of many economic, social and political indicators—factor analysis being particularly useful where an inductive approach is preferred and no specific hypotheses are used to pre-structure the data—they find that (estimated) GNP per capita is closely associated with the non-economic factors of development, but that the complex "factor" of "*socio*-economic" indicators (including such variables as "extent of dualism", importance of an indigenous middle class, etc.) corresponds much better to what we commonly think of as the conditions of underdevelopment than the purely economic "factor" does.[36] In addition, tracing the links between economic, social and political variables leads Adelmann and Morris to a useful three-stage version of underdevelopment in which GNP per capita becomes more closely related to purely economic factors as development proceeds (from "very underdeveloped" to "less developed") and also, in the third stage of underdevelopment, more closely associated with political ones.[37] To sum up: these results suggest to me that historians of development have something to gain by an extension ef the indices of measurement to non-economic factors, particularly for study of the earliest phases of industrialization. However, for investigations of western European development since around 1850—corresponding to the third phase—they are not likely to be misled very much by relying on per capita income—so long as their main concern

34. Cf. e.g., King M. A., *Economic Growth and Social Development,* in: Review of Income and Wealth, 20 (1974). I owe this reference to Rolf Dumke. For Germany, see Zapf W., *Lebensqualität in der Bundesrepublik. Methode der Messung und erste Ergebnisse,* in: Soziale Welt (1977).
35. Adelman I., and Morris C. T., *Society, Politics and Economic Development: A Quantitative Approach,* Baltimore 1967. Their goal, to be sure, is an improved explanation of *economic* development, not an analysis of "modernization". That branch of the indicators movement is not discussed here at all.
36. One way of putting this is that GNP per capita categories bring together much more diverse collections of countries with respect to socio-economic characteristics (such as size of traditional agriculture, extent of dualism, etc.) than the "factor" "Socioeconomic Variables" does. See Adelman and Morris, *Society,* p. 169, and the appendix to this paper where some of their results are reproduced. See also Kuznets, *Modern Economic Growth,* pp. 437–60, for a discussion of non-economic characteristics of underdeveloped countries.
37. The Adelman and Morris discussion of this third stage with its emphasis on the emergence of strong leadership commitment to economic growth and corresponding economic and financial policies gives it a resemblance to the experience of some European countries in the 19th century, e.g., Germany in its "Take-Off" phase (in the 1850's and 1860's).

is with *economic* development, and not the social and political changes which accompanied it.

5. *Productivity*

Aggregate labor productivity bears a close resemblance to per capita income. Indeed, where the entire population is gainfully employed, capital consumption negligible, and the foreign accounts are in balance, the two are virtually identical. This conceptual likeness is important, for it reflects a duality in the way we look at the economy and the real income it generates: it may be seen as a system of prices and quantities of goods and services generating real income and welfare as a function of consumer preferences; or it can be interpreted as a system of production possibilities generating output (real income) as a function of technology. For some purposes either perspective will do; but where interest centers on the measurement of real income as an index of development economists differ on this issue. As suggested earlier, quite a few economists believe that interpreting output or income per capita as an index of productive capacity avoids the problems of interpersonal comparisons of utility and distributional considerations associated with income seen as welfare.[38] They see development as an economy's progression from, say, position A to position B, where B represents an economic state capable of producing all of the goods produced (per capita) in position A plus some non-negligible quantity of goods reflecting income growth, call it P—for increased productive capacity. Thus $B = A + P$. The words "capable" and "capacity" are used to stress that while B represents more "potential welfare" than A, it need not mean more realized welfare.

I disagree with this interpretation. In terms of the example just given, I suspect that we are likely to say that an economy is better off in position B than in position A, a statement which to my way of thinking has welfare connotations. The notion of "potential welfare" is, on this view, unnecessary baggage. More importantly, historically relevant comparisons will typically involve economies with different bundles of goods and services. Referring back to our example, we may wish to view states A and B as two separate economies. If we observe them to produce the same products, x and y, but B to produce more of each, there is no ranking problem. However, it is thinkable that we might observe that economy B produces more of final goods x and y than economy A but much less of an intermediate good z (say, transport), mainly because consumers in economy B have localized tastes causing localized consumption and reduced need of transportation. Even if relative prices of goods x and y were identical as between economies A and B, so long as transportation is an intermediate good (and resources are perfectly convertible) there would be a difference in per capita real income between A and B dependent upon demand differences.[39]

38. Leibenstein, *Economic Backwardness*, p. 12. This distinction has sometimes been applied in the national accounts to the difference between national income at market prices (welfare measure) and at factor costs (productive capacity measure). See, e.g., Gilbert and Kravis, *International Comparison* (cited in note 20). For critical discussion of this disinction see Usher, *Measurement*, Chapter 4, and Sen, *Welfare Basis*.

39. The example and much of this entire discussion is derived from Usher, *Measurement*, Chapter 4.

Alternatively, turning to the topic of productivity comparison, we can imagine economy A having a higher productivity or output per head than B in the production of the only commodity it is capable of producing, say, good x, but B having the ability to produce a greater variety of goods and services, say, goods x *and* y rather than just x. Any comparison of the productivity of the two economies will have to take account of a bias connected with the comparison of non-identical bundles of goods and services. We have here, once again, the "index number problem", in this case in an extreme form. Now, if we were to substitute into our example the economies of the American ante-bellum South (for B) and the North (for A), we could cite in support of our argument an important criticism which P. David and P. Temin levelled against Fogel and Engerman's analysis of slavery in their book on the American South—*Time on the Cross*.[40] Those reviewers argued that the extent of the South's productivity (or "efficiency") advantage over the North in agriculture was dependent on the relative price of cotton (and other goods) in 1860 and not only or even mainly on the superior productive organization and "labor efficiency" of Southern plantations. Because the South could produce much cotton and because world demand for it was buoyant, the value of its agricultural output could and did expand above Northern levels. These values, divided by estimates of the available productive factors, produced a "relative efficiency" or "productivity" differential favoring the South. But behind that differential lay the crucial weight of demand. For this reason, David and Temin suggested replacing the terminology "relative efficiency"—having physical and technical connotations—with the label "revenue—getting efficiency".[41]

I have neither the competence nor the desire to adjudicate in the ongoing debate on American slavery, but the particular criticism of interpretation of productivity in-

40. The literature of criticism of this book is immense. Some of the landmarks are: Fogel R. W., and Engerman S. L., *Time on the Cross,* Vol. I: *The Economics of American Negro Slavery;* Vol. II: *Evidence and Methods,* Boston 1974; David P., and Temin P., *Slavery: The Progressive Institution?,* in: Journal of Economic History, 34 (1974); the entire issue of *Explorations in Economic History,* 12 (1975); R. W. Fogel and S. L. Engemarn, *Explaining the Relative Efficiency of Slave Agriculture in the Antebellum South,* in: American Economic Review, 67 (1977); Haskell, T., et al., in: American Economic Review 69, (1979); and Fogel R. W., and Engerman S. L., *Explaining the Relative Efficiency of Slave Agriculture in the Antebellum South: Reply,* in: American Economic Review, 70 (1980); and David P., et al., *Reckoning with Slavery,* N. Y. 1976.

41. The David-Temin discussion (in 1974 and 1977) suggests that the bias favoring the South is unknown, but that it could, in the extreme, explain the whole of the relative advantage recorded by Fogel and Engerman. Interested readers are referred to the Fogel-Engerman reply to this criticism in the American Economic Review, 70 (1980). I should add that the point I am making is not identical with the general thrust of the David-Temin critique of *Time on the Cross.* For the purposes of the present argument, the South's alleged productivity lead can be seen as a welfare advantage over the North, though one which is demand-dependent. David and Temin, however, would doubt whether the assumptions of welfare economics apply to unfree societies such as the antebellum South at all. I find it hard to resist their arguments on this point, though I have the feeling that a strict construction of their remarks could considerably narrow the range of comparative economic growth history. My point, it must be reemphasized, is that productivity comparisons will involve welfare judgements in many relevant cases. The reader is referred, once more, to the rather loose, non-optimal concept of welfare applied here—and discussed in sections 3d. and 3e. of the paper.

dices as indicators of physical or technical efficiency articulated there does have general validity for all comparative studies of productivity. For there are not very many sets of productivity figures which will stand comparison without translation into some common denominator. There are some, e.g. grain yields, or tons of coal mined per miner-hour, but their range of application is limited. The desired translation, in any case, will involve consideration of prices and quantities of commodities, weighting them, and as an inevitable part of the counterfactual experiment which choosing such weights involves, bias. Historians of comparative productivity, that is the conclusion to be drawn here, should neither deny the existence of such biases nor seek to escape them, but should instead attempt to construct their studies so that the inevitable biases will not invalidate their results.

Although I do not believe that productivity data offer us more "objective" evidence of economic progress than do those on real incomes per capita, they are nevertheless essential. They are essential, because the supply side is just as indispensable to analysis of economic development as the demand side and probably more accessible to research. For this reason an entire generation of economists and economic historians over the past several decades has discussed economic growth in terms of them. Those scholars have conceived of economic growth (or development), for better or worse, as a technical process in which inputs of productive factors are transformed via a production function into output. They have retained this schema of relationships while disaggregating the process down to the sectoral or regional level, and they have managed to refine some of the input measures (e.g., by converting the labor input with the help of educational data into a range of labor inputs of differing quality) without making the entire set of accounts—for that is what this system of production—function relationships is—inconsistent or noncomparable.[42] Given its widespread acceptance, this system of relationships offers possibilities for further comparative study which it would be foolish to ignore.

A possibly superficial, but nonetheless logical, argument for focusing on productivity change is the latter's contribution to long-run changes in per capita income. Long-run economic growth in those countries for which estimates exist, has resulted largely from increased output per unit of input, i.e., from productivity growth.[43]

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42. This is clearly not the proper place for a bibliographical survey, but a few major contributions to the "growth paradigm" should be mentioned: Abramovitz M., *Resource and Output Trends in the United States since 1870,* in: American Economic Review, 56 (1956); Solow R. M., *Technical Change and the Aggregate Production Function,* in: Review of Economics and Statistics, 39 (1957); Denison E., *The Sources of Economic Growth and the Alternatives before Us,* N.Y. 1962; Ibid, *Why Growth Rates Differ,* Washington 1967; Jorgenson D., and Griliches Z., *The Explanation of Productivity Change,* in: Review of Economic Studies (1967); Kuznets, in *Modern Economic Growth* and elsewhere has extended the empirical basis for growth studies and thus deserves mention here. I have found useful discussions of growth and technical change in Usher, *Measurement,* Chapter 12, and also in Gould, *Economic Growth,* Chapter 5.

43. See, for example, the discussion of Denison's findings for the U.S. (1909–57) in Kuznets *Modern Economic Growth,* pp. 80–82 (where an anual rate of growth per capita income of 1.44 per cent is attributed to the growth of capital and land inputs (.18), quality improvements of labor (.58) and factor productivity (.67). See also the correlation between per capita income and output per man-hour for 14 industrial countries (1870–1965) indicated in Gould,

There is no need to reproduce the basic estimates here, for they are common knowledge. Rather more useful may be some discussion of the qualifications of those findings, for they are likely to be relevant to some of the historical studies of productivity currently getting underway.

Our point of departure is the discussion of the so-called "residual", the increase in *total* factor productivity which—according to the earliest estimates of aggregate production functions—accounted for between 50 and 85 percent of modern growth in industrial countries such as the U. S. A. (in the 20th century).[44] Diagram 1 taken from J. D. Gould's excellent survey of growth history, offers an incomplete list of dangers associated with residual analysis. Missing there, but worthy of mention, are quality changes or differences in the inputs of labor (obvious and often noted), capital (less obvious, but also of probable significance), and natural resources. This deserves mention because the productivity of these factors should be standardized according to quality or comparisons will be misleading. In the studies cited by Gould (and others), for example, stronger, healthier and better educated labor as well as improved capital equipment contribute to enlargement of the measured productive inputs and reduction of their measured productivity.[45] What the diagram—and the literature supporting it—makes clear is that many factors explain (measured) productivity growth. That could mean that the traditional emphasis upon the role of technical change—on one interpretation "D_1" in the diagram and according to another interpretation. "C_1"—requires modification. In its place we might want to install improved allocation of resources (C_2), economies of scale (C_3), and/or what historians tend to call "entrepreneurship" (here D_2). However, no consensus on the weighting of these various components has yet emerged, so it is too early to forecast a justified neglect of technology.[46]

Some of the components listed in Gould's diagram have their counterparts in the recent historical literature on economic growth. Interestingly, agricultural history is relatively rich in examples. To mention just three, David and Griliches for the U. S. in two different periods, and O'Brien and Keyder in their 19th-century British-French comparisons, have identified both improved resource allocation and econom-

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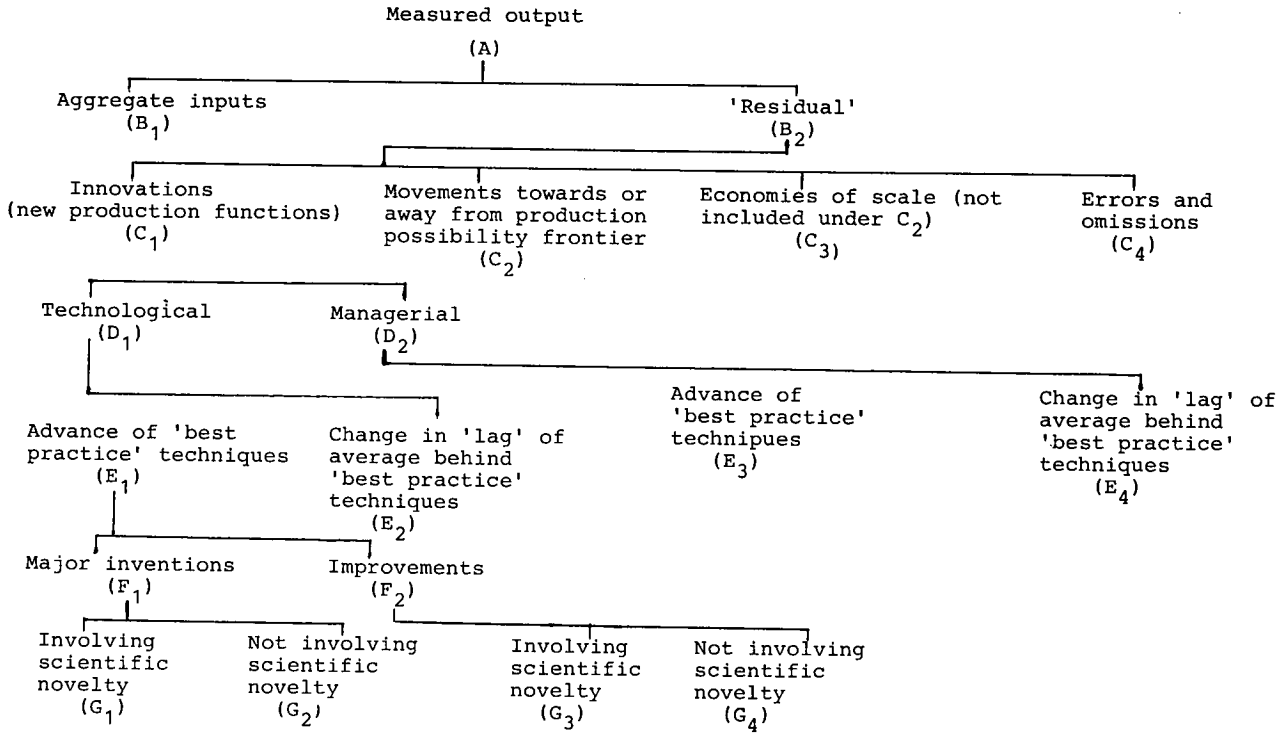
Economic Growth, p. 22. However, these results depends on the assumption that the factor inputs have been correctly measured—and the assumption has been questioned. Index number bias may be significant. On this see Usher, *Measurement*, Chapter 12.

44. The earliest and perhaps most striking result was Solow's finding that about 85 per cent of American productivity change, 1909–1949 was attributable to technical change. Correction for the quality of labor, however, reduced this contribution to the share indicated in the previous footnote. Further research brought further fluctuations in the share, one study (by Jorgenson and Griliches) even virtually eliminating technical change (or factor productivity). But see on this Usher, *Measurement*, Chapter 12.

45. In *Why Growth Rates Differ* (Chapter 7–9 and Appendix F) Denison justifies an increase in the growth share attributable to the labor input for "Northwest Europe", 1950–62, from .52 to .83 per cent when the latter is corrected for education and age-sex composition. This reduces the "residual" from 3.33 to 3.07 in percentage points of change per annum.

46. Much depends on how technical change has been and is understood. One can clearly forecast a reduced importance for concern with technical change in the narrow, engineering sense. Technical change, however, can take on an extremely broad meaning, e. g., to include changes in the quality of output. It is not inconceivable that experiments along these lines could enlarge the residual once again. On this see Usher, *Measurement*, Chapter 12.

Diagram 1



The sources of increase in (measured) output
Source: J.D. Gould, Economic Growth in History, P. 299

ies of scale as major sources of productivity growth and/or productivity differences.[47] D. Mc Closkey, R. Allen, and S. Webb, on the other hand, have discussed these sources plus entrepreneurship and technical change against the background of the comparative history of heavy industrial growth in Great Britain, Germany and the U.S. in the 19th century—without arriving at any general agreement on their relative importance.[48] Disagreement can be instructive, however, and in the case at hand, we come to realize how much results depend upon assumptions (e.g., concerning the degree of competition), the choice of data, and/or the scope of the investigation. For example, whereas the Mc Closkey study concluded—on the basis of international input and output price comparison and the competitive, marginal-cost pricing assumption—that British steel producers were losing ground to U.S. and German rivals towards the end of the 19th century because of demand and relative input cost shifts but *not* because of declining relative efficiency, both Allen and Webb challenged this pricing assumption—particularly as applied to German data. Allen examined both German and American costs and prices and Webb German ones, and both showed that the use of cost data not deduced from prices indicates a clear British lag in relative efficiency, i.e. a lag in relative total factor productivity. What is not clear from all of this, as suggested above, is whether such a lag represents a deficiency in "entrepreneurship", a technological gap, an economies of scale gap, a lack of demand, or all of these things. The answer to this question, it seems, will require further modelling.[49]

It would be easy to expand on the relationship between the "residual" and comparative productivity history. The preceding remarks have barely scratched the methodological surface. But instead of continuing this rambling journey through the litera-

47. David P., *The Mechanization of Reaping in the ante-bellum Midwest,* reprinted in David P., *Technical Choice, Innovation and Economic Growth, Essays on American and British Experience in the Nineteenth Century,* Cambridge 1975; Griliches Z., *The Sources of Measured Productivity Growth: United States Agriculture,* 1940–60, in: Journal of Political Economy, 71 (1963); O'Brien and Keyder, *Economic Growth,* Chapter 5. It may be worth adding that this is consistent with the traditional view that the reallocation of labor out of agriculture into industry must have been a major source of aggregate productivity growth in the 19th century, but that consistency cannot be assumed. For the postwar European situation see Gould, *Economic Growth,* p. 320 (drawing on Denison, *Why Growth Rates Differ*).
48. McCloskey D., *Economic Maturity and Entrepreneurial Decline: British Iron and Steel, 1870–1913,* Cambridge 1973; Allen, *International Competition;* Webb, *Tariffs.*
49. The summary in the text cannot pretend to do justice to a complicated "cliometric" debate. On the German side, Webb stresses market imperfection and scale economies leading to more investment and "embodied" technical change. By implication, the lack of these factors could explain Britain's relative stagnation. For Britain, however, McCloskey and even Allen acknowledge natural resource disadvantages with consequences for technical change, profitability and investment. McCloskey, to be sure, tends to stress slow demand in Britain rather than slow productivity as the reason for this industry's relative decline and he expressly rejects the thesis of "entrepreneurial failure", whereas Allen finds slow productivity change and possibly faulty entrepreneuership. Given the comparative nature of much of the analysis, it is rather surprising to find virtually no discussion of index number problems—either on the output or input side. That could be a source of bias in the results reported. On the whole, this discussion casts doubt on the operational usefulness of the residual components of Diagram[1] for quantitative sectoral studies of productivity.

ture, let me conclude by returning, once more, to the discussion of Fogel and Engerman's controversial interpretation of slave agriculture in the ante-bellum American South.

The justification for taking up this particular example is that it illustrates better than most the key significance which productivity measurement can have for major historiographical questions. I believe that Fogel and Engermann approached an important question—the problem of southern slavery—correctly. They wished to establish, in a quantitative manner, what the economic bases of southern slavery were, without losing sight of the broader issues of social and political history at stake. I happen to disagree with their own interpretation of their findings,[50] but for present purposes it is the findings themselves and their derivations which deserve discussion. It must suffice here to point out that both findings and interpretations have enormous implications for history, that is, that the example is not a trivial, obscure, or narrowly technical one.

Our concern is with the productivity or "relative efficiency" question. Fogel and Engerman argued that, contrary to what a generation of historians had believed and propagated, the ante-bellum slave economy was not only highly profitable for its plantation-owning elite but also relatively efficient—as measured by its aggregate rate of growth of output per head of population and per input of productive factors, and as measured by the level of its output per factor input in relation to the rest of the United States. By a process of elimination, those authors attributed this "relative efficiency"—and here is where controversy arose—to the high quality or efficiency of slave labor. Our discussion touches on four points: (1) the representativeness of the data; (2) the identification of labor efficiency as the key factor; (3) the quality of labor inputs; and (4) the quality of land inputs. (1) Despite its lengthy discussion of sources and methods (in Volume II) *Time on the Cross* does not permit readers to clearly identify the sample of evidence going into the estimates of relative efficiency (or total factor productivity). It is clear that the U.S. Census of Agriculture for 1860, with data on individual farms and plantations operating in that year, is the main source. We also know the basic sample used (taken from the 1860 census and known as the "Parker-Gallmann sample" after the names of the two economic historians who produced it). However, that information on the size distribution of these production units or on the variance of productivity measures across it which *Time on the Cross* gives does not suffice to firmly establish the representativeness of the data

50. I disagree with their clear distinction between slavery as a retrograde political and moral institution and slave agriculture as a viable, successful economic system. Since the essence of slavery was, in G. Wright's succinct words, the "involuntary reallocation of family labor from nonmarket economic activity to production of crops for sale," it meant a loss of leisure and freedom which had, in terms of the imputations discussed earlier, a significant economic dimension imperfectly reflected in the market results summarized under the heading of "efficiency". Cf. Wright G., *The Efficiency of Slavery: Another Interpretation*, in: American Economic Review, 69 (1979), p. 225. I also disagree with their belief that the demonstration of high productivity and positive work attitudes among black slaves rescues them from posthumous denigration. On the contrary, one could argue that since, historically, much meaningful labor protest has taken the form of sabotage of work processes through slowdowns, absenteeism and breakage, Fogel and Engerman's attempt to find positive work attitudes among slaves amounts to an attempt to denigrate them.

base. Since the basic, Parker-Gallmann sample was restricted to counties specializing in cotton production, it is hard to know how generalizations about the South as a whole or comparison between free farming and slave farming within the South should be assessed. Thus, the findings that slave agriculture was 28 percent more efficient than free agriculture in the South in 1860 or that Southern agriculture was 35 percent more efficient than Northern agriculture in the same year are difficult to interpret.[51] Finally, we are not told to what extent the findings are sensitive to the disproportionate weight of 1860 data. It seems doubtful whether the entire ante-bellum period (1820–60?) is well characterized by this procedure. (2) Among the many components of productivity increases, *Time on the Cross* singles out the "personal labor efficiency" of black slaves as the main source of the superiority of Southern slave agriculture (in Diagram 1, C 4). In so doing, they assign to the other components such as economies of scale, technical know-how or managerial ability, an insignificant role. They do find scale effects on large, slave plantations, but choose to interpret them in part as a product of the character of slave labor. Management ability receives the same treatment: "In a certain sense", they write, "all, or nearly all of the advantage is attributable to the high quality of labor, for the main thrust of management was directed at improving the quality of labor".[52] The trouble is, there is no clear demonstration of how their implicit weighting of the sources of productivity differentials (between slave and free labor) can be justified. (3) Fogel and Engerman's comparative estimates of agricultural labor inputs in 1860 are biased upward against the North (i.e., they understate the Southern input relative to the North). The reason for this is that they treat a southern man-year as equal to a northern man-year in spite of the fact that (a) the southern climate permitted a fuller utilization of the entire workyear—possibly by as much as 60 days, or at least one third of the northern workyear—and although (b) slaves worked more hours per year than did free farm workers (in the North *and* South) and were significant, of course, only in the South.[53] Plausible corrections, suggested by David and Temin in their critique of *Time on the Cross* and based on a comparison of hours worked by blacks before and after eman-

51. The two estimates may not be comparable since the latter figures must represent a weighted average of a sample whereas the former may or may not. They rest on the Parker-Gallman sample, but nothing is said on extrapolation techniques or sample variances. In fact, the book contains very little raw data with which readers could check on the Fogel-Engerman claims. See David and Temin, *Progressive Institution?*, pp. 764- 65, esp. notes 37 and 38.

52. Fogel and Engerman, *Time on the Cross*, I, p. 210. I find this plausible, given the nature of slave agriculture and the input shares Fogel and Engerman use. However, those shares are not explicitly justified—they could embody an index number problem of their own—and even if they could be deemed satisfactory, we are given little basis for choosing between a high work intensity caused by management and that produced voluntarily by labor. See Haskell T., *Explaining the Relative Efficiency of Slave Agriculture in the Antebellum South: A Reply to Fogel-Engerman*, in: American Economic Review, 69 (1979).

53. As David and Temin point out, *Time on the Cross* does not document its assertion concerning the rough equality of the workyear in slave and free agriculture. Moreover, in one huge correction they deduct 25 per cent of rural slave labor from their input measure on the grounds that this share represented "domestics". But they do not make it clear whether this deduction is maintained in the next estimate, which is corrected (downward) for age-earnings profiles. This amounts to a bias ageinst the North whose labor force is not so corrected.

cipation, lead to an increased labor input to slave agriculture of between 28 and 34 percent. (4) By using average land values to adjust acreage figures and, hence, land inputs in North and South, *Time on the Cross* implicitly applies the theory of rent to natural differences in soil fertility and assumes perfectly competitive national capital, land and agricultural product markets. But given the high rate of interest on mortgages in the South and the preferred position of presumably risk-averse southern landowners in the land market there, land prices in the South might well tend to understate the productive contribution of land's natural fertility. Moreover, land prices would also be likely to be lower in an area relatively poorly served by transportation facilities—such as the South—because prices received by farms for agricultural products in the South would be lower relative to final market prices (according to which outputs were weighted) than those received by farmers in the North. This could be corrected for by reducing southern land productivity by the appropriate amount (or by other means). In any case, recalculation of land inputs along these lines would increase Southern land inputs relative to the North.[54]

The upshot of this brief discussion is that a great deal can depend on historical productivity measurement, whereas the latter can depend, in turn, on assumptions about outputs, inputs, and residual components whose verification may be extremely difficult. In the present example, had the questioning of such assumptions early on led in the directions suggested here, the puzzle of a high-productivity slave economy propelled by its qualititively superior labor force might have never emerged. The moral of the story, for our purposes, is not simply that a provocative thesis may be essential to get research activity into significant problems going, but also that where such research is dominated by systematic and explicitly quantitatively comparative methods, corrections of provocative theses and puzzles are possible.

Conclusion

Given the essentially descriptive and taxonomical character of this paper, it would be inappropriate to conclude with statements even more sweeping and summary than those already made. I have attempted, no doubt presumptiously, to define the field of national income and productivity history from the point of view of methodology. At the same time, the paper seeks to call attention to certain areas within the field which coincide, in my opinion, with the research needs and interests of comparative Europeans economic history (the comparative history of prices and consumption pattern and tastes stands out, it seems to me, as such an area). And finally, there is the question of the wider implications of comparative income and productivity history. The last section of the paper discussed one example taken from American history (though the comparison was *intra*-national rather than international) but European history must also be bristling with comparable issues. One such might be seen in the liberal agrarian reforms carried out in the nineteenth century, and to which one may attach the question: did they help, hinder, or result from productivity change? And to what

54. There is some reason for believing that national price weights overvalue southern agricultural output relative to the North in 1860. Cf. David and Temin, *Progressive Institution?* p. 774.

extent was the rise of free trade in western Europe during the middle decades of the nineteenth century the product of rising income and productivity levels? No doubt, such themes lack the political clout of the problems of American slavery. But what about the German Weimar Republic and its aftermath? If the problem of the Weimar Republic in Germany can be seen as dependent upon gaps between real wages and productivity, how are we to interpret that gap in other European countries during the same time? And what about subsequent periods? Lack of patience, lack of knowledge, and perhaps lack of imagination, on my part, limit the list; but I am sure it can be extended. The more difficult task will be the income and productivity studies themselves. They will be welcome.

Zusammenfassung: Pro-Kopf-Einkommen und Produktivität als Indikatoren für Entwicklung und Wohlstand. Bemerkungen zur Kuznetsianischen Wirtschaftsgeschichte

1. Die Verwendung der makroökonomischen Größe Volkseinkommen pro Einwohner (VpE) in wirtschaftshistorischen Untersuchungen hängt mit dem sog. „Wachstumsparadigma" zusammen: geht es in solchen Untersuchungen um die Beschreibung und/oder Interpretation des Wirtschaftswachstums, so ist jene Größe (oder ein gleichwertiger Ersatz) - und deren Komponenten - unentbehrlich. Kritik an das Paradigma sollte dennoch von Kritik an der Größe selbst unterschieden werden.
2. Dieser Beitrag geht von der Annahme aus, daß Länder, wie einzelne Wirtschaftssubjekte, nach materieller Wohlstandsteigerung streben, und daß der Erfolg dieses Strebens, d. h. Wohlfahrt, an der Entwicklung des VpE gemessen werden kann.
3. Kritik an der Verwendung des VpE als Wohlstandsindikator kann in 5 Punkten aufgegliedert werden: (1) das Problem nichtmaterieller Güter; (2) das Problem der nichtmarktwirtschaftlichen Aktivitäten; (3) die Definition der End- bzw. Zwischenprodukte; (4) die Annahme von konstanten Präferenzen (einschließlich Indexzifferprobleme); und (5) das Problem der Verteilung. Diese Probleme qualifizieren die Interpretation von VpE als Indikator der Wohlfahrtssteigerung, rechtfertigen aber nicht deren gänzliche Zurückweisung.
4. Alternativen zum VpE wie z. B. Tobin und Nordhaus' M. E. W. oder die „sozialen Indikatoren" sind in einzelnen Fällen empfehlenswert aber kein allgemein akzeptabler Ersatz für das VpE.
5. Produktivitätsmessung als Instrument der wachstumsorientierten Geschichtsschreibung unterliegt demselben methodischen Problem wie das VpE. Dies kann an der Diskussion einiger neuerer wirtschaftshistorischer Arbeiten insbesondere der Arbeit von Fogel und Engerman über die amerikanische Sklavenwirtschaft im 19. Jahrhundert, gezeigt werden. Diese Diskussion zeigt aber zugleich die große Bedeutung der „Produktivitätsgeschichte" für allgemeine historiographische Fragen.

William P. Kennedy

Problems of Accountancy and Interpretation in Assessing Long-Term Economic Performance

> "In intensity of feeling ... and not in statistics, lies the power to move the world. But by statistics must this power be guided if it would move the world aright."
>
> Charles Booth, 1891.

In the popular mind, economic growth has generally been regarded as a "good thing." This attitude no doubt springs from the widely-shared feeling that if only one's (real) income were higher—that is, if economic growth in the past had been more rapid—one would be better off in some concrete sense. It would then be possible to afford better housing, better transport, more varied and interesting leisure, and so on. A little daydreaming will generally be sufficient to lengthen this list to almost any desired limit. Although such attitudes not only suggest a natural and feasible means of measuring economic activity but also accurately reflect important aspects of that activity, historical analysis, in common with the demands of public administration, requires a more searching evaluation of economic effort. For the historian, this requirement stems perhaps most fundamentally from the need to measure change over time combined with the realization that societies are complex entities made up of many individuals whose preferences differ and whose welfares are therefore differentially affected by any given change. Thus important conceptual problems arise both in aggregating for one individual the value of the different goods consumed (because of the necessity of assuming identical marginal utility of expenditures on all goods) and in aggregating across many individuals the value of the consumption of the same good (because personal circumstances differ). These problems are then enormously compounded by the aggregation of all goods across all consumers. The use of market prices to accomplish these essential tasks of aggregation, without which no analysis is possible, often imposes such unacceptable assumptions upon the historian as the belief that all observed prices are full-information equilibrium prices, that the distribution of wealth is "optimal", or that all individuals' preferences are identical.[1] But if observed market prices are rejected, how else is measurement to be made? Moreover, factors such as productivity, widely recognised to be

1. Sen, Amartya K., *The Welfare Basis of Real Income Comparisons: A Survey*, in: Journal of Economic Literature, 17 (1979), pp. 3-35.

of signal importance, depend for measurement critically upon the precise designation and valuation of economic input and outputs. Here again, any inadequacies of observed prices have very serious consequences for measurement and analysis as well as for resource allocation.

Because historians have always been sensitive to the intricacy of the past and because historians' purposes are those of broad assessment and evaluation, clumsy and insensitive systems of measuring economic change must invariably be disturbingly inadequate. Yet the construction of satisfactory measures has proved to be almost paralyzingly difficult. The result has been an uneasy, resented compromise between what can be done and what should be done. While this situation will not be altered easily or quickly, the first step in amelioration must be for all historians, as both consumers and producers of statistics, to be more consciously aware of both the difficulties that have been encountered in the past and the possible strategies that may be open for progress in the future. To that end this essay has three objectives: to review the most important inherent difficulties in measuring economic activity; to consider some of the most promising remedies offered for those difficulties; and, where possible, to consider for the remaining problems some strategies that may prove fruitful in the future.

I

The problems of measuring economic activity may usefully be divided into two categories differentiated by their amenability to the use of observed price data.[2] The first and more tractible category contains those issues where prices that in principle can be observed can be used. The second, more intractible and perhaps—at least for historians—more important, category contains those issues that must be resolved by the use of estimated prices because observed prices are for a number of reasons defective. Such defects may arise because observed prices are in fundamental disequilibrium and therefore, given the preferences, technology, and resources of a particular economy, seriously deceptive; because observed prices change over time due to both general inflation (or deflation) and relative price movements; because, observed prices are deemed to be unacceptably determined by a particular, possibly arbitrary, distribution of wealth; or because observed prices are considered distorted by tariffs, quotas, or various other types of administrative action. The conventional National Income and Product Accounts are constructed mainly using observed prices, although imputations of unobserved but market related prices are made in certain crucial instances—most notably the value of the services accruing to the owner-occupiers of houses who pay no explicit rent for their accommodation and the value of agricultural output consumed on farms—and most National Income and Product Ac-

2. The stress placed in this essay on the use of prices should not be construed as limiting the analysis only to market economies. Centrally planned economies implicitly or explicitly, consciously or unconsciously, must produce prices in order to co-ordinate activity and those prices (or shadow prices) will reflect the strengths and weaknesses of the planning mechanism in the same way that market-based prices reflect the strengths and weaknesses of market mechanisms.

counts (NIPA) provide estimates of income and output over a span of years in constant prices even though the prices used could have at best been observed at only one instant.

At the present, however, even disregarding problems of the second category, the conventional NIPA are inadequate for two main reasons. First, and less importantly, the accounts, even in their own limited terms of reference, are not yet completely consistent logically. Broadly, the NIPA are designed to measure a nation's economic activity in three theoretically independent methods. One method measures the incomes of all factors of production (including those located abroad but owned or residing domestically and excluding those located domestically but owned or residing abroad) before transfers for taxes, gifts, or other unilateral payments not matched by a countervailing flow of goods and services. A second method measures net value added in economic activity by each of a nation's productive enterprises. The third method measures the flow of national expenditures on final goods and services, including exports but excluding imports. The accounts represent a series of compromises between what may be measured easily and accurately and what is logically required. Although the resolution of such problems is comparatively easy, extensive reworking of the conventional accounts is often necessary and the difficulties imposed by the inevitable sparseness of historical data can transform tedious but conceptually routine calculations into substantial and demanding tasks of indirect estimation.

An example of the sort of anomaly of this variety likely to cause historians difficulty can be drawn from the convention employed in the British NIPA for measuring the value added to national income by financial intermediaries. Financial intermediaries have two main sources of income: (1) service charges and commissions, which together typically account for only a small proportion of their operating income, and (2) the net revenue resulting from charging to final borrowers a higher rate of interest than they as a group pay to depositors. However, the British accounts, in common with many others, treat interest payments and receipts as transfers and not as payments and receipts for final services.[3] Thus the net earnings of financial intermediaries are generally understated, the net earnings of borrowing companies are correspondingly overstated and, to the extent that private individuals rather than companies are final borrowers, consumers' expenditure on final goods and services is understated. Consistency would require (1) that non-financial company profits be reduced by the amount of net interest paid to intermediaries and intermediaries' net income be similarly increased and (2) net interest payments by the personal sector to intermediaries be treated as payment for a final (consumption) service rather than as a transfer. In the belief that sufficient accessible evidence has not been available to permit such reallocations among companies and between companies and individuals, the Central Statistical Office has decided that indirect imputation of intermediaries' value added would be more misleading than the obvious paradox of flourishing intermediaries appearing to make steady annual losses, a paradox that has been preserved in Charles Feinstein's indispensible volume, *National Income, Expenditure, and Output of the United Kingdom, 1855–1965,* in order to maintain consistency be-

3. Maurice, Rita, (editor), *Central Statistical Office National Accounts Statistics: Sources and Methods,* London 1968, pp. 204–205.

tween current and historical data series.[4] However, it is made abundantly clear on all sides that the paradox in the British NIPA of intermediaries steadily making large losses exists only for expediency and that logically acceptible, albeit labour intensive, alternative accounting conventions exist, as may be seen in proposals made by the U. N. in *A System of National Accounts and Supporting Tables* (New York: United Nations, 1964) and by the OEEC, *A Standardized System of National Accounts* (OEEC: Paris, 1959). It is important to stress, however, that the fundamental problem is not one of non-existent data or of unavoidable logical inconsistency but rather a lack of commitment and interest by both the national income accounts authorities and historians to utilize what is available. Indeed one might argue that the quickest way to secure progress in this area would be for an historian to make a provisional allocation of interest payments as dictated by logical consistency, thereby exploiting and drawing attention to the available data and setting upper and lower bounds to the data series most affected. Although it is only to be expected that the first estimates will be thouroughly revised, a successful pioneering effort, by clearly defining the problem and identifying the necessary data will greatly aid subsequent work.

Another anomaly of a related type likely to create difficulties for historians, simply because it creates grave problems for conventional accountants, arises in the treatment of profits, which conceptually are calculated net of depreciation to distinguish them clearly from cash flow but are often reported gross of depreciation because depreciation is so difficult to estimate, particularly when the quality and the relative price of capital goods changes as a result of technological progress. At the very least, the timing of profit peaks and troughs will be affected by the procedures for measuring depreciation, but it can easily be seen that other important issues related, for example, to the distribution of income and the size, composition, and productivity of the capital stock are also involved. The treatment of depreciation also affects the measured levels of of consumption, most notably the services derived from consumer durables such as automobiles and household appliances. Logically, these items should be treated in the same way as houses, being noted as additions to the capital stock—that is, as investment—upon completion and thereafter yielding a flow of consumption services gradually diminishing as depreciation occurs. Consumer durables other than houses, however, are not treated as additions to the capital stock that subsequently yield flows of services but as consumption items that are counted as if they were consumed immediately upon acquisition.[5] Such treatment, if accepted without reflection, leads to nonsensical results for it implies that for identically priced goods the rate of depreciation does not matter whereas in reality it matters a great deal. Cars that last for four years without major repairs yield a greater flow of services than do cars that last only for two, although this fact is ignored in the conventional accounts except to the extent that the price of the more durable car is greater than the price of the less durable one. In this case, as in the case of the value added by financial intermediaries, the remedy—allocating the value of the durable good over the time period in which it depreciates while yielding service—is straight-

4. Feinstein, Charles H., *National Income, Expenditure and Output of the United Kingdom, 1855-1965*, Cambridge 1972, pp. 141-43.
5. Maurice, *Sources and Methods*, p. 365.

forward, albeit tedious in terms of calculation and demanding in terms of data requirements.[6]

The more important inadequacy of the contentional accounts, however, arises not from logical inconsistency but from an inappropriate but understandable choice of objective. The conventional accounts are designed to measure marketed production whereas historians, in common with most other users of the accounts, are ultimately interested in sustainable consumption, the obvious objective of all economic activity.[7] To be sure, marketed production is an important component, perhaps even the most important single component, of consumption and in addition substantial benefits are derived from a choice of objective which lends itself—as marketed production does—to relatively straightforward extrinsic measurement. Nevertheless, marketed production is not in itself an objective of economic effort and is therefore inherently a poor indicator of it. Furthermore, in precisely those periods when economic activity is undergoing important structural changes—periods such as the classical Industrial Revolution or the emergence of post-industrial society—the relationship between marketed production and non-marketed economic activity is most likely to be changing as well. At such times, the conventional accounts will not be merely an indirect and imprecise means of monitoring economic activity but will also be systematically misleading. As long as the relationship between measured and unmeasured activity is constant, the conventional accounts will at least reflect reasonably faithfully changes in overall economic activity, but if the relationship itself is changing, it is no longer possible, without additional information, to infer the characteristics of aggregate economic change.

The nature of the problems that arise from the consideration of marketed production rather than sustainable consumption might best be conveyed by illustration. It has been stressed, for example, that virtually all societies at all times have provided themselves by one means or another with textiles, tools and other simple manufactures. For much of human history these simple goods have been produced directly by those, or the mear kin of those, who were ultimately to consume them and this production was often totally removed from any sort of market transaction.[8] Gradually,

6. It perhaps should be noted that William D. Nordhaus and James Tobin, in a preliminary calculation, show that the depreciation of consumer durables other than houses is more significant for its logical implications than for its practical consequences. See Nordhaus, William D., and Tobin, James, *Is Growth Obsolete?* in: National Bureau of Economic Research, Economic Research: Retrospect and Prospect—Economic Growth, Fiftieth Anniversary Colloquium V, New York 1972. There is another complication, however, which Tobin and Nordhaus do not consider. This concerns the incidence of capital gains and losses that occurs because of unanticipated changes in the relative prices of capital goods. Such relative price changes cause the anticipated time profile of depreciation to differ from the actual pattern. If relative capital goods prices rise, the firm simultaneously realizes a capital gain (because it bought the equipment relatively cheaply) but also must adjust upwards its depreciation allowances (because the equipment is more expensive to replace). The reverse occurs when relative capital goods prices fall: the firm suffers a capital loss and must adjust downwards the appropriate depreciation allowance.
7. It is necessary to stress "sustainable" consumption in order to exclude from consideration consumption that is made possible by a temporary deterioration in the capital stock.
8. Hymer, Stephen, and Resnick, Stephen, *A Model of an Agrarian Economy with Non-Agricultural Activities*, in: American Economic Review, 59 (1969), pp. 493–506.

however, this domestic production became more specialized in certain regions and surplus producers began to sell an increasing fraction of their output in formal markets, often organized by a merchant entrepreneur who would "put out" raw materials to cottage workers and market the finished goods produced by those workers. Eventually, when the technology of manufacture was sufficiently sophisticated, specialization would advance further and workers would no longer toil in their own cottages but were forced or lured into factories.[9] Thus over time an increasing proportion of economic activity came to be mediated by markets. If this process were to be measured by the conventional NIPA, the rate of increase of output, which was often quite rapid in any case due to undeniable technical progress, would be greatly overstated, for self-sufficient production would not be counted. Thus the changes recorded in the NIPA would include the effects *both* of more productive techniques *and* of changes in the proportion of total output marketed. The timing and intensity of an "industrial revolution" can, by the mechanical application of conventional methods, be more apparent than real, with output levels much higher at an earlier date than indicated by the conventional accounts and growing much more slowly.

A problem similar in nature is currently affecting contemporary national income accounting as female labour force participation rates rise.[10] Imagine two neighbouring households, in each of which a housewife does her own cooking and cleaning. The NIPA would record only the intermediate inputs (e.g. unprocessed foods and soap) that each bought, the value of the transformed inputs—the hot meals on the table and the clean sheets on the bed—being ignored. Now suppose that each housewife decides to specialize, one doing only cooking and the other only cleaning, and that each sells her surplus in a formal market and buys in the same market the good she no longer produces. In this case, the market value of the labour of each woman is duly recorded in the NIPA, along with, as before, any intermediate purchases. The NIPA will record a great increase in activity but clearly a large fraction of this recorded increase is nominal and not real because home labour was previously ignored by convention. To be sure, this change may also be accompanied by a legitimate output increase as a result of economies of scale and technological progress, but such an increase is likely to be small compared to the recorded change. This deliberately simple example captures the essence of important structural changes currently taking place in the labour forces of modern industrial economies. As an increased proportion of women leave their children in day-care centres, buy prepared foods in supermarkets and fast-food carry-outs, send their cleaning and mending to specialist firms, recorded national income rises, but the increase is obviously greater than the increase in real output simply because such a large proportion of home-centered production had previously been ignored. This problem is the exact reverse of the one encountered in the nineteenth century British NIPA which show the rate of growth of household production falling with the decline in the rate of increase of domestic servants.[11]

9. This process has recently been reviewed by Pollard, Sidney, *Peaceful Conquest*, London 1981, pp. 63–78.
10. The extent of this problem has been explicitly recognised by the British Central Statistical Office. See Maurice, *Sources and Methods*, p. 8.
11. Ebury, Marke, and Preston, Brian, *Domestic Service in Late Victorian and Edwardian England, 1871–1914: Reading Geographical Papers No. 42*, Whiteknights/Reading/England

It is safe to assume that consumption of household production did not fall as the recorded number of domestic servants fell but rather that it was the market mediation involved in household production that changed.

The corrections of the obvious anomalies introduced into historical analysis by changes in the extent of market mediation are not conceptually difficult to comprehend but are likely to prove difficult to implement because the amount of indirect estimation required is likely to be large and because the resulting estimates are unlikely to be highly robust with respect to various assumptions. Clearly what is needed is an estimate in the one example of the manufacturing output of self sufficient farms and in the other an estimate of the value of various household tasks. What is being sought is a measure of final output for consumption that is independent of the degree of market mediation. If such a measure can be found, only real output changes that are independent of marketing changes will be recorded. Although this requirement is a daunting one, before despairing, it should be recalled that it is with precisely such matters and details that economic and social historians have recently concerned themselves. While the necessary data may at present be highly fragmentary and incomplete, there is every prospect that it will become more complete in the future, especially as research attention is directed to issues where competing historical interpretations are particularly sensitive to the choice of analytical assumption. Furthermore, recent advances in simulation modeling offer means of utilizing fragmentary information much more efficiently than has been possible previously.[13] Simulation modeling involves describing a fragmentary data series by the known distribution (such as the normal, exponential, or gamma distribution) which on both empirical and theoretical grounds is most consistent with the currently available evidence and then using combinations of such distributions to yield a distribution of operating results for the process being studied. For example, Jeremy Atack used the procedure to assess the relative capital and operating costs of steam and water power in the early nineteenth century American economy but it can easily be seen that the same techniques can be used to estimate the average costs of providing, for example, various types of household consumption, using manuals of domestic management and isolated wage data for servants where Atack used contemporary engine price lists and engineering estimates.

Much more serious problems, both conceptually and quantitatively, arise in the treatment of leisure, obviously a highly esteemed element of consumption. The nature of this problem, which is clearly related to the general problem of assessing nonmarketed output, is easily seen. Imagine two economies, identical in all respects ex-

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1976, Table 5a, p. 23 and Lewis, W. Arthur, *Growth and Fluctuations, 1870-1913,* London, 1978, Table A3.

12. On pre-industrial manufacturing, see for example, Mendels, Franklin, F., *Proto-industrialization: The First Phase of the Industrialization Process,* in: Journal of Economic History, 32 (1972), pp. 241-261. On household labour, see Goldin, Claudia, *Household and Market Production of Families in a Late Nineteenth Century American City,* in: Explorations in Economic History, 16 (1979), pp. 111-131; Ebury and Preston, *Domestic Service,* pp. 85-104 and Horn, P., *The Rise and Fall of the Victorian Servant,* London, 1975.
13. See, for example, Atack, Jeremy, *Fact in Fiction? The Relative Costs of Steam and Water Power: a Simulation Approach* in: Explorations in Economic History, 16 (1979), pp. 409-437.

cept the way in which the benefits of technological change in a particular year are consumed. Suppose that in the first economy the hours of work and intensity of effort remain unchanged and that all of the benefits of the technological advance accrue in the form of more goods and services. By contrast, suppose that in the second economy the initial output of goods and services is maintained and that all of the benefits of the technological advance accrue in the form of fewer hours worked in order to obtain an unchanged level of material output. While by assumption, the two economies differ only in the composition of consumption, they appear markedly different in the conventional NIPA. In the first case, measured marketed income rises by the maximum amount permitted by the hypothesized technological advance. In the second case, measured marketed income does not rise at all although by assumption the increase in real productive capacity in the two economies was identical. It is obviously a critical weakness of the NIPA that the measure of economic activity should be so sensitive to its structure and composition. Moreover, in their pioneer reworking of the conventional NIPA, William Nordhaus and James Tobin found that the assumptions they employed to evaluate changes in available leisure dominated their measure of sustainable economic welfare.[14]

This result stemmed from the authors' inability to determine whether leisure time was itself a final consumption good or whether leisure time was only one of several inputs into a consumption process. If leisure time itself were the final consumption good, the necessary adjustments to the NIPA are straightforward. The change in the number of leisure hours, measured most plausibly as reductions in standard working hours but strictly excluding involuntary unemployment, is estimated for the economy as a whole and weighted by the average hourly earnings of those workers who obtain such reductions.[15] Note that this procedure assumes that workers are indifferent at the margin between earning another hour's income with which to consume more material goods or forgoing the material goods in favour of leisure. In this case, where leisure time itself is the final consumption good, comparisons across time are quite easy. An hour of leisure in 1880 is worth in ultimate consumption exactly as much as an hour in 1913 or in 1980 (assuming a constant marginal utility of leisure).

If on the other hand, however, the historian wishes to argue that leisure time is only one of a number of inputs into a consumption process, changes in the economy over time, most notably technological and demographic changes, make intertemporal comparisons for a particular economy or contemporaneous comparisons among economies with different technological capabilities much more difficult. Consider, for example, the impact of cheap rail transport in the nineteenth century on the leisure activities of the British working class.[16] The rapid growth of seaside resorts and other amusement centres following the advent of cheap rail travel is strong testimony of the contribution this form of technological change had on the enjoyment of leisure

14. Nordhaus and Tobin, *Is Growth Obsolete?*, pp. 38–48. Involuntary unemployment is strictly excluded from measures of leisure time. (pp. 44–45).
15. Standard working hours may change through variations in the working hours per day, in the working days per week, in the working weeks per year, or in the working years per lifetime.
16. Hawke, G. R., *Railways and Economic Growth in England and Wales, 1840–1870*, Oxford 1970, pp. 37–40, 52–54.

time. Similar arguments can be made for the impact of cheap books and magazines, bicycles, automobiles, cinemas, television, sports facilities and equipment and so forth. To the extent that technological progress enlarges and enriches the consumption of leisure time, a comprehensive set of NIPA must value leisure more highly over time as technological progress occurs. Nordhaus and Tobin propose doing this by deflating the nominal value of leisure hours over time (and by implication, between countries) by the price index of consumer goods, an index which over long periods of time has risen less rapidly than an index of nominal wages or earnings. The conceptual problems inherent in choice of index cannot readily be evaded because the decision taken makes a crucial difference in outcome. Nordhaus and Tobin's estimate of the per capita increase in measured economic welfare in the U.S. between 1929 and 1962 is 18.6% if leisure itself is a final good but 126.4% if leisure is considered a process fully participating in the benefits of technological change.[17]

Nordhaus and Tobin do not venture a resolution of the uncertainty created by the need to devise an appropriate measure over time of the value of leisure. Their purpose rather was to illustrate a means by which a complex, vital problem could be approached, in the belief that sustained investigation would ultimately yield greater understanding. In pursuing this problem further, historians may very reasonably employ a much more detailed index of leisure activities than the illustrative one used by Nordhaus and Tobin. Each component of a more detailed index would have its own separate price deflator and the weights attached to each component would be chosen to reflect the relative significance, as contemporaries are believed to have seen it, of each component. Here again is an opportunity to use systematically and quantitatively the results of recent research in social history. Such work has added greatly to the knowledge of how the past was actually lived by most people and the revision of the conventional NIPA offers an opportunity to use this new knowledge extensively.

Unfortunately, beneficial technological change is not the only influence on leisure enjoyment which must be assessed. Non-market costs, particularly those associated with congestion and overcrowding as more people tried to take advantage of new leisure facilities, must also be considered. There are a number of ways this task could be approached. For example, cross-section studies could be used which would relate, say, rent charges in various resort areas to the density of vacationers. The steepness of the slope of such a relationship would permit appropriate adjustments for the effect of congestion. The purpose of such adjustments would be more in the nature of ascertaining the relative magnitudes of the considerations involved than of generating precise estimates of what must ultimately be arbitrary magnitudes.

It is of great importance that historians do not expect resolution of the problems raised by the consumption of goods and services whose value cannot be directly calculated—goods such as proto-industrial manufactures and ill-defined but highly desirable services such as leisure—to be achieved quickly. Rather resolution will occur through the slow, controversy-prone process of creating a concensus among historians regarding the significance of the various assumptions made to produce quantitative estimates. Progress will not occur because a correct answer can be found—for there is unlikely to be a unique correct answer—but because the *process* of investiga-

17. Nordhaus and Tobin, *Is Growth Obsolete?*, Table A16, line 16, pp. 52-53.

tion will methodically expose important issues and problems and allow the quantitative significance of different assumptions to be carefully recorded.

II

Concentration on marketed production rather than sustainable consumption encourages the blurring of the critical distinction between intermediate and and final goods. It is well-known that failure to preserve this distinction results in serious double counting. The most obvious example of an intermediate service routinely recorded in the British NIPA as a final output ist the expense incurred by workers commuting to work.[18] As in many other similar situations, this convention has been adopted due to a desire to obtain a precise measurement rather than engage in what amounts to speculation, even if this requires an inappropriate definition of what is to be measured. The problem is that it is difficult to distinguish travel for pleasure, indisputably part of final consumption, from travel required for work. Thus expenditures on final goods and services are overstated by the amount spent on commuting, which is not a consumption item but an intermediate input; factor incomes, which should be calculated net of commuting expenses, are overstated to the extent such expenses are not deducted; and value added by productive enterprises is overstated because the payments for the intermediate inputs of commuters' travel have not been properly deducted. Double counting has taken place in this case just as if both the cost of bread and the cost of the flour that went into the bread were added together to estimate total expenditure. Commuters' expenditures, however, are only the most obvious form of double counting. There are quantitatively much more important sources of this error, the most important of which are connected with government expenditure. Such government services as national defense, police, and public health and sanitation are not reasonably enjoyed for their own sake but because their provision makes possible genuine consumption. It is of critical importance to realize that the decision to disallow such government expenditure as final consumption in no way implies that such expenditures are not useful or important. Indeed, an inadequate provision of them will invariably result in a sharp reduction in properly measured final consumption. At the same time, the consistent classification of such expenditures as intermediate prevents any deterioration of a society's postition which necessitates higher levels of national defense and police spending from being recorded as a condition that improves social welfare. Accordingly, expenditures on intermediate government services should be excluded from national income, factor incomes should be calculated net of the taxes and other payments necessary to finance these services, and calculations of value added must be made net of the value of such services which are properly considered intermediate inputs. It remains an interesting exercise to recalcuate conventional historical NIPA for the major European countries excluding such instrumental and regrettably necessary intermediate expenditure as defense and police services. For example, the levels of regrettably necessary defense expenditures required by the diplomatic and military positions of France and Britain respectively in the years between 1871 and 1914 were sufficiently different to suggest that the differ-

18. Maurice, *Sources and Methods,* pp. 173–76.

ence between the two countries in the level of net output, properly defined, and the level of conventional output, counting defense services in national output as a final good, was sufficiently great that choice of accounting procedure, if applied uniformly in the two countries and making proper allowance for the value of conscripted soldiers' services, would substantially alter perceptions of economic performance.

The existence of important intermediate goods such as national defense and police protection present no difficult conceptual problems. The interpretive decisions are made in determining what is to be designated a final good or service and what intermediate. Very little need be done to the present procedures for collecting statistics for the NIPA. The conventional NIPA can be easily altered to yield estimates of final output, expenditure, and related net factor incomes by re-allocation. However, concern with intermediate goods and services that are properly considered regrettable necessities and instrumental expenditures is closely related to negative externalities and disamenities, the significance of which are much harder to measure, Nordhaus and Tobin, who otherwise are able generally to suggest attractive, operational approaches to national income accounting problems, have no systematic solution to offer for the most fundamental problem that historians must consider in this regard: whether population growth should be seen ultimately as the source of most negative externalities and disamenities or whether population growth genuinely reflects both a society's conscious desire and its physical ability to support more people. Because population-related issues appear so frequently in the conceptually difficult area of negative externalities and disamenities, consideration of this question is fundamental. Wherever decreasing returns to scale exist, or where important resources such as fuels, minerals, and arable land are in inelastic supply, a society's ability simultaneously to support more people *and* to raise real living standards is an impressive economic achievement. Clearly, it costs societies a great deal in terms of forgone consumption to nurture and equip a growing labour force. Using a constant returns to scale Cobb-Douglas production function, which assumes an economy-wide ease of factor substitution rarely encountered in specific industries, and making a variety of assumptions about desired wealth-income ratios for given steady-state rates of population increase, Nordhaus and Tobin estimated that for the relatively moderately growing U.S. population of 1960, a move from an equilibrium population growth rate of 2.14% per year to zero population growth would have raised *per capita* consumption levels by the order of 10%.[19] The assessment of this figure obviously depends upon how off-spring are regarded. The material value of off-spring can be estimated by a variety of means. One of the most promising, for example, would use a sample of linked Census and tax records to calculate age-specific fertility rates across income groups.[20] A finding that wealthier families had on average fewer children and that the fertility patterns of wealthier families were imitated in the rest of society with a lag would lend support to the argument that in such circumstances the observed material cost of child-rearing was greater than the anticipated gain. If the patterns were reversed, with wealthier families for a long period of time having more children

19. Nordhaus and Tobin, *Is Growth Obsolete?*, pp. 18–24.
20. For the possibilities of record linkage in general, see McCloskey, Donald N., *Does the Past Have Useful Economics?* in: Journal of Economic Literature, 14 (1976), pp. 441–448.

than poorer families, the conclusion that children were viewed as income elastic consumption goods would be appropriate. In any case, a careful study of the relationship between income levels and population growth for different countries at different periods would offer a much richer data base from which to assess, as Nordhaus and Tobin have done for the U.S., the material cost of child-rearing. These estimates in turn would allow a calculation of the material gains (or losses) that should be contrasted with the negative externalities and disamenities of population growth.[21]

Although at present there are only the crude estimates of consumption forgone in favour of child-rearing derived from simple growth models, Nordhaus and Tobin do offer an illustration inviting imitation of how the complex question of negative externalities might be handled.[22] They note that there appears to be a systematic variation in earnings across U.S. cities of different sizes, with earnings highest in the largest, most densely populated cities most fully exposed to the costs and disadvantages of congestion, pollution, and other negative externalities and disamenities. They then suggest that two sets of factors might explain this pattern. In the first set are those factors unrelated to negative externalities and disamenities: these are taken to be (1) median years of schooling achieved by the labour force; (2) proportion of the population over 65 and presumed to be retired with low earned incomes; (3) proportion of the population Negro and presumed to suffer from non-environmentally related discrimination; (4) the migration rate where a net inflow is presumed to reflect anticipation of high and rising real incomes and a net outflow the reverse; (5) property taxes *per capita*, included to capture the impact of physical capital which can be expected to cause patterns of observed earned income, especially those of self-employed shopkeepers, merchants, and various other types of local businessmen, to vary; (6) local government expenditures *per capita*, included to capture the benefits of public services. The remaining factors are those related to environmental costs for which an earnings premium would be necessary, other things being equal, in order to induce people to work in a less pleasant environment. This second set of factors includes: (1) population size; (2) population density; and (3) proportion of the population in a metropolitan county living within urban boundaries, a variable dictated by the manner in which the data were available. The logarithm of median family income in a sample of metropolitan counties was regressed against the nine independent variables listed above. The estimated coefficients on the three variables in the second set, presumed to reflect negative externalities and disamenities, were then used to calculate the implicit premiums necessary in order to compensate people for living in a more crowded, dangerous, noisy, dirty urban environment. Nordhaus and Tobin estimated that for the U.S. in 1965 the premium was equal to 8% of average U.S. disposable family income and that this figure would have risen to about 30% had the entire U.S. population been concentrated in the most densely populated cities.

The great value of Nordhaus and Tobin's pioneering work is not so much the specific quantitative estimates obtained, although those estimates are of great interest because they represent the most informed evaluation currently available of the im-

21. Interestingly, Nordhaus and Tobin suggest that population growth in the recent U.S. past has been as rapid as it has been because the social costs of children have not been borne by parents but by society at large. See Nordhaus and Tobin, *Is Growth Obsolete?*, pp. 18–24.
22. Nordhaus and Tobin, *Is Growth Obsolete?*, pp. 48–54.

pact of many important but hard to measure factors, but rather the opportunity it offers to enrich and extend the already elaborate historical collections of national income statistics.

It is very reasonable to expect, on the basis of what has been done so far, that the process of enrichment and extension will give new meaning and significance to historical data that has not been heavily drawn upon for lack of a systematic means of assimilation and assessment.[23] The NIPA, modified to ensure logical consistency and refocussed to measure consumption rather than marketed production, provide a framework capable of processing, categorizing and evaluating data on a much greater scale than has been attempted so far. Furthermore, the national income accounts, in both modified and unmodified form, can be combined with what Mervyn King has described as "social indicators" to assess more broadly and more searchingly trends in welfare.[24] King compiled an index of 17 social indicators scaled such that high values reflected improvement and low values deterioration of welfare. The indicators, chosen for wide coverage across countries rather than for intrinsic importance, included: public expenditure on education as proportion of GNP, students per 100,000 of the population, proportion of total students who were female, doctors per 10,000 persons, infant mortality rate, suicide rate, stomach ulcer death rate, and telephones per 100 persons. King's procedures could be easily extended to cover such indicators as: male and female life expectancy, average length of work week and work

23. A variant of Nordhaus and Tobin's procedure has already been applied to nineteenth century Britain by Jeffrey G. Williamson, *Urban Disamenities, Dark Satanic Mills, and the British Standard of Living Debate,* in: Journal of Economic History, 41 (1981), pp. 75-83. His conclusions are not dissimilar to Nordhaus and Tobin's. Williamson found that the disamenity premium required to induce workers to endure harsh urban environments was no more than 8% of observed urban wage rates. However, in two important aspects of his study, Williamson appears to have biased downwards his estimate of the disamenity premium. First, he included a cost of living index as an independent variable to capture wage rate variations *not* related to environmental disamenities. But, since the object of estimating the disamenity premium was to determine what proportion of higher nominal wage rates went to compensate for the disadvantage of urban life, which would include high site rents as one aspect of congestion, the highly significant coefficient on the cost of living index should have been used in rather than excluded from the estimation of the disamenity premium, particularly since the cost of living variable is picking up influences that would otherwise be captured by the population density and population size variables. Secondly, he assumed that the variable infant mortality would pick up the main impact of urban disamenities. But many other factors, especially overall fertility levels, which in the short term are at best only remotely related to either wage rates or urban disamenities will also effect infant mortality and this remote relationship will be reflected in a small, relatively insignificant coefficient. On the other hand, Williamson did not control, as Nordhaus and Tobin did, for other factors, notably returns to education and skills, differential labour force participation rates, and migration rates, that would cause wage rates to vary, thus making his results incompatible with Nordhaus and Tobin's and hard to interpret.
Williamson's effort does hold out the promise that further, systematic exploitation of historical data will provide more illumination on this issue. To the extent that Williamson's objective was to provoke further research, his paper is certain to be a success.

24. King, Mervyn A., *Economic Growth and Social Development: A Statistical Investigation,* in: The Review of Income and Wealth, 20 (1974), pp. 251-272.

year, occupational accidents, unemployment, divorce rates, strike records, public expenditure on leisure and the arts, and net migration. Such greater coverage would make interpretation easier. For the 17 indicators that he did choose, King found that the movements of his unweighted composite index tended to be positively correlated with conventionally measured economic growth, although the strength of this relationship showed some signs of diminution over time. Such findings, if confirmed more widely in historical studies for a broader range of social indicators would allow researchers to use the conventional NIPA with increased confidence.

Such analysis also suggests a natural and practical way to modify the interpretation of the conventional or modified NIPA when a substantial and persistent divergence in measures does occur. It would thus be possible to isolate those social indicators whose behaviour was particularly badly reflected by the income measures and to identify the causes and to estimate the quantitative consequence of that behaviour.

In this regard, because of the quantitative importance of leisure in Nordhaus and Tobin's study, it is interesting to note the high degree of correlation in late Victorian Britain between the reduction of the length of the average full-employment workweek—a reduction which should be seen as increasing the amount of leisure time potentially available to workers—and the strength of conventionally measured economic growth. Between 1860 and 1914, the length of the average British workweek was reduced by 10%.[25] The reductions occurred in discontinuous bursts concentrated in periods of vigorous conventionally measured growth.[26] The period of greatest reduction, accounting for perhaps two-thirds of the entire reduction in normal working hours achieved between 1860 and 1914 occurred during the intense boom years of 1872–74. On the other hand, virtually no reduction at all occurred when the rate of conventional growth perceptibly declined between the Boer War and the First World War.[27] The most plausible explanation of this pattern is that a reduction in the standard workweek was viewed by employers as a major and essentially irreversible concession to the labour force and hence granted only in exceptional circumstances. In the stable, competitive, environment of the pre-1914 British economy, only during those infrequent times when both workers and employers could anticipate sufficient technological advance to make the bargain feasible were normal hours reduced. Without such expectations employers would, during periods of normal cyclical expansion, "buy off" demand for reduced hours by a combination of higher wages for the normal workweek and an insistence that any reduction in hours be accompanied by a proportional reduction in pay. During periods of cyclical contraction the workers' position was too delicate to withstand the effort to win a major concession. As long as such factors are generally involved in the process of reducing normal working hours, it is reasonable to anticipate that movements in conventionally measured economic growth will generally be found, as they were in Victorian Britain, to be correlated with increases in leisure.

25. Bienefeld, Manfred Alfons, *Working Hours in British Industry: An Economic History*, London 1972, pp. 98, 111, 121, 146.
26. Bienefeld, *Working Hours*, pp. 193–94, 197, 201,
27. Bienefeld, *Working Hours*, pp. 146–48.

III

The problems considered so far have all relied for their resolution, at least implicitly, either upon observed prices directly or upon imputations based on observed prices. The value of leisure, for example, was determined with reference to average income payments for additional work. Where adjustment for enhanced leisure benefit due to advances in transport or consumer durables was nesessary, the degree of adjustment was calculated by deflating a suitable consumer price index. Allowances for urban disamenities were evaluated by the observed earnings premium which had to be paid to induce workers voluntarily to endure harsh urban conditions. The use of social indicators was linked to the degree of correlation between measured income and an index of non-market indicators. Thus one way or another, directly or indirectly, observed market prices have represented an indispensible component of the assessment and evaluation of economic activity.

But there are important circumstances where the historian may feel that observed prices are fundamentally distorted and that any economic measure ultimately based on such prices must be misleading. Fred Hirsch has recently presented a detailed critique of economic growth based on a belief in the fundamental fallibility of observed market prices.[28] Hirsch argues that much of the consumption desired in modern economies is centred on "positional" goods and services whose value is determined by the satisfaction they can provide through relative position alone, from the quality of being in front or from the fact of others being behind.[29] In this view the real value of, for example, a desirable home site or the rewards of a responsible and fulfilling job cannot greatly change. The value of purely positional goods is taken to be almost completely independent of technological change. If consumers can use only so many television sets or so many cars, after which the value of another such good becomes virtually zero, then the limits to growth are clearly and unalterably set.

This argument is tantamount to the claim that if equilibrium prices could only be known, the high and rising relative value attached to those things whose output could not be increased would be clear, as would the low and falling relative value of those things whose output could be increased. Ultimately, in "true equilibrium" value terms, real growth would be impossible as long as substitution in consumption between positional and material (or reproducible) goods was strictly limited. In this situation, the appearance of growth can only be an illusion created by weighting the various categories of output by prices in fundamental disequilibrium. Such a procedure would give current period weights to positional and reproducible goods, ignoring the fact that as reproducible output is increased the relative value of such output would fall while that of positional goods would rise. Current period disequilibrium prices undervalue positional goods and overvalue reproducible goods thereby creating a "mirage" of economic growth, since the price weights attached to positional goods, whose output cannot increase, rise over time whereas the price weights of reproducible goods, whose output can increase, fall over time. The presumed benefits of growth thus continually recede even as strenuous efforts are made to realize them.

28. Hirsch, Fred, *Social Limits to Growth*, London, 1977.
29. Hirsch, *Social Limits*, p. 20.

The implications of this line of argument for the interpretation of the national income accounts is serious, for it implies that the use of the observed prices upon which the accounts are necessarily based are fundamentally incorrect and misleading. Clearly Hirsch has identified a process which accounts at least in part for the inability of even very rapid sustained economic growth to provide the full anticipated benefits. Yet the claim that positional goods are so dominant in aggregate consumption and so immune to substitution by reproducible goods as largely to remove the possibility of real economic growth is an empirical question which must be resolved not by assertion but by extensive historical and international comparisons of economic development. Such research would probe the strangely ahistorical nature of Hirsch's critique. On the one hand, the benefits of economic growth in the past are acknowledged but on the other it is felt that continued benefits of growth cannot be expected in the future. But why should such a situation occur now and not a quarter of a century earlier or later? Comparative historical research would establish the extent to which expenditure on specific positional goods actually has comprised, after allowing for the effects of population growth which amplify the inherent scarcity of positional goods, a stable or rising proposition of total real income, as Hirsch's analysis predicts should occur.

Although it is not possible to anticipate completely the results of research still to be carried out, it would appear Hirsch underestimated the ability of modern technology to create substitutes for positional goods. Since Hirsch often illustrated his argument by reference to the example of a limited number of desirable sites for houses, it is useful to recall how transport improvements, trains in the nineteenth century and cars in the twentieth, by making accessable desirable sites that were previously too remote or inaccessible for extensive use have increased the stock of choice sites, thereby undermining in this instance the very concept of positional goods. Similarly while it remains an open question whether the relative availability of rewarding and fulfilling jobs and occupations has increased as measured growth has occurred, it is clear that modern household appliances, like refrigerators, washing machines and dishwashers, whose production and sale if not use is fully recorded in the conventional NIPA, have renoved a substantial amount of the drudgery that blighted and limited the lives of most people in the past. Furthermore, it would appear that the greater variety of consumption goods that has become available over time has acted to diffuse both the pleasure of possessing highly esteemed positional goods and the dissatisfaction of not doing so. After all, as R. C. O. Matthews noted in his generally appreciative review of Hirsch's book, in an economy where no growth takes place, all goods are positional and the possibilities for substitution among consumption goods is much more harshly limited than is true in an expanding economy.[30] Finally, it should be noted that health care and education, two services whose provision has moved in close parallel with movements in the conventional income accounts and are thus manifestly not positional goods, have come to account for a larger share of output in most countries over time.[31] Ultimately Hirsch's argument serves to stress the

30. Matthews, R. C. O., *Review of 'Social Limits to Growth'*, in: The Economic Journal, 87 (1977), p. 576.

31. Some care must be taken when measuring these services to avoid double counting. Thus education that is solely for occupational and professional advancement should be consid-

importance of careful construction of indices of economic activity, supported by close observation of consumption patterns over time, a task in which Simon Kuznets' pioneering work should offer a most useful base for further research.[32] If anything, Hirsch's reservations concerning the desirability or even the possibility of economic growth provides further rationale for a revision of the conventional NIPA along the consumption-oriented lines proposed by Nordhaus and Tobin.

There is, however, a dynamic variant of Hirsch's argument which increases even further the importance of comparative, historical research. The variant was first given explicit expression by E. J. Mishan and subsequently was formalized by Stephen Glaister.[33] The phenomenon that Mishan and Glaister were concerned with was the potentially unstable nature of desirable economic equilibria and the subsequent likelihood that normal competitive behaviour would lead to the abandonment of desirable equilibria in favour of substantially less desirable equilibria which would then be very difficult to change. Indeed, in the final, undesirable, equilibrium position, the structure of prices would create a very strong disincentive for any change. The argument is most easily grasped in the form of an example, but it is readily seen that generalizations can easily be made. Consider a transport system where no private vehicles exist and only public trams and buses are available. Now suppose that one person suddenly realizes that with a private car be could reduce his travel time to work by half, so long as his were the only private car on the road. If, however, many others shortly afterwards make the same discovery independently and attempt the same action, without reckoning on the congestion costs, the anticipated benefits will prove illusory for all. The congestion caused by only one car will be negligible, but the effect of many people simultaneously switching to private cars, even if each is correct in realizing that the impact of his own action alone is trivial, is not at all negligible. The trouble is clearly that travellers are making decisions on information that will begin to change and be incorrect as soon as the decisions are made, yet no individual traveller can by himself know what the final outcome, and hence what the correct information for a rational decision, will be. In the example, eventually a new equilibrium is reached where many people use private cars, many fewer than previously use public transport, and travel time for all is increased. The previous equilibrium, where no private transport existed, is actually superior to the one that eventually emerges from the introduction of private transport because of the unregulated increase in congestion. But for the same reasons which created the problem in the first place, the original equilibrium is very difficult to regain. The benefit perceived by any one individual in taking public transport rather than his own car is negligible but if many could be persuaded to take public transport, all would gain, those continuing to use their

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earned incomes of those who received the education and should not, therefore, be counted separately. The educational expenditure that should be recorded as final output must be limited to that which enhances leisure and living in general. Similarly, expenditures on health and medicine necessitated by environmental deterioration and occupational hazards must be excluded.

32. Kuznets, Simon, *Modern Economic Growth: Rate, Structure and Spread,* New Haven/Conn. 1966, pp. 262–284.

33. Mishan, E. J., *The Costs of Economic Growth,* Harmondsworth/Middlesex/England 1969, pp. 232–240, and Glaister, Stephen, *Transport Pricing Policies and Efficient Urban Growth,* in: Journal of Public Economics, 5 (1976), pp. 103–117.

own cars gaining most. Hence everyone hopes that everyone else will take public transport, but no one does and the situation never improves. These obvious difficulties are greatly compounded if public transport is competitively eliminated as travellers switch to private cars. The greater is the proportion of fixed to total costs of public transport, the more dependent it is on intensive utilization and hence the more vulnerable its revenue to any decline in traffic. The elimination of public transport, by removing any choice in transport mode, clearly is the worst outcome, yet one which may be difficult to prevent without the imposition by a central authority of a set of "shadow" transport prices which take account of the costs of congestion and the importance of choice. The calculation of efficient shadow prices is not simple. The planning authority must correctly price a veriety of transport systems whose operations it cannot directly observe but must deduce from knowledge of both the technical characteristics of transport equipment and the preferences of travellers and shippers.[34]

In the Mishan-Glaister example, only with correct equilibrium shadow prices could the benefits of current consumption be evaluated and plans for future investment rationally made. Yet the congestion externalities that caused such price calculations to be so difficult to make are likely to be a pervasive feature of modern economic life and to intensify as development proceeds, for they are, as in the Mishan-Glaister example, created as a by-product of the same process of technological change that is the source of economic growth in the first place. But if prices are systematically distorted in the way suggested, the national income accounts will not just measure the wrong thing; movements in the NIPA may even be perverse in relation to the real underlying economy. In the example above, when private transport was introduced, measured expenditure on private transport rose, measured expenditure on public transport fell, and the benefits of private vehicle ownership increased. But the increased benefits of private vehicle ownership were due to the deterioration of public transport and it can be shown that the net change in total social welfare may easily be negative even when observed total expenditure has risen, because more consumer's surplus is being extracted by the provision of transport services than was true previously. In such a situation, the same observed prices that lead to suboptimal resource allocations will yield incorrect and inappropriate national account estimates.

As the Mishan-Glaister example suggests, and Levin's study of railroad deregulation confirms, the analytical derivation of even a few of the prices needed for rationaldecision-making and accurate NIPA is a difficult undertaking. For the foreseeable future it will not be realistic to anticipate plausible calculations of equilibrium prices.[35] Thus the only reliable means of assessing the market prices the historian ob-

34. See Levin, Richard C., *Railroad Rates, Profitability, and Welfare Under Deregulation,* in: Bell Journal of Economics, 12 (1981), pp. 1-26, for a discussion of the complex considerations involved in such analysis.

35. A recent paper by James, John A., *The Welfare Effects of the Antebellum Tariff: A General Equilibrium Analysis,* in: Exploration in Economic History, 15 (1978), pp. 231-256, has demonstrated that equilibrium price vectors of interest to historians can in principle be calculated. It is likely that such work will become more common in the near future, offering historians a very powerful new analytical tool.

serves require extensive international, historical comparisons. While it is, of course, always possible that all countries will make the same mistakes and move towards the same inferior equilibrium, it is not likely. Thus examples of unusually successful organization or of notably sustained advance may be effectively used to investigate the nature of feasible equilibria. While this procedure may fail to capture the best possible outcome available to an economy at any point in time, it is unlikely that a large number of societies with different economic, political and technological arrangements and capabilities will all miss the best solution equally badly. The results of such comparisons may de difficult to interpret, but, since cross-country historical comparisons are as close as the economic observer can get to a controlled experiment, there is very little choice but to use them.

If the analysis of economic performance inevitably requires extensive international comparisons, more attention must be devoted to the notoriously difficult task of improving the statistical basis for such comparisons. While no comprehensive solution exists, two recent proposals promise marked improvement. These proposals will also aid in the comparison of a given economy's performance at different points in its own history.

The first proposal advocates facing directly the problem that price structures are determined jointly by the distribution of wealth and productive capacity. When comparing the efficiency of two economies, performance is to be measured by reference to how well the needs of specific groups common to both are met. Such an approach has been used by A. K. Sen to compare inter-state disparities of welfare standards in India.[36] Sen explicitly gave higher consumption weights to the relatively poor so that his comparison of performance was particularly sensitive to the consumption experience of his bench mark social group. Such a procedure has the great benefit of making the welfare basis of comparisons explicit. Of course the assessment of performance may vary with the benchmark consumer group chosen, but even this factor is beneficial, for historians have often realized that common developments have differential impacts and the use of several benchmark groups, to the extent that experiences are sharply different, serves to indicate quantitatively the variety of experience the historian wants to examine. Furthermore, because the approach using benchmark groups relies on knowledge of expenditure patterns, knowledge which is largely independent of the conventional accounts, it offers a valuable supplementary cross-check to those accounts. Also it can readily be combined with the second recent proposal to aid international comparisons.

The second proposal has used detailed calculations of purchasing power parities between countries in order to obtain a more "realistic" set of exchange rates.[37] Such adjustment is necessary because tariffs, quotas, and other forms of administrative intervention—such as central bank operations—distort exchange rates from the levels that would rule if only pure demand and supply factors were operating. Furthermore, even if exchange rates were in fundamental real equilibrium, countries with different productive structures or consumption patterns may have sufficiently different ratios

36. Sen, Amartya K., *Real National Income,* in: Review of Economic Studies, 43 (1976), pp. 19–39.

37. David, Paul A., *Just How Misleading Are Official Exchange Rate Conversions?* in: The Economic Journal, 82 (1972), pp. 979–90.

of tradeable and non-tradeable production that cross-country comparisons based on exchange rates alone may be misleading or unnecessarily incomplete. The procedure proposed by Paul David to adjust market exchange rates uses the relative price weights that obtain in the benchmark country—in his case, the U.S. on the grounds that by common consent for the period he was considering (1950–1965) the U.S. was internationally the most advanced economy, with its structure increasingly approximated by the rest of the world—to value output and consumption in other countries. The levels of output in all countries are then compared using the benchmark country's prices and the relative rankings of countries obtained on this basis are compared with the relative rankings obtained by valuing national outputs at market exchange rates. Specifically, the following equation was estimated:

$$\left\{\frac{Y_o}{Y_i}\right\} = \underset{(0.063)}{0.671} + \underset{(0.022)}{0.408}\left\{\frac{Y_o}{\hat{Y}_i}\right\}$$

where Y_o = *per capita* output in the benchmark country valued at the benchmark country's relative prices.

Y_i = *per capita* output in the ith country valued at the benchmark country's relative prices.

$\hat{Y}_i$ = *per capita* output in the ith country valued in the benchmark country's currency using the market exchange rate rather than the benchmark country's relative prices.

The numbers in brackets under the estimated coefficients are standard errors. The equation may be interpreted to show that on average the difference in *per capita* incomes in purchasing power parity terms[38] between a given country and the U.S. was only 40.8% of the percentage gap indicated by a straight exchange rate conversion expressing all incomes in dollars. The explanation for this sharp reduction in income differentials using purchasing power parity price weights and market exchange rates is that the higher manufacturing productivity in the U.S. also raised the opportunity cost of providing labour intensive services which accounted for a substantial proportion of total consumption not only in the U.S. but also in all the other countries in the comparison. When the U.S. price weighting, with its relatively high cost of services and low cost of manufactures was used to value output in various developed countries, those countries gained more in the revaluation of their comparatively abundant services than they lost in the revaluation of their comparatively sparse manufacturing output.

David's procedure goes an important way towards adjusting exchange rate data to permit its use in a much more meaningful way than was previously possible. The full potential in this procedure is gained when different countries are used as bench-

38. A classic index number problem prevents a true estimation of purchasing power parity. That would require knowledge of what the citizens of one country would have bought had they faced with their incomes the price structure of another country. What purchasing power parity means here is a measurement of the bundles of output in two different countries by the same price structure. It is clear that even this restricted purchasing power parity concept allows a significant improvement on official exchange rate estimates of *per capita* income differences.

marks in repeated calculations. Comparisons of the rankings obtained for a variety of benchmark countries will offer a systematic means of identifying and assessing important differences in the consumption and production structures of different countries at different points in time. Furthermore, David's procedure can readily be combined with Sen's so that the purchasing power parity calculations are based on explicit welfare orderings rather than observed price structures which impose a welfare basis founded on the existing distribution of wealth.[39]

As may readily be seen, these various procedures cannot be vested with an aura of infallibility and precision. In their way, they are as arbitrary as the conventional accounting procedures they are intended to supplement and replace. Their great virtue, however, is that used in combinations they each illuminate in a different way a particular aspect of a nation's (or a region's) historical experience. They allow most of the subjective and judgemental differences that divide historians to be systematically exposed and quantified. They permit sensitivity tests to determine which assumptions are crucial to conclusions and which affect conclusions very little. They use in a structured way vast amounts of historical data that simply cannot be assimilated without an explicit analytical framework. The results of these efforts may never command universal agreement, but the issues in dispute among historians will become systematically clearer because of them. And that surely can only be considered progress.

Zusammenfassung: Probleme der volkswirtschaftlichen Gesamtrechnung und ihrer Interpretation bei der Bewertung langfristiger wirtschaftlicher Leistungen

Hier wird davon ausgegangen, daß es bei der Messung ökonomischer Aktivitäten im wesentlichen zwei Arten von Problemen gibt. Die erste besteht aus solchen Fragen, die zumindest prinzipiell dadurch lösbar sind, daß man beobachtete oder abgeleitete Marktpreise verwendet. Der zweite Problemtyp besteht aus Fragen, die nur über die Verwendung geschätzter (oder „synthetischer") Preise gelöst werden können, weil die beobachteten Preise aus vielerlei Gründen fehlerhaft sind. So könnte z. B. ein fundamentales Marktungleichgewicht vorliegen oder eine nichttolerierbare Abhängigkeit von einer besonderen - möglicherweise willkürlichen - Vermögensverteilung. Oder es könnten Verzerrungen durch Schwankungen der relativen Preise oder auch durch eine allgemeine Inflation oder eine Deflation hervorgerufen worden sein. Derartige Verzerrungen können auch von Zöllen, von festgesetzten Handels- oder Produktionsquoten und unterschiedlichen anderen administrativen Eingriffen in den Markt verursacht werden. Beide Problemtypen werden diskutiert und mit neueren Lösungsversuchen dargestellt. Am Schluß der Arbeit finden sich einige Vorschläge zur weiteren Forschung.

39. Incomes are converted into wealth equivalents by using the present discounted value of future income streams.

Fragen, die zum ersten Problemtyp zählen, sind nach zwei übergeordneten Gruppen klassifiziert. Die erste kleinere Gruppe befaßt sich mit logischen Widersprüchen in der herkömmlichen volkswirtschaftlichen Gesamtrechnung, die bisher deshalb hingenommen wurden, weil die verfügbaren Daten so leichter zu erfassen waren. Die zweite weitaus größere und wichtigere Gruppe befaßt sich mit Problemen, die aus der theoretisch unangemessenen Zielvorstellung über die zu messende Größe erwachsen. Eigentlich sollte der Endverbrauch erfaßt werden, doch bezieht sich die herkömmliche volkswirtschaftliche Gesamtrechnung im allgemeinen auf die vermarktete Produktion. Die Diskussion der veränderten Meßmethoden, die bei einer Abänderung der Zielgröße für die volkswirtschaftliche Gesamtrechnung erforderlich wären, schließt die Darstellung der Pionierarbeit von Nordhaus und Tobin ein. In diesem Abschnitt werden Punkte abgehandelt wie die Berwertung von nicht-vermarkteter Haushaltsarbeit oder von Freizeit sowie Kosten und Nutzen des Bevölkerungswachstums. Am Schluß wird die Möglichkeit erörtert, den Bereich der bisherigen volkswirtschaftlichen Gesamtrechnung durch die Einbeziehung sozialer Indikatoren zu erweitern.

Fragen, die zum zweiten umfassenden Problemtyp zählen, werden in Anlehnung an das kürzlich erschienene Werk von Hirsch, Mishan und Glaister erörtert und mit den Lösungsvorschlägen von Sen und David vorgestellt.

Nun können Historiker keine eindeutigen definitiven Antworten auf die Mehrzahl der Probleme in der volkswirtschaftlichen Gesamtrechnung, wie sie in diesem Artikel angesprochen wurden, erwarten. Die Vorschläge, die hier zu verschiedenartigen Revisionen und Modifikationen der herkömmlichen volkswirtschaftlichen Gesamtrechnung gemacht wurden, sollen vielmehr dazu dienen, daß die subjektiven Meinungsunterschiede (die Historiker voneinander trennen) in systematischer Weise offen dargelegt und quantifiziert werden. Damit ließen sich fundamentale Fragen und Probleme viel klarer umreißen, wenn nicht endgültig lösen.

Patrick K. O'Brien

The Analysis and Measurement of the Service Economy in European Economic History

*1. Introduction**

The economic history of Western Europe in the 19th century witnessed population change of around 0.82% a year, a growth rate in the region's product of 1.74%, and real per capita income increased at just under 1% per annum.[1] This growth was accompanied by structural change which refers to the fact that the rise in the volume of output was accompanied by the reallocation of the work force in a clearly defined way (see table 1) as well as the familiar change in the composition of national outputs.[2]

Table 1: The allocation of Labour in Europe, 1800-1900

Year	Agriculture	Industry	Services
1800 (a)	73%	16%	11%
1860 (a)	57%	26%	17%
1900 (a)	50%	29%	21%
1900 (b)	34%	36%	30%

Notes: (a) excludes Russia;
(b) Western Europe only.

Sources: Bairoch, Paul, Commerce exterieur et developpement economique, (1976), p.26, and Bairoch, Paul and Limbor, J. M., Evolution of the Working Population in the World by Sector and Region, in: International Labor Review (October 1968), p.330.

* My ideas on the development of services in the 19th century were clarified by reading: Fuchs, V. *The Service Economy,* New York 1968; Singleman, J., *From Agriculture to Services,* London 1978, and Gershuny, J., *After Industrial Society,* London 1978. All three books are, however, focused on the 20th century.

1. Bairoch, Paul, *Commerce exterieur et developpement économique,* Paris 1976, pp. 148-53.
2. Kuznets, S., *Economic Growth of Nations,* Cambridge/Mass. 1971, chs. 4 and 6.

This paper has been designed to stimulate discussion on the meaning and measurement of output from services during the first phase of modern economic growth (1800–1914). That design was in turn prompted by two suggestions: (a) that employment in services and output originating from the service sector are not well defined in the literature on structural change, and, (b) that the contribution of services to levels of income and productivity observed across Western Europe could produce a misleading impression of levels of development attained by different national economies before 1914.[3]

2. *Taxonomy: Intermediate and Final Output*

The service sector includes such a heterogeneous collection of economic activities that it is difficult to see why it survives as an analytical category in economic history. Nevertheless services do possess one obvious feature which distinguishes them from the products of agricultural, extractive and manufacturing industry. Services are *not* physical commodities which can be touched, weighed, measured or stored. Only physiocrats and Marxists would deny that services (as well as commodities) provide consumers with utilities and should, therefore, be counted and included in estimates of national output. For that purpose a service could be defined as something which satisfies demand, which adheres not to goods but to producers of a service and which disappear at the moment of production.

When historians try to measure the place of services in national economy they normally fall back upon the data and standard classifications used by censuses of population and production to distinguish emplyment and output "originating in" particular industries. In such documents certain industries (see the list under table 2 above) are deemed to produce services and others agricultural or industrial output. But censuses do not demarcate service *occupations* from those connected directly to the transformation of inputs into commodities. Yet historians are certainly aware that (for example) the German chemical industry employed doctors, that French steel firms had lawyers on the payroll and that factories employed servants in their canteens. Jobs and outputs emanating from these "service occupations" are, however, classified in studies of structural change as industrial jobs which generated industrial outputs.

Service occupations were not confined to service industries.[4] As the division of labour extended over the 19th century the share of the work force undertaking service tasks within the productive system went up. In occupational terms there was surely a long term reallocation of labour away from cultivators, operatives, miners and artisans towards "service" jobs. That trend accompanied mechanization in industry and agriculture. Slowly but steadily the majority of workers moved away from direct involvement with cultivation and with the transformation of raw materials into finished industrial output. Our statistics on structural change grossly undereport the share of the work force whose jobs should be called services.

3. O'Brien, Patrick, and Keyder, Caglar, *Economic Growth in Britain and France*, London 1978, pp. 28–32.
4. Bauer, P., and Yamey, B., *Economic Progress and Occupational Distribution*, in: Economic Journal, 61 (1951).

My final taxonomical point concerns output which emanates from workers employed in the service sector. Historians appreciate the distinction between final and intermediate output. But once services are also viewed functionally it becomes clear that perhaps a majority of workers classified by censuses as employed in services did not produce services as final output. They were not, on inspection, doctors, lawyers, teachers, policemen, entertainers, domestics, etc.; from whose services consumers derived direct and defineable utilities. Rather they sold their labour time to producers of commodities to facilitate the transformation of inputs into goods or they assisted producers to distribute commodity output to consumers. A high but unmeasurable proportion of the output of the service sector was "intermediate" in the sense that it was closely linked to and dependant upon the production of primary and industrial commodities.

Unfortunately neither population nor production censuses assist historians who wish to divide the labour force engaged in the service sector between workers supplying final output on the one hand and workers instrumental in transforming raw materials into commodities and engaged in the distribution of those goods to consumers on the other. They are stuck with categories found useful by officials concerned to count and classify populations and to measure production in the 19th century. Detailed research on the original returns needs to be undertaken before anything firm can be said about the proportion of the work force employed in the service sector whose jobs simply complemented the production and distribution of commodities.

Meanwhile, and at this "premature" stage of the argument, I made some arbitrary assumptions in order to manufacture rough orders of magnitude. Taking population censuses for Britain, France, Belgium and Germany for selected years, just before 1914,[5] I reclassified the work force employed in services by assuming:

(a) everybody classified as employed in banks, insurance and finance, plus 50% of those listed under professional occupations of all kinds were deemed to be indirectly engaged in the production of industrial and primary commodities;
(b) labour included in the censuses as employed in transport, commerce and wholesale and retail trade supplied services complementary to commodity production;
(c) half of all "non-military" employees in Government service assisted indirectly in the operation, expansion and protection of agricultural and industrial production;
(d) all other personnel (classified by the censuses as employed in services and including: the armed forces, domestic and personal services, 50% of the professions and 50% of Government employees) supplied their services as final output to consumers.

This crude manipulation of the primary sources suggests that very high proportions of those classified by 19th century population censuses (and by historians of structural change) as employed in services could be redefined (on a respecification of their functions in the economic system) as engaged in the production of industrial and agricultural goods. The proportions my arbitrary assumptions generated were: for Great Britain 48%, Belgium 55%, for France 63% and Germany 64%.

5. The data are tabulated in Bairoch, Paul, et al., *La Population active et sa structure*, vol. 1 de Statistiques internationales retrospectives, Brussels 1968.

But whatever definitions are adapted to rework the available data on the deployment of the work force the basic point that the majority of men and women (conventionally classified as employed in services) worked to facilitate the production and distribution of commodities will stand. Furthermore rates of growth of employment in different branches of the service sector reveal that work forces engaged in activities connected with industry and agriculture (particularly transport, finance and distribution) increased more rapidly than work forces employed in sub sectors supplying services for final consumption. Over the 19th century services grew as some function of commodity output and the long run development of Western Europe witnessed a substitution of commodities for services in final consumption. The economies of early modern Europe consumed higher proportions of services partly because of low productivity and relatively high prices in commodity production and partly because of an abundant supply of labour in relation to the demand for workers from agriculture and industry. Modern economic growth gave people their opportunity to consume more goods and the labour force was (despite the misleading impression derived from census classifications) reallocated towards the production of commodities.

3. The Service Sector and Economic Development

But this hypothesis seems to receive little support from the literature on structural change which is not inclined to "associate" the long term (1800–1914) rise in per cap-

Table 2: Share of the Labour Force Employed in Services: 1840's to 1900's

Country	1900–10	1880–90	1860–70	1850–60	1840–50
Netherlands	39%	36%	34%	31%	
Great Britain	38%	35%	30%	28%	30%
Norway	34%	28%	25%		
Denmark	33%	22%	22%	22%	
Belgium	31%	24%	18%	16%	13%
Switzerland	28%	16%			
France	28%	27%	22%	21%	22%
Spain	24%	16%	16%		
Sweden	27%	24%	19%		
Germany	22%	16%			
Italy	18%	19%	16%		
Austria	18%	21%			

Services include: transport, storage, communication, public administration, armed services, professional and business services, entertainment, recreation and personal services. The ratios relate to a particular year during the decade specified.

Sources: Bairoch, Paul, et al. La Population active et sa structure (1968) and Kuznets, S. The Economic Growth of Nations (1971) and Modern Economic Growth (1966).

ita income with a reallocation of the work force towards commodity production (see table 2) or with any decline in the share of national output emanating from services.[6]

Except for Britain variations over the long run in the share of the service sector in GDP have not, however, been measured in current or constant prices. For Norway the share (in current prices) went up by 5% points between 1865 and 1910.[7] Arthur Young estimated that 31% of Britain«s national income for 1770 originated from services. By 1911 that share had risen to 55%.[8] For the United States the proportion moved from 21% in 1839 to 33% six decades later.[9] Furthermore such evidence as exists from the household budget surveys for the 19th century (conducted by Engel, Eden, Le Play and other investigators) suggests some positive correlation between household incomes and the share of household expenditure on services.[10] Finally cross sectional data from national accounts for the contemporary period also reveals a positive correlation between levels of per capita income and the share of national income from services.[11]

But historical trends cannot be inferred from cross country data for our own times, particularly as the correlation coefficient between levels of per capita income and the share of services in GDP (measured in current prices) for eight European countries for the period 1900–10 turned out to be extremely weak.[12] Evidence from household budgets is, moreover, inconclusive because although there is (as one would expect) some tendency for households with higher incomes to spend a higher percentage of their incomes on services, that tendency is not systematic across the income range. Nor is it inconsistent with a possible (indeed plausible) distribution of the data in which European households spent *lower* proportions of their incomes on final services in, say, 1910, than they did a century earlier. The correlation may persist but the mean proportion of total household income allocated to final services could in theory decline. At present the growth of output from final services has not been measured. To estimate it historians are required to measure the value (in constant prices)

6. Hartwell, R. Max, *The Service Revolution,* in: Cipolla, C. (ed.), The Fontana Economic History of Europe, vol. 3, London 1973.
7. Kuznets, S., *Modern Economic Growth,* New Haven 1966, chs. 3 and 8, and Katouzian, M. A., *The Development of the Service Sector: A New Approach,* in: Oxford Economic Papers, 22 (1970).
   Kuznets, *Modern Economic Growth,* p. 89.
8. Deane, P., and Cole, W. A., *British Economic Growth, 1688–1959,* Cambridge 1962, pp. 156 and 166.
9. Gallman, R. E., and Weiss, T., *The Service Industries in the 19th Century,* in: Fuchs, V. (ed.), Production and Productivity in the Service Industries, New York 1969, p. 291.
10. Fishlow, A., *Comparative Consumption Patterns, etc.* in: Ayel, E. (ed.), Micro Aspects of Development, London 1973, and Minchinton, W., *Patterns of Demand, 1750–1914* in: Cipolla, C. (ed.), Fontana Economic History of Europe, vol. 3, London 1973.
11. Kuznets, *Economic Growth of Nations,* ch. 3.
12. I correlated the share of services to GDP (measured in current prices to levels of per capita income measured in dollars for 1913. The per capita income estimates are from Bairoch, Paul, *Europe's Gross National Product, 1800–1975,* in: Journal of European Economic History, (Fall, 1976). The ratio of services to GDP was calculated from data in Kuznet's *Economic Growth of Nations,* ch. IV and Kuznets, *Modern Economic Growth,* ch. 3. The correlation coefficient for a sample of 8 observations was $r = 0.4$.

of output originating from the sale of services to consumers for base and final years. Both the output and inputs required to produce services should then be double deflated by indices which reflect movements in the prices of final output and the costs of capital and raw materials embodied in that output. Ifsuch estimates (in constant prices) could be manufactured they could then be compared with rates of growth of GDP in order to ascertain how the ratio of services to national output actually changed over the 19th century. Meanwhile, it cannot be taken as axiomatic that countries with larger shares of their work forces engaged in services and with bigger proportions of their national incomes originating from the service sector were more "developed" than their neighbours in Western Europe.

4. Services and Per Capita Incomes

In the last decade social accountants have moved forward in their attempts to devise proxies for the "outputs" provided by banks, shops, insurance companies, hospitals, public administration and other branches of the service sector.[13] Unfortunately, the data at their disposal is rarely available to historians labouring to compile exceedingly rough figures for the 19th century and who are reluctantly compelled to measure service output as equal to the sum of factor incomes (employment times remuneration) earned by those classified by population censuses as employed in services. While such compromises are inevitable, they systematically bias the measured per capita incomes of countries with relatively large service sectors in an upward direction and thus lead to inflated notions of differences in levels of real per capita consumption attained by Western European economies during the 19th century. The force of this contention should become apparent as we now move on to consider: first forces behind the variations in the recorded levels of employment in services and secondly the factors which helped to determine the remuneration of those engaged in the service sectors of various European economies.

I have already argued that increases in the demand for labour to supply services was derived in large part from the growth of commodity output. But changes in the level or service sector employment connected with the production and distribution of agricultural and industrial output was not a simple function of the growth of those sectors. Among other things it also derived from the organization of industry and agriculture, the division of labour and the location of production. Figures in population censuses which record the numbers of people employed in services reflect levels of commercialization, urbanization and specialization attained by economies in the process of development. For example, the relationship between the share of commodity output marketed either inside or outside a country and the numbers of merchants, shopkeepers, carters, carriers, etc. will be obvious. But the level of employment in distribution also depended on the kind of services required and the preferences of consumers. Societies like Britain with a high import component in their consumption and which offered distribution services all hours of the day and night needed a larger work force to meet such demands.

13. Fuchs, (ed.), *Production and Productivity in Service Industries* and Moss, M., (ed.), *The Measurement of Economic and Social Performance*, New York 1973.

The association between the growth of towns and employment in services is also not difficult to discern. Between 1860–80 about 55% of the urban work force in the United States were employed in services and something like 60% of the additional jobs created in services between 1840–1910 could be explained by the reallocation of population between rural and urban areas.[14] Again the mechanisms are not difficult to describe. As manufacturing activity located in towns so did services complementary to industrial production. Geographically concentrated populations also required more transport, distribution, environmental and other urban services.

In essence the growth of employment in services is yet another manifestation of Adam Smith's division of labour. That process proceeded not merely within the framework of an enterprise but as agricultural and industrial production grew this created possibilities for the development of firms specialized on sales, transport, finance, insurance, maintenance and other functions connected with the transformation and distribution of commodities. Classical style entrepreneurs who in the early stages of industrialization supervised nearly everything gradually evolved into formal organizations—firms, whose controllers found it efficient to "contract out" tasks tangential to their central objectives in order to realize economies of scale (e.g. the shift from private to public transport systems); and to reap advantages from purchasing specialized knowledge (e.g. from bankers merchants and insurance agents) and to eliminate the need to maintain underemployed employees for intermittent tasks such as repairs and maintenance.

Any explanation for the growth of employment in services solely in terms of demand would be seriously incomplete. For agriculture and for urban services, to some extent the supply of labour available created its own jobs. Urban history has reminded us that before 1914 services remained as an area of residual employment for thousands upon thousands of workers who could not obtain regular and better paid jobs in factories or farms. The sector almost certainly employed higher proportions of child, female and part time labour than was typical of industry or even agriculture. Apart from public transport, ratios of capital to labour for most branches of the services sector were low and flexible. Entry into service jobs through family firms or self employment (isolé) was relatively easy except for professional occupations which required real skills or at least paper qualifications. Thus the skill structure of the work force engaged in services was skewed towards the professional salariat at one end of the scale and a poorly educated and unskilled labour force engaged in transport, retail trade and domestic service at the other. Throughout Europe the service economy of the 19th centurn towns supported large numbers of underemployed workers who had somehow fitted themselves into an economic system which expanded too slowly in relation to the pace of population growth and internal migration to provide somewhat less than half of urban workers with jobs in manufacturing industry.

Turning to wages and salaries received by those employed in services over the 19th century, three observations seem valid. Firstly, long run trends in remuneration depended upon demands for labour in agriculture and industry and the growth of labour productivity in the service sector. Since the potential in most branches of that sector for both technical progress and more capital intensive methods of production

14. Weiss, T., *Urbanization and the Growth of the Service Workforce*, in: Explorations in Economic History (1974), pp. 242–58.

was limited, increasing the productivity of labour depended upon improving the quality of the work force and extending the division of labour in order to realize economies of scale and specialization. Apart from transport, productivity of labour in the service sector increased at rates below those achieved in industry and agriculture.

Secondly, population growth and high rates of internal migration to towns restrained the rise in the wage rates of unskilled service workers which then rose in large measure as a response to the growth of commodity output. But supplies of skilled and professional manpower available to the service sector were far less elastic basically because capital markets to support private investment in vocational training were almost non-existent and Government expenditures on education were negligible before 1914. Both private and public investment required to meet the growing demand for skilled, professional and managerial workers to fill higher level occupations in services was surely sub-optimal. In such conditions the salaries of skilled labour went up rapidly but (with the possible exception of engineers) there can be no assumption that the quality of the services offered improved in line with the additional remuneration commanded over time. It is far more likely that costs per unit of labour time rose without any significant improvements in productivity.

Thirdly domestic labour markets for recruitment to the professions to commerce and to public services exhibit few of the conditions prescribed for the operation of efficient and competitive markets for labour. This group of workers presumably enjoyed rents—that is by institutional and legal restrictions they managed to command wages and salaries above their social opportunity costs.

Now the threads of their argument can be drawn together. Europe's national accounts for the 19th century have inevitably measured net value added generated by the service sector as equivalent to estimates of factor incomes received by those employed in services. That procedure imparts an upward bias to measured national incomes of economies with larger shares of their work forces classified by population censuses as employed in services. Over the 19th century most of the growth of service occupations (regardless of whether these jobs remained institutionally or legally within the industrial or agricultural sectors or formed part of a sector of an economy demarcated by historians of structural change as services) can be attributed to the growth of commodity output. For some economies (Britain, Belgium and Holland come to mind) their levels of commercialization, urbanization and their organization of agriculture and industry promoted a division of labour which lead to a more rapid emergence of a service sector which historians and social accountants readily demarcated from industry and agriculture. What is being claimed here is that differences across countries in the numbers classified as employed in services is not simply a manifestation of variations in the level of final output from services but also reflects the manifold ways in which the countries and regions of Europe organized their systems of production, located economic activity and carried on social life. The numbers in services also reflect the pressure which population growth exerted on rates of migration to towns. Urbanized commercial societies spawned larger service sectors not necessarily correlated with higher levels of final output and consumption. While services performed to produce and distribute agricultural and industrial commodities within the confines of rural and less commercialized societies are unlikely to be recorded in ways that can be estimated by accountants of national income. Once a cen-

sus has classified a worker as employed in distribution transport or some other branch of services his contribution to output is unlikely to remain unrecorded by historians. But the unspecialized and multifarious part time services performed in less commercialized economic systems are easily missed—and are always difficult to measure; particularly when national accounts can only be built up from the product side. Finally two basic assumptions almost invariably deployed to estimate service output are extremely dubious. First, I refer to the assumption that the work force in services was fully employed—surely a misapplied notion for a large percentage of unskilled labour employed in that sector. Secondly our historical accounts are again compelled to assume that the wage rates or salary and other figures we possess on the remuneration of workers employed in services reflect the social opportunity cost of labour. That premise is valid only for competitive labour markets. And few historians would be prepared to claim that the salaries of professional and skilled grades in services were determined by conditions which produced anything other than a tangential relationship between pay and the social value of the services produced.

5. Services and Economic Welfare

One of the main tasks of economic history is to measure changes in the welfare of populations over time and to compare levels of welfare across countries. To assist with that objective European historians have put together sets of national accounts which embody compromises between what is theoretically ideal and the data at their disposal. Although there are serious problems involved in the estimation of commodity output this paper has discussed the biases and ambiguities contained in the available estimates of service output. In brief, I have tried to argue that the available estimates of service output reflects the growth of commodity output and that urban commercialized economies generate higher levels of measured service output than less urbanized rural based economies. Part of service product (as estimated) reflects a real contribution to both international and to historical differences in consumer welfare. But some unmeasurable but perhaps significant share of the extra service output included in the national accounts of more urbanized economies reflects little more than differences in the location and organization of economic activity. Social accounts are simply recording the 19th century shift from household to market economies but they generate indices where that shift emerges (or is interpreted as) "extra" output.

But long before 1800 households allocated labour time to education, to the care of the sick, to entertainment, to protection, to repairs and maintenance and to the transport and distribution of agricultural and industrial goods they produced. Unfortunately, it is impossible to estimate much more than the value of the commodities produced and sold in early modern Europe. The national accounts now available for the years after 1800 pick up Europe's long transition from household to market economies. In our times when the price of marketed services goes up, and households find they have more labour time available to them, the shift may be going the other way. The modern trend for bourgeois families to do their own ("unpaid") cooking, housework, cleaning, repairs, maintenance, health care, education of the young, etc., assisted by labour saving gadgets, packet foods, do-it yourself tools, instruction manuals, etc. is familiar.

Meanwhile, to make valid comparisons of welfare over long periods of time or across countries seems to require sets of national accounts which measure changes in the *volume* of service output and a clear recognition that the majority of households of early modern Europe produced services. The current convention of measuring service output as the sum of factor incomes earned by those classified by censuses as employed in the service sector is clearly inadequate for the purposes of comparisons of welfare.

Finally, historians must be more careful in accepting the conventions adopted by economists and social accountants to measure economic progress. For example, conventional definitions of final output include all expenditures on services for the protection of people and property. Now no dispute could emerge in relation to the supply services which improved or added to social welfare. But social and urban history has again made us aware that an increased volume of "final" services which emerged when European societies became more urbanized served less to improve and rather more to defend or maintain an environment and ways of life which had for centuries been taken for granted. Examples are numerous and range from urban police forces to garbage collection, sewage and other services concerned to "maintain" the health, safety and comfort of populations concentrated in the confined spaces of towns. And there is no need to adumbrate upon those large transfer payments to domestic servants which were features of an age of surplus population, inequality in the distribution of income and another manifestation of the break up of household economies. Historians must continue to reflect on the nature and quality of economic change. They alone can supply a view of a world that was lost despite the "progress" which appears in the indices derived from national accounts.

Zusammenfassung: Messung und Analyse des Dienstleistungssektors in der europäischen Wirtschaftsgeschichte

Das westeuropäische Wirtschaftswachstum im 19. Jahrhundert ging mit einem Strukturwandel einher. Bis 1914 stieg der Anteil des Bruttoinlandproduktes, der dem Dienstleistungsbereich zuzuordnen ist, auf 25% bis 50% an, und der Anteil der im Dienstleistungssektor Beschäftigten wuchs von ungefähr 11% im Jahre 1800 auf 21% im Jahre 1900. Bei der fortschreitenden Arbeitsteilung im 19. Jahrhundert erhöhte sich der Beschäftigtenanteil in verschiedenen Dienstleistungstätigkeiten, wobei die verfügbaren Statistiken jedoch den Umfang der Dienstleistungsberufe in der Wirtschaft unterschätzen. Weitere Verzerrungen treten auf, weil die Mehrheit der Beschäftigten, die dem Dienstleistungsgewerbe zugeordnet wurden, tatsächlich keine Dienstleistungen für den Endverbraucher erbrachte, sondern ihre Arbeitskraft an Warenproduzenten verkaufte. Somit ist also ein großer Teil dessen, was die volkswirtschaftliche Gesamtrechnung als Dienstleistungen verbucht, tatsächlich Herstellung von Zwischenprodukten und folglich mit der Produktion von Primärgütern und Industrieerzeugnissen eng verbunden. Für die Zeit von 1900 bis 1914 kann man den Anteil der im Dienstleistungssektor Beschäftigten, die Zwischenprodukte herstellten,

in Großbritannien auf 48% schätzen, in Belgien auf 55%, in Frankreich auf 63% und in Deutschland auf 64%.

Wirtschaftshistoriker, die sich mit dem Strukturwandel befassen, schließen aus Zeitreihen und Querschnittsdaten auf eine Assoziation zwischen dem Niveau des Pro-Kopf-Einkommens und erstens dem Anteil des Bruttoinlandsproduktes, das dem Dienstleistungsbereich zuzuordnen ist, und zweitens dem Beschäftigtenanteil dieses Sektors. Dem ist zweierlei entgegenzuhalten: Zum einen konnten keine stabilen Korrelationen für das 19. Jahrhundert aufgestellt werden; zum anderen haben die vorliegenden Schätzungen das langfristige Wachstum nicht in konstanten Preisen gemessen, zu denen die Dienstleistungen dem Endverbraucher verkauft wurden. Dieser Index hätte dann mit dem Wachstum des Bruttoinlandproduktes verglichen werden müssen.

Vielmehr wurde diese Assoziation aus Schätzungen abgeleitet, die in laufenden Preisen errechnet wurden. Das aber ist irreführend, denn man definiert diesen Output üblicherweise als die Summe der Faktoreinkommen, die aus diesen Dienstleistungen stammen. Der Beschäftigtenanteil des Dienstleistungssektors wurde aus folgenden Angaben abgeleitet: Aus der Wachstumsrate der Warenproduktion, aus dem Grad der Kommerzialisierung, der Urbanisierung und der Arbeitsteilung, aus dem Umfang des Bevölkerungswachstums und aus der Binnenwanderung. Die Lohnsätze im Dienstleistungsgewerbe dagegen wurden bestimmt durch die Produktivität in der Landwirtschaft und in der Industrie, durch das Bevölkerungswachstum und durch die Binnenwanderung (welche die Löhne der ungelernten Arbeiter niederdrückten) sowie durch das unelastische Angebot von Facharbeitern und hochqualifizierten Beschäftigten.

Der Beitrag entwickelt folgende Argumente:

1. Historiker haben das Wachstum der Dienstleistungen nicht in konstanten Preisen gemessen, und es gibt keine gesicherte Korrelation zwischen dem Niveau des Pro-Kopf-Einkommens und dem Anteil der Dienstleistungen am Bruttoinlandprodukt.
2. Wenn Dienstleistungen als die Summe der Faktoreinkommen, die in diesem Sektor verdient wurden, gemessen werden und man mit diesen Daten Trendentwicklungen im Zeitverlauf oder das Pro-Kopf-Einkommen verschiedener Länder vergleichen will, so könnte das zu irreführenden Vorstellungen von den tatsächlichen Änderungen des Lebensstandards im Zeitverlauf und im Ländervergleich in Westeuropa führen.
3. Nach der üblichen Meßmethode erbrachten Dienstleistungen im 19. Jahrhundert einen großen und noch wachsenden Anteil am Volkseinkommen. Doch sind die bisher verwendeten Daten fehlerhaft, verzerrt und mehrdeutig. Was wir mit unseren Zahlen bis jetzt aufspüren, ist nur *teilweise* ein zusätzlicher Beitrag zur Warenproduktion für den Endverbraucher und für dessen Wohlfahrt. Hauptsächlich aber weisen die Zahlen lediglich die Verlagerung von bisher hauswirtschaftlich erzeugten Gütern auf den Markt nach.

Robert C. Allen

Recent Developments in Production, Cost, and Index Number Theory, with an Application to International Differences in the Cost and Efficiency of Steelmaking in 1907/9

I Introduction

In the middle of the nineteenth century the British iron and steel industry was the largest in the world and its exports dominated international markets. By the First World War, the American and German industries produced considerably more steel than the British and were major exporters. Britain, indeed, had become the world's largest importer of iron and steel. The immediate cause of this reversal (at least the reversal in international trade) was a change in relative production costs: in the middle of the nineteenth century British costs were lower than German or American costs, but by 1913 the latter two industries produced more cheaply than Britain. This paper is concerned with understanding why Germany and America produced steel less expensively than Britain in the first decade of the twentieth century.

In this paper it will be assumed that steel production exhibits constant returns to scale so that long run average total cost is independent of the rate of production. In that case, it is intuitively clear that differences in the prices of steelmaking inputs and differences in the efficiency of production are the two factors that might account for differences in unit costs. To explain the differences in international steelmaking costs in the early twentieth century, therefore, one must ascertain the relative importance of efficiency differences and input price differences. (After this task is completed, the analysis can go on to explain these differences themselves.) Recent work in duality theory and the theory of index numbers provides the basis for this decomposition. Since the problem is so common in economic history, we shall consider it thoroughly both from a theoretical and a practical point of view. Then the theory will be applied to the problem of ascertaining and decomposing relative production costs in Britain, Germany and America at the time of their industrial censuses of 1907 and 1909.

II Productivity measurement and Cost Decomposition

There is no point developing theory independently of the data it will be applied to, so we begin by specifying the data we intend to analyze. The data pertain to two firms or industries (values for which are denoted by superscripts 0 and 1). The two industries might be contemporaneous (i.e. the British and German steel industries in 1907) or they might be the same industry or firm at two times (i.e. the German steel industry in 1870 and 1910). For each industry, the investigator observes output, Q^0 and Q^1,

the vectors of the quantities of the N inputs consumed, $Z^0=(Z_1^0, \ldots, Z_n^0)$ and $Z=(Z_1^1, \ldots, Z_n^1)$, and the vectors of prices of those inputs $w^0=(w^0, \ldots, w_n^0)$ and $w^1=(w^1, \ldots, w_n^1)$. For instance, Q might be steel production in a year, the elements of Z might be total man-hours worked, tons of iron ore smelted, tons of coke consumed, etc., in the same year, and the corresponding elements of w would be the wage rate per hour and the price per ton of ore and coke. Clearly, one can divide the total consumption of an input by the corresponding output rate, to determine unit input consumption:
$x^0=Z^0/Q^0=(Z_1^0/Q^0, \ldots, Z_n^0/Q^0)=(x_1^0, \ldots, x_n^0)$ and
$x^1=Z^1/Q^1=(Z_1^1/Q^1, \ldots, Z_n^1/Q^1)=(x_1^1, \ldots, x_n^1)$. The data are specified in this way since these are the sorts of data one might hope to obtain form two industrial censuses or from the income statements of two firms.

One can directly compute unit production costs for the two industries, $w^0 \cdot x^0 = \sum_{i=1}^{n} w_i^0 x_i^0$ and $w^1 \cdot x^1 = \sum_{i=1}^{n} w_i^1 x_i^1$, and form their ratio $w^1 \cdot x^1 / w^0 \cdot x^0$. This number is relative production costs in the two cases. *Our object is to work out how to express $w^1 \cdot x^1 / w^0 \cdot x^0$ as the product of two terms, one of which captures the effect on costs of any differences in efficiency that might obtain between the two industries, and the other of which encompasses the effect on costs of any differences in the prices the two industries (or firms) pay for their inputs.* Only by computing these two terms can we talk clearly about the effect of efficiency differences and input price differences on relative production costs.

It is simplest to start by considering the problem of measuring efficiency differences. Economists usually define greater efficiency to be the "capacity to produce more output from a given bundle of inputs" and that is the pertinent concept for the problem at hand. We assume that the technologies of the two firms can be represented by production functions and that the functions are identical up to a multiplicative coefficient: $Q^0=A^0 \cdot f(Z^0)$ and $Q^1=A^1 \cdot f(Z^1)$. f is assumed to be a linearly homogeneous neoclassical production function. Since Q increases with A for an unchanging Z, A indexes efficiency in the sense we are using it here. The problem of measuring efficiency differences is, therefore, the problem of determining the relative differences in A, i.e. ascertaining A^1/A^0, from the quantities and prices of the inputs and outputs in the two situations. If f were known, A^1/A^0 could be imputed by direct substitution:

$$\frac{A^1}{A^0} = \frac{Q^1/Q^0}{f(Z^1)/f(Z^0)} \tag{1}$$

In general, we do not know f so this straightforward calculation is not feasible. Later, we shall see how different input quantity indices might be used to estimate $f(Z^1)/f(Z^0)$. At the moment, however, one might notice that the numerator of equation 1 is relative output and the denominator is a ratio (mediated by f) of relative inputs, so the equation is a ratio of "total output" to "total input". We shall refer to $f(Z^1)/f(Z^0)$ as the "true input quantity index" and to A^1/A^0 as the "true total factor productivity index".

To decompose relative unit costs into efficiency and input price terms, one must introduce further assumptions about the input markets and the behaviour of the

firms or industries. We shall assume that Z^0 and Z^1 are available in perfectly elastic supply at prices w^0 and w^1. Further, we shall assume the industries minimize production costs given those input prices and their production functions. Minimized total costs then depend on total production, input prices, the level of efficiency, and the form of the function f. Since we are assuming constant returns to scale, we can speak equally well of unit costs, which depend only on input prices, efficiency and f. Moreover, since the efficiency term A was assumed to be multiplicatively separable in the production function, the unit cost function, which shows how unit costs depend on efficiency and input prices, has a particular form:

$$w^0 \cdot x^0 = \frac{c(w^0)}{A^0} \tag{2a}$$

$$w^1 \cdot x^1 = \frac{c(w^1)}{A^1} \tag{2b}$$

The functional form of c is determined by – in the jargon is "dual to" – f. A represents the impact of efficiency on unit costs. Since A is in the denominator, increases in A lower costs. c(w) represents the inpact of input princes on costs. It can be shown that c is increasing in w and linearly homogeneous as well, so that increases in input prices raise costs and equiproportional increases in the prices of all inputs raise costs in the same proportion.

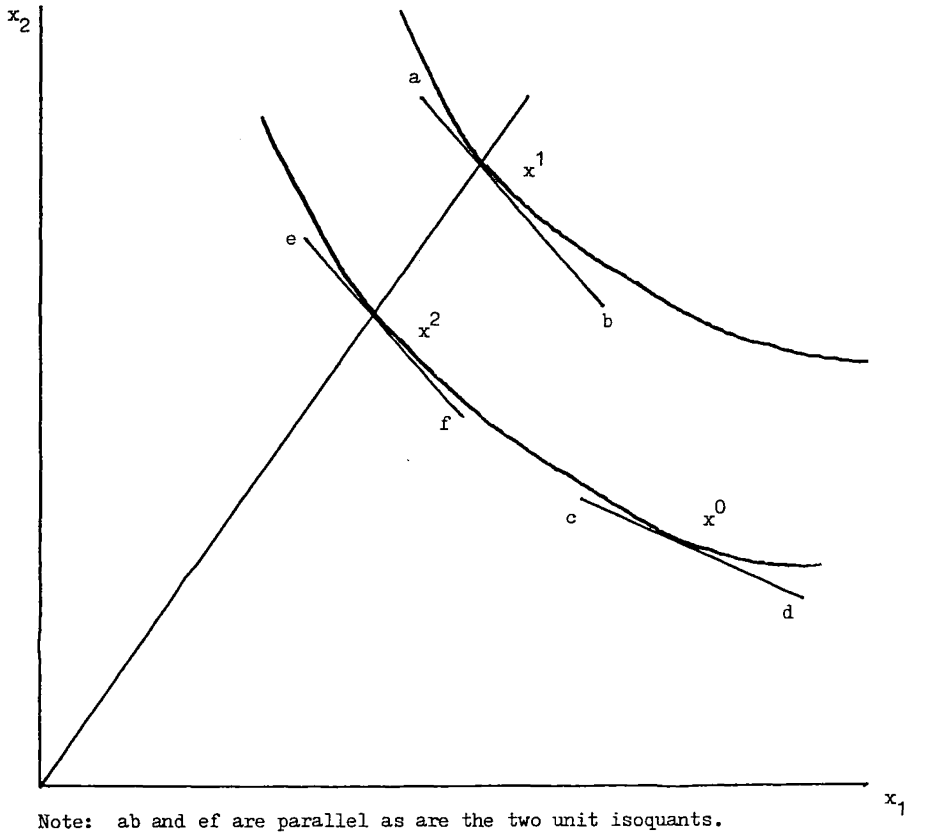
By dividing equation 2b by equation 2a, we obtain an equation for decomposing unit costs into efficiency and input price effects:

$$\frac{w^1 \cdot x^1}{w^0 \cdot x^0} = \frac{A^0}{A^1} \cdot \frac{c(w^1)}{c(w^0)} \tag{3}$$

The left side – relative unit costs – is observable. A^0/A^1 is the term that indicates the contribution of the difference in efficiency to the difference in costs. $c(w^1)/c(w^0)$, which is called the "true input price index", represents the effect of input price differences on costs.

One can imagine proceeding in either of two ways. If c were known, $c(w^1)/c(w^0)$ could be computed directly, and then A^0/A^1 could be calculated by deflating relative unit costs (the left side of equation 3) by the true input price index. Comparing A^0/A^1 and $c(w^1)/c(w^0)$ would then show the relative contributions of efficiency and input price differences on unit cost differences. Unfortunately, c is not known in general, but we shall shortly show how to approximate the true input index by computable price indices that allow the practical application of this procedure. Alternatively, of course, one could compute A^0/A^1 from equation 1 and proceed in a parallel manner to the same end. Analagous index number problems still arise, however, as we have already noted.

Before considering the solution of these index number problems, we can give the theory a geometric interpretation in terms of the standard isoquant diagram. Since we are assuming constant returns to scale, we can simplify the geometry by working only with unit isoquants. Figure 1 shows these isoquants for the case of two inputs x_1 and x_2. The points $x^0=(x_1^0, x_2^0)$ and $x^1=(x_1^1, x_2^1)$ are the observed unit input vectors for the two industries, and the unit isoquants are drawn through them. Since the pro-



Note: ab and ef are parallel as are the two unit isoquants.

Figure 1: The Geometry of Cost Decomposition

duction functions are identical up to the multiplicative efficiency term A, the isoquants are parallel, i.e. the isoquants have equal slopes for points that intersect the same ray from the origin. It is assumed that x^0 and x^1 are cost minimizing input combinations so the slopes of the tangents to the isoquants at the points (lines ab and cd) equal the prevailing input price ratios. x^0 and x^1 and the slopes of ab and cd are observable. Point x^2 is not observable. x^2 is the input combination on the isoquant through x^0 that would minimize costs at the input prices w^1. (line segment ef is parallel to ab.) Since the isoquants are parallel, x^2 is on the same ray from the origin as x^1.

The following identity is obviously true:

$$\frac{w^1 \cdot x^1}{w^0 \cdot x^0} = \frac{w^1 \cdot x^1}{w^1 \cdot x^2} \cdot \frac{w^1 \cdot x^2}{w^0 \cdot x^0} \tag{4}$$

$w^0 \cdot x^0$ is the unit cost of production for firm 0 at input prices w^0, and $w^1 \cdot x^2$ is the unit production cost of the same firm at prices w^1. Hence, by equation 2a, $w^0 \cdot x^0 = c(w^0)/A^0$ and $w^1 \cdot x^2 = c(w^1)/A^0$.

What of the term $w^1 \cdot x^1 / w^1 \cdot x^2$? Since x^1 and x^2 are on the same ray through the origin, $x^2 = \lambda x^1$ where λ is a scalar. Substituting $x^2 = \lambda x^1$ into $w^1 \cdot x^1 / w^1 \cdot x^2$ yields $w^1 \cdot x^1 / w^1 \cdot \lambda x^1 = 1/\lambda$. But what is the meaning of λ? It equals the true total factor productivity index. To see that, recall that x^1 is on the unit isoquant for industry 1 so $1 = A^1 \cdot f(x^1)$. x^2 is, likewise, on the unit isoquant for industry 0; hence, $1 = A^0 \cdot f(x^2)$. Equating these expressions and substituting $x^2 = \lambda x^1$ yields:

$$\begin{aligned} A^1 \cdot f(x^1) &= A^0 \cdot f(x^2) \\ &= A^0 \cdot f(x^1) \\ &= \lambda A^0 \cdot f(x^1) \end{aligned}$$

since f is linearly homogeneous. Division gives the desired result:

$$\frac{A^1}{A^0} = \lambda.$$

Making the substitutions $w^0 \cdot x^0 = c(w^0)/A^0$, $w^1 \cdot x^2 = c(w^1)/A^0$, and $w^1 \cdot x^1 / w^1 \cdot x^2 = A^0/A^1$, equation 4 becomes

$$\frac{w^1 \cdot x^1}{w^0 \cdot x^0} = \frac{A^0}{A^1} \cdot \frac{c(w^1)}{c(w^0)}$$

which is equation 3.

We can now interpret the terms of equation 3 in terms of the geometry of Figure 1. Relative unit costs equals the product of two terms. The first term A^0/A^1, is the efficiency difference or the relative distance the two isoquants are from the origin. The second term, $c(w^1)/c(w^0)$, equals the impact on costs as one "slides along" an isoquant (i.e. adjusts the cost minimizing input mix) in response to differences in input prices between industries 0 and 1.

To apply equation 3, i.e. to decompose relative units costs into efficiency and input price terms, one must either ascertain $f(Z^1)/f(Z^0)$ in equation 1 or $c(w^1)/c(w^0)$ in equation 3 or both. In practice, one uses input quantity and input price indices to approximate these "true" indexes. There is a vast - indeed an infinite - number of indices one might use. Which should be chosen? Considerable progress has been made by economists in recent years in solving this problem. A fundamental notion in this work is that of "exactness". An input quantity index, for instance, is exact for a particular production function f(Z), if the index number equals $f(Z^1)/f(Z^0)$. Similarly an input price index is exact for a unit cost function c(w) if the index equals $c(w^1)/c(w^0)$. Perhaps the most obvious exactness relationship is that a geometric input index is exact for a Cobb-Douglas production function. Mathematical economists have worked out the functions for which common index numbers are exact, and vice versa. Some of these results are summarized in Table 1. The results are stated in terms of production functions and input quantity indices but analogous results are true for cost functions and input price indices. Notice that Paasche and Laspeyres indices are both exact for both Leontief and linear functions. Exactness relations are not unique. Exactness results have also been derived for a more general function that includes the Törnqvist and square-root-quadratic functions as special cases. There are an infinite

Table 1: Exactness Relationships

Production Function		Corresponding Exact Index Number	
Name	Equation	Name	Equation
Leontief	$f(Z) = \text{Min}\left\{\frac{Z_1}{b_1}, \ldots, \frac{Z_n}{b_n}\right\}$	Laspeyres	$\frac{f(Z^1)}{f(Z^0)} = \frac{\sum_{i=1}^{n} w_i^0 Z_i^1}{\sum_{i=1}^{n} w_i^0 Z_i^0}$
linear	$f(Z) = \sum_{i=1}^{n} a_i Z_i$	Paasche	$\frac{f(Z^1)}{f(Z^0)} = \frac{\sum_{i=1}^{n} w_i^1 Z_i^1}{\sum_{i=1}^{n} w_i^1 Z_i^0}$
Cobb-Douglas	$\ln f(Z) = \alpha_0 + \sum_{i=1}^{n} \alpha_i \ln Z_i$ where $\sum_{i=1}^{n} \alpha_i = 1$	geometric	$\frac{f(Z^1)}{f(Z^0)} = \prod_{i=1}^{n} \left[\frac{Z_i^1}{Z_i^0}\right]^{s_i}$
translog	$\ln f(Z) = \alpha_0 + \sum_{i=1}^{n} \alpha_i \ln Z_i + \sum_{i=1}^{n}\sum_{j=1}^{n} \alpha_{ij} \ln Z_i \ln Z_j$ where $\sum_{i=1}^{n} \alpha_i = 1$, $\alpha_{ij} = \alpha_{ji}$ for all i,j and $\sum_{i=1}^{n} \alpha_{ij} = 0$ for $i = 1,\ldots,N$	Törnqvist	$\frac{f(Z^1)}{f(Z^0)} = \prod_{i=1}^{n} \left[\frac{Z_i^1}{Z_i^0}\right]^{(s_i^0 + s_i^1)/2}$
square-root-quadratic	$f(Z) = \left[\sum_{i=1}^{n}\sum_{j=1}^{n} a_{ij} Z_i Z_j\right]^{\frac{1}{2}}$ where $a_{ij} = a_{ji}$ for all ij	Fisher ideal	$\frac{f(Z^1)}{f(Z^0)} = \left[\frac{\sum_{i=1}^{n} w_i^0 Z_i^1}{\sum_{i=1}^{n} w_i^0 Z_i^0}\right]^{\frac{1}{2}} \left[\frac{\sum_{i=1}^{n} w_i^1 Z_i^1}{\sum_{i=1}^{n} w_i^1 Z_i^0}\right]^{\frac{1}{2}}$

number of production functions and corresponding exact index numbers to choose from. It must also be emphasized that these exactness relations only obtain if the firms or industries concerned have minimized costs. In Table 1, the symbols s_i, s_i^0, and s_i^1 refer to the shares in cost of input i.

In his fundamental paper, "Exact and Superlative Index Numbers", Diewert[1] has suggested that one can discriminate among index numbers on the basis of the production and cost functions for which they are exact. Some functions (e.g. Cobb-Douglas and Leontief functions) can be shown to be first-order approximations to any constant returns-to-scale production function whereas other functions (e.g. translog and square-root-quadratic) can be shown to be second-order approximations to such production functions. Since second-order functions would be expected to fit the data better, Diewert urges that index numbers exact for such functions ought to be preferred to index numbers exact for first-order functions. Diewert calls the index numbers that are exact for second-order approximating functions "superlative" index numbers.

1. Diewert, W. E., *Exact and Superlative Index Numbers,* in: Journal of Econometrics, 4 (1976), pp. 115-145.

The Törnqvist and Fisher idea index numbers shown in Table 1 are superlative. Diewert has found that the dispersion among superlative index numbers is generally less than the dispersion among indexes exact for first order approximators when all are evaluated for the same set of data.

In a more recent paper, Allen and Diewert[2] have proposed another criterion for solving the index number problem. The object of the index number, of course, is to ascertain $f(Z^1)/f(Z^0)$ and $c(w^1)/c(w^0)$. Since f and c are both linearly homogeneous, it can be shown that they are bounded by Paasche and Laspeyres indices, irrespective of the functional form of f or c. In other words, Paasche and Laspeyres input price indices bound $c(w^1)/c(w^0)$, and Paasche and Laspeyres input quantity indices bound $f(Z^1)/f(Z^0)$ so long as f exhibits constant returns to scale. This result is convenient if the Paasche and Laspeyres indices are close together, for then one may closely bound the cost decomposition without worrying further about the choice of an index number. Provided either the input prices, w^1 and w^0, or the input quantities, Z^1 and Z^0, be roughly proportional, the bounds will be tight and the problem of choosing an index number satisfactorily finessed.

One is tempted to go somewhat further. The Fisher ideal index is a superlative index number and so favoured by Diewert's original criterion. Further, since it is the geometric mean of the Paasche and Laspeyres indices, it always lies within those bounds. No other superlative index number has this property. Unless one had extraveous information as the form of f or c, the Fisher ideal index might always be preferred since it always satisfies both criteria.

III Productivity and Steelmaking Costs, 1907/9

We shall now apply the theory developed in the last section to the problems of measuring productivity, input prices, and costs in the British, German and American steel industries in the early twentieth century.[3]

Equation 3 will be the fundamental tool. In the last section, it was suggested that either A^0/A^1 or $c(w^1)/c(w^0)$ could be determined residually by dividing $w^1 \cdot x^1/w^0 \cdot x^0$ by the other. In this section, we will use the equation differently. A^0/A^1 and $c(w^1)/c(w^0)$ will be estimated directly and $w^1 \cdot x^1/w^0 \cdot x^0$ computed as their product.

First, the difference in total factor productivity (A^0/A^1) among the three countries must be determined. Equation 1 is the relevant equation for this task. f will be assumed to be Cobb-Douglas so a geometric index of inputs will be used to compute $f(Z^1)/f(Z^0)$. In that case,

$$\frac{A^1}{A^0} = \frac{Q^1/Q^0}{\prod_{i=1}^{n} \left[\frac{x_i^1}{x_i^0}\right]^{s_i}} = \prod_{i=1}^{n} \left[\frac{Q^1/x_i^1}{Q^0/x_i^0}\right]^{s_i} \tag{5}$$

2. Allen, R. C., and Diewert, W. E., *Direct Versus Implicit Superlative Index Number Formulae*, in: Review of Economics and Statistics, 63 (1981).
3. The numbers discussed in this section were originally published in Allen, R. C., *International Competition in Iron and Steel, 1850–1913*, in: Journal of Economic History, 39 (1979), pp. 911–937. Readers are referred to that paper for sources and elaboration.

The right hand equality follows since the shares sum to 1. The difference in efficiency (total factor productivity) is a weighted geometric average of the relative average products of the inputs (i.e. the various partial productivity indices). Notice that if the average product of an input is the same in cases 0 and 1, the term for that input equals one and, in that sense, disappears from the total factor productivity index.

In steelmaking, the four principal inputs were labour, capital, fuel, and metallic inputs (mainly pig iron and scrap). 1907 and 1909 are the years chosen for the productivity comparison because they were the years of industrial censuses in the three countries. Unfortunately, as is often the case in historical work, the censuses were not as complete as we would like or indeed presumed in the last section. Output and employment were recorded for the three countries, as was installed horsepower, which shall be used as a measure of the quantity of capital. The consumption of metallic inputs and of fuel, however, was not consistently recorded. Elsewhere[4] I have argued that these inputs were consumed in technologically fixed proportions to output in the early twentieth century. That assumption will be adopted here, in which case, total factor productivity will be measured as

$$\frac{A^1}{A^0} = \left[\frac{Q^1/L^1}{Q^0/L^0}\right]^{.26} \left[\frac{Q^1/K^1}{Q^0/K^0}\right]^{.08} \tag{6}$$

where the shares are as indicated. Labour productivity was 47.5, 70.6 and 84.4 tons per man-year in Britain, Germany and America, while capital productivity (measuring capital by installed horsepower) was 9.0, 14.6 and 7.8 tons per horsepower per year, respectively. Taking the British values as case 0, substitution into equation 6 shows both the German and American industries to have been 15% more efficient than the British (i.e. $A^1/A^0 = 1.15$ for both the German-British and American-British comparisons).

As equation 3 makes clear, the greater efficiency of the German and American industries would tend to give them lower production costs than the British, but that effect might either be attenuated or accentuated by the levels of input prices prevailing in the three countries. We explore that possibility by computing an input price index to estimate the true input price index in equation 3. It is convenient to distinguish four inputs for this calculation - iron ore, fuel, scrap, and labour. The ratios of the prices of these inputs in America to their prices in Britain in 1906–9 were .98, .73, 1.13 and 1.70 respectively. When we use a geometric input price index to aggregate these price relatives we find that, on average, American input prices relative to British were 9% higher (i.e. the index equals 1.09) in 1906–9. Comparing Britain and Germany in the years 1906–13, the relative prices of the inputs were .69, .88, .95 and .72 - all were lower in Germany - and the input price index equals .83.

Equation 3 indicates that production costs in Germany relative to Britain can be computed by multiplying the reciprocal of the German-British total factor productivity index by the German-British input price index. Likewise for America. Table 2 displays the calculations. (Note that the reciprocal of the efficiency index equals $.87 = 1/1.15$.) German costs were 72% of British costs in the first decade of the twentieth century. Germany's greater efficiency and lower input prices made approximately equal contributions to her cost advantage. At the same time American costs

4. Allen, *International Competition*, pp. 919–920.

Table 2: German and American Steelmaking Costs Relative to British

relative cost	=	reciprocal of total factor productivity index	x	input price index
$\frac{w^1 \cdot x^1}{w^0 \cdot x^0}$	=	$\frac{A^0}{A^1}$	·	$\prod_{i=1}^{n} \left[\frac{w_i^1}{w_i^0}\right]^{s_i}$
for German (1) - British (0) Comparison				
.72	=	.87	x	.83
for American (1) - British (0) Comparison				
.95	=	.87	x	1.09

were 95% of British costs. America's costs were lower solely because of her greater efficiency. In fact, American input prices exceeded British prices, mainly because the American steel industry paid wages 70% higher than British wages. To put the matter differently, the superior efficiency of the American industry allowed it to pay higher wages and still produce at lower cost.

IV Conclusion

This paper has summarized recent developments in the theory of production and cost functions, as well as in the theory of index numbers. This theory provides a powerful set of tools to answer questions that have long concerned economic historians. These methods were used to analyze the differences in the cost of producing steel in Germany, Britain and the United States in 1907 and 1909. It was found that the American and German industries were each 15% more efficient than the British. Germany's position in the world market was further enhanced by particularly low input prices, while America's productivity advantage was somewhat offset by the high level of wages prevailing there.

Zusammenfassung:
Neuere Entwicklung in der Produktions- und Kostentheorie sowie in der Indexzifferntheorie und ihre Anwendung auf internationale Kosten- und Leistungsunterschiede bei der Stahlherstellung in den Jahren 1907 und 1909

Dieser Beitrag stellt neuere Entwicklungen in der Theorie der Produktions- und Kostenfunktionen sowie der Theorie der Indexziffern zusammenfassend dar. Die Indexzifferntheorie bietet das nötige Instrumentarium, um Probleme zu lösen, denen sich Wirtschaftshistoriker schon lange gegenübersahen. Hier wurden diese Methoden angewendet, um die Kostenunterschiede bei der Stahlherstellung in Deutschland, Großbritannien und in den Vereinigten Staaten in den Jahren 1907 und 1909 zu analysieren. Dabei ergab sich, daß sowohl die amerikanische als auch die deutsche Stahlindustrie um 15 Prozent effizienter produzierten als die britische. Darüber hinaus vermochte Deutschland seine Position auf dem Weltmarkt noch durch besonders niedrige Inputpreise zu verbessern, während Amerika seinen Produktivitätsvorteil durch das dort vorherrschende hohe Lohnniveau ziemlich wieder einbüßte.

Part 2: Empirical Studies

Angus Maddison

Measuring Long Term Growth and Productivity Change on a Macro-economic Level

This note is intended as a comment on Patrick O'Brien's proposal for a cooperative research effort to measure performance of the West European economies. It has three parts:
a) it summarises the findings of a study I recently finished on long term changes in per capita income and productivity in sixteen advanced capitalist countries;
b) it makes some suggestions pertinent to further research by economic historians in this area in which I stress the virtues of trying to make rather aggregative macro-economic measures for periods usually considered too remote for such treatment;
c) the annex provides long term estimates of GDP in 16 countries with source notes, as an illustration of the wealth of material already available for performance measurement on the macroeconomic level.

Findings

In my own recent work[1] I have attempted to analyse the changes in the rhythm of growth in capitalist countries since 1820, dividing the past 160 years into four phases, each with significantly different economic performance as measured by macro-economic indicators. I also made a rough comparison of the macro-economic performance of the "capitalist" epoch as a whole, since 1820, with characteristic performance in three preceding epochs in Western Europe's economic history, i.e. an epoch of "agrarianism" from 500 to 1500 AD during which there were fluctuations but little net growth in population and income; an epoch of "expanding agrarianism" from 1500 to 1700 during which population rose by half and real income per head by about a quarter; and an epoch of "merchant capitalism" from 1700 to 1820 when both population growth and real income per capita increased twice as fast as from 1500 to 1700.

Performance in the four epochs and four phases is summarised in table 1. It can be seen that in all the four phases of "capitalist" development, macro-economic performance has been very much better than in any of the previous epochs.

1. Maddison, A., *Phases of Capitalist Development*, Oxford 1982 (also in French, in 1981, *Les Phases du Développement Capitaliste*, Paris).

Table 1: Performance Characteristics of Epochs and Phases

annual average compound growth rates

	Population	GDP per Head	GDP
		Epochs	
500–1500	0.1	0.0	0.1
1500–1700	0.2	0.1	0.3
1700–1820	0.4	0.2	0.6
1820–1980	0.9	1.6	2.5
		Phases	
1820–1913	1.1	1.2	2.3
1913–1950	0.7	1.2	1.9
1950–1973	1.0	3.8	4.9
1973–1980	0.4	2.0	2.5

Source: This table and the following ones are all derived from A. Maddison, *Phases of Capitalist Development,* Oxford University Press, 1982 (available in French in 1981 Les *Phases du Développement Capitaliste,* Economica, Paris).

For the periods before 1820, the quantitative evidence on growth is, of course, quite weak, and it may seem foolhardy to advance quantitative assessments at all in such a situation. Nevertheless, given the fact that there are important differences of opinion on performance in e.g. the 1500–1700 period, even rough quantitative specification of likely amplitudes helps to sharpen critical analysis of the evidence, and points to areas where the evidence can be improved by further research. For 1500–1700, opposing schools of thought on Western per capita performance are represented by Kuznets and Landes on the one hand, Le Roy Ladurie and Abel on the other.[2] My own tentative view of performance in this period (as represented in table 1) is a compromise between the Kuznets and Le Roy Ladurie positions, but it is clearly possible to improve on evidence by further research directed to the performance of nation states. One weakness of the distinguished work of French quantitative historians for this period is that it is nearly all regional or oecumenic rather than national in scope.

For the 1700–1820 period, more elaborate analyses of growth are available and the best evidence on output trends in Western performance is for France, the Netherlands, and the U.K. I have relied heavily on the work of Phyllis Deane for the U.K.

2. Kuznets, S., *Population Capital and Growth,* London 1974, pp. 139 and 167 suggests a growth rate of 0.2 per cent a year for per capita income in Europe from 1500 to 1750. Landes, D.S., *The Unbound Prometheus,* Cambridge 1969, p. 14 suggests that from the year 1000 to the eighteenth century European real income per head may have tripled. Le Roy Ladurie, E., *Les Paysans de Languedoc,* Paris 1966 suggests stagnant income from 1500 to 1700. Abel, W., *Agrarkrisen und Agrarkonjunktur,* Hamburg 1978, pp. 285–9 suggests a per capita decline in this period.

and Jan Marczewski for France.[3] For the Netherlands, which was still the economic leader for most of this periods, there is a good deal of evidence on economic performance which has yet to be recast systematically in national accounting terms.[4]

There is rather little early evidence on working hours, activity rates or unemployment, so estimates of GDP per man hour are more shaky than those for GDP per head of population. However, if one relies on the reasoning of Esther Boserup[5] about the likelihood of increased labour effort as a source of increase in agricultural output in the early stages of accelerated growth, it seems quite unlikely that in the pre-capitalist epochs labour productivity grew faster than output per capita. If anything it was likely to have grown more slowly.

Within the "capitalist" period since 1820, my estimates of labour productivity generally start only in 1870, but since then average working hours have fallen by roughly half, from around 3,000 to 1,600 a year, so it is clear that labour productivity has increased faster in the "capitalist" epoch than per capita GDP—probably around 20 fold from 1820 to 1980 compared with a 13 fold increase in per capita GDP.

Table 2: Growth of Output (GDP at Constant Prices) per Head of Population 1700-1979
annual average compound growth rates

to	1700 1820	1820 1870	1870 1913	1913 1950	1950 1973	1973 1979	1820 1979
Australia		n.a.	0.6	0.7	2.5	1.3	n.a.
Austria		0.7	1.5	0.2	5.0	3.1	1.5
Belgium		1.9	1.0	0.7	3.6	2.1	1.7
Canada		n.a.	2.0	1.3	3.0	2.1	n.a.
Denmark		0.9	1.6	1.5	3.3	1.8	1.6
Finland		n.a.	1.7	1.7	4.2	2.0	n.a.
France	0.3[a]	1.0	1.5	1.0	4.1	2.6	1.6
Germany		1.1	1.6	0.7	5.0	2.6	1.8
Italy		n.a.	0.8	0.7	4.8	2.0	n.a.
Japan		0.0	1.5	0.5	8.4	3.0	1.8
Netherlands	−0.1	1.5	0.9	1.1	3.5	1.7	1.5
Norway		1.0	1.3	2.1	3.1	3.9	1.8
Sweden		0.6	2.1	2.2	3.1	1.5	1.8
Switzerland		1.7	1.2	1.5	3.1	−0.2	1.6
U.K.	0.4	1.5	1.0	0.9	2.5	1.3	1.4
U.S.A.		1.4	2.0	1.6	2.2	1.9	1.8
Arithmetic Average	0.2	1.1	1.4	1.2	3.8	2.0	1.6

a) 1701/10-1820

3. See their work cited in the annex.
4. See the annex.
5. See Boserup, E., *The Conditions of Agricultural Growth*, London 1965, for a major contribution to anti-Malthusian analysis of growth processes and productivity.

Table 3: Growth of Output (GDP at Constant Prices) 1700–1979

annual average compound growth rates

	to 1700	1820	1870	1913	1950	1973	1820
	1820	1870	1913	1950	1973	1979	1979
Australia		n.a.	3.2	2.1	4.7	2.5	n.a.
Austria		(1.4)	2.4	0.2	5.4	3.1	2.0
Belgium		2.7	2.0	1.0	4.1	2.3	2.3
Canada		n.a.	3.8	2.9	5.2	3.2	n.a.
Denmark		1.9	2.7	2.5	4.0	2.1	2.6
Finland		n.a.	3.0	2.4	4.9	2.3	n.a.
France	0.6[a]	1.4	1.7	1.0	5.1	3.0	2.0
Germany		2.0	2.8	1.3	6.0	2.4	2.6
Italy		n.a.	1.5	1.4	5.5	2.6	n.a.
Japan		(0.4)	2.5	1.8	9.7	4.1	2.7
Netherlands	0.1	2.4	2.1	2.4	4.8	2.4	2.7
Norway		(2.2)	2.1	2.9	4.0	4.4	2.7
Sweden		(1.6)	2.8	2.8	3.8	1.8	2.5
Switzerland		(2.5)	2.1	2.0	4.5	−0.4	2.4
U.K.	1.1	2.4	1.9	1.3	3.0	1.3	2.0
U.S.A.		4.4	4.1	2.8	3.7	2.7	3.8
Arithmetic Average	0.6	2.1	2.5	1.9	4.9	2.5	2.5

a) 1701–10 to 1820. The figures are adjusted to exclude the impact of boundary changes.

One of the objectives of my study was to examine the Schumpeterian literature on the dynamics of capitalist development, but I reject Schumpeter's theories about regular long term rhythms and waves of innovation in favour of more *ad hoc* explanations of changes in momentum which in my view are due to factors such as wars, changes in economic policy, and in the productivity gaps between the successive lead countries (the U.K. and the U.S.A.) and the follower countries. I also argue that the pace of technical progress has been much smoother than Schumpeter suggested.

Another conclusion I reach is that the Rostow-Gerschenkron thesis of staggered take-offs into capitalist type growth in the nineteenth century is in conflict with the evidence we have, and that all the sixteen countries I examined (except Japan and possibly Italy) probably maintained a significant growth rhythm from 1820 onwards. This conclusion is based largely on the GDP and GDP per capita evidence in tables 2 and 3 but is also buttressed by the evidence on foreign trade growth.

My productivity estimates are in terms of labour, rather than total factor productivity. Estimates of the latter are now feasible, because measures of growth in capital stock are available for the seven biggest countries over rather long periods, using existing national estimates, of which those of Feinstein for the U.K. have the longest coverage. Apart from major theoretical problems in finding appropriate weights for

total factor productivity indices, there are obvious pitfalls in their use in historical analysis as revealed in McCloskey's comparison of the British and U.S. iron and steel industry which finds little difference in the performance of the two countries in terms of total factor productivity.[6] This tends to conceal the fact that U.S. labour productivity grew faster than that of the U.K. because its investment effort was bigger.

Table 4: GDP per Man Hour in 1970 U.S. Relative Prices ($)

	France	Germany	Japan	Netherlands	U.K.	U.S.A.
1700				0.35		
1785				0.33	0.32	
1820				n.a.	0.38	
1870	0.42	0.43	0.17	0.74	0.80	0.70
1890	0.58	0.62	0.24	0.97	1.06	1.06
1913	0.90	0.95	0.37	1.23	1.35	1.67
1929	1.31	1.19	0.64	1.82	1.70	2.45
1950	1.85	1.40	0.59	2.27	2.40	4.25
1960	2.87	2.72	1.03	3.17	2.99	5.41
1973	5.80	5.40	3.49	6.17	4.84	7.60
1979	7.11	6.93	4.39	7.48	5.48	8.28

Table 5: Gross Non-Residential Fixed Capital Stock per Person Employed 1820–1978

(Dollars of 1970 U.S. purchasing power)

	1820	1870	1890	1913	1950	1973	1978
Canada	n.a.	n.a.	n.a.	n.a.	16.279	29.760	33.553
France	n.a.	n.a.	n.a.	6.481	10.346	23.653	28.800
Germany	n.a.	3.597	5.311	7.888	9.386	26.733	34.877
Italy	n.a.	n.a.	2.059	3.150	6.151	16.813	20.178
Japan	n.a.	n.a.	.713	1.178	2.873	14.172	20.103
U.K.	3.922	6.068	6.658	7.999	9.204	17.718	20.931
U.S.A.	n.a.	5.066	6.838	13.147	18.485	30.243	32.001

Research Strategy in Measuring Productivity and Growth Trends

There is, of course, a huge literature on problems of growth analysis, and some of

6. See McCloskey, D. N., *Economic Maturity and Entrepreneurial Decline, British Iron and Steel 1870–1913,* Harvard 1973.

these e.g. index number problems, have been pretty exhaustively diagnosed. I confine myself to four points which are relevant to the type of comparative research effort which Patrick O'Brien has been advocating.

a) Use of a National Accounts Framework

My first recommendation is to anchor analysis of growth trends in aggregates which measure total economic activity. The economic significance of GDP or GNP as a measure of economic performance is clearer than that of partial measures such as agricultural or industrial output, or indicators for individual commodities, which earlier growth analysts were forced to use. The fact that aggregate activity can be crosschecked in several dimensions e.g. as a sum of expenditures, of incomes, or of output is also of major help. Estimates of these aggregates are now available for many countries back into the nineteenth century, and can be pushed back further. A concerted effort for a number of countries will throw up many hints of how data gaps can be filled. It is now about twenty years since Kuznets and Abramovitz launched a cooperative research effort of this type which led to production of Malinvaud's study on France, Fua's on Italy, Ohkawa and Rosovsky on Japan, and the forthcoming Matthews' study on the U.K.[7] What I am suggesting is another round of this type but pushed back to 1820.

There are, of course, problems in measuring output for the whole economy, but this is true for partial measures too. The logic of the national accounts aggregates has been explored in a highly sophisticated way over the past 40 years, and I think the literature already provides negative answers to some of the arguments of O'Brien and Keyder in favour of excluding services from the aggregates to be studied.[8]

I am not suggesting that partial measures are not worth using in growth analysis, but there has been a rather marked tendency in the past for users of partial measures to claim that they can thereby discern movements in aggregate economic activity. This temptation is much weaker if an articulate national accounting framework is used.

b) Measure Levels as Well as Growth

A second point worth stressing in productivity or growth analysis is the great value of benchmark estimates which make it possible to compare levels of performance between countries as well as their growth rates. Here O'Brien and Keyder are on the right path in their U.K./French comparisons, but the whole business of international comparisons has been greatly faciliated over the past thirty years by the work of Irving Kravis.[9] This work is another firm anchor for international comparisons which should be exploited wherever possible in long run analysis of productivity trends.

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7. These studies are all cited in the annex, except Matthews, R. C. O., Feinstein, C., and Odling-Smee, J., *British Economic Growth,* Stanford, forthcoming.
8. See O'Brien, P., and Keyder, C., *Economic Growth in Britain and France 1780–1914,* London, 1978, pp. 28–32.
9. See Kravis, I. B., Heston, A., and Summers, R., *International Comparisons of Real Product and Purchasing Power,* Baltimore and London 1978.

c) Appropriate Periodicity
A third important problem in such studies is getting the most appropriate periodicity for the analysis or comparison. Getting this right usually involves a good deal of iterative testing. But there are some traps to be avoided. One is to neglect the economic history of war years. This has been the practice in several distinguished studies of long term growth, e.g. Hoffmann's study on German growth. But if we compare peacetime growth in Germany and another country with a totally different war experience, judgements on the causes for differential peacetime performance can be heavily distorted. Another trap is to compare the growth performance of one country with that of another at a different period when they are alleged to have experienced similar "stages of growth". This type of comparison must be handled very carefully because the technological options of countries are different at different times, and the lead country- follower country gap may also be very different.

d) Identifiable National Aggregates
Finally, I would stress that in spite of changes in boundaries, it is worth trying to frame quantitative analysis of European progress over the past two centuries in terms of national units. In the case of GDP or population it is probably possible to do this. For individual sectors of the economy this is more difficult, and for foreign trade it may be very difficult for periods when the customs boundaries were changed. These problems are perhaps most important for Germany, and are not very satisfactorily handled in Hoffmann's basic study. But the problem arises in several other countries to an important degree, e.g. there is the problem of Ireland whose pace and level of development was different from that in the rest of the U.K. economy in the nineteenth century. But this point is often neglected in international comparisons and may lead to error.

Zusammenfassung:
Die Messung von langfristigem Wirtschaftswachstum und Produktivitätsänderungen auf makroökonomischer Ebene

Mit diesem Beitrag soll ein Kommentar zu Patrick O'Briens Vorschlag geliefert werden, in einem kooperativen Forschungsvorhaben die wirtschaftliche Leistung westeuropäischer Länder zu messen. Die Arbeit gliedert sich in drei Teile:

a) zunächst werden die Ergebnisse meiner kürzlich fertiggestellten Studie über die langfristigen Änderungen des Pro-Kopf-Einkommens und der Produktivität in sechzehn fortgeschritten kapitalistischen Ländern zusammengefaßt;
b) sodann werden Wirtschaftshistorikern, die weitere Forschung auf diesem Gebiet betreiben, einige Vorschläge gemacht. Vor allem wird dabei betont, wie sinnvoll es ist, makroökonomische Messungen auf ziemlich hohem Aggregationsniveau selbst für die Zeiträume durchzuführen, die wegen ihrer zeitlichen Distanz dieser Methode nicht zugänglich sein sollen;
c) in einem Anhang sind langfristige Schätzungen des Bruttoinlandsproduktes (Gross Domestic Product) von sechzehn Ländern aufgeführt. Die Quellenhinweise dazu belegen, wie reichhaltig schon jetzt Material über die Messung wirtschaftlicher Leistung auf makroökonomischer Ebene zur Verfügung steht.

Table 6: Movement in G.D.P. 1700–1849[a]

1913 = 100

	Austria	Belgium	Denmark	France	Germany	Netherlands	U.K.	U.S.A.
1700				12.51[b]		11.20	3.91	
1760				15.52		10.50	5.52	
1800							9.13	
1810							10.93	
1820		(11.3)	12.6	24.2	(11.2)	12.56	13.8	2.03
1821			13.2	26.1				
1822			13.4	25.1				
1823			13.4	26.5				
1824			13.8	27.6				
1825			13.9	26.6				
1826			14.1	27.2				
1827			14.5	27.8				
1828			14.7	28.0				
1829			14.4	28.7				
1830	21.1		14.5	27.2			18.8	
1831			14.4	27.5	14.6		19.7	
1832			14.8	30.1			19.5	
1833			14.7	30.4			19.7	
1834			15.5	30.0			20.5	
1835			15.4	31.8			21.6	
1836			15.4	31.2			22.4	
1837			15.8	32.6			22.1	
1838			15.9	33.0			23.3	
1839			16.1	30.4			24.4	
1840	24.0		16.6	34.7			23.7	5.07
1841			16.6	35.1			23.2	
1842			16.7	34.9			22.7	
1843			17.6	35.4			23.1	
1844			18.5	37.5			24.5	
1845		22.5	19.0	36.0			25.8	
1846		23.6	19.4	35.2			27.5	
1847		23.7	19.3	40.5			27.7	
1848		24.4	20.3	38.4			28.0	
1849			21.5	39.9			28.5	

a) Estimates adjusted as far as possible to exclude the impact of frontier changes. Figures in brackets derived by interpolation or extrapolation.
b) 1701–10.

Table 7: Movement in G.D.P., Annual Data 1850-1869[a]

1913 = 100

	Australia	Austria	Belgium	Denmark	Finland	France	Germany	Italy	Norway	Sweden	U.K.	U.S.A.
1850		27.8	25.4	22.7		40.0	20.3				28.2	7.8
1851			26.1	21.6		39.4	20.2				29.4	
1852			26.8	22.4		41.5	20.6				29.9	
1853			27.5	22.5		39.1	20.5				31.0	
1854			29.2	22.6		41.2	21.0				31.8	
1855			29.4	25.1		40.7	20.7				32.7	
1856			31.0	23.7		42.6	22.4				34.0	
1857			31.8	24.1		46.1	23.5				34.6	
1858			32.0	23.9		48.5	23.4				34.7	
1859			32.0	25.5		44.8	23.5				35.6	
1860		32.1	33.6	25.3	22.8	47.1	24.9				36.4	12.7
1861	15.2		34.1	25.7		45.4	24.3	48.7		24.1	37.4	
1862	15.0		35.0	26.5		48.3	25.5	49.7		24.9	37.7	
1863	15.5		36.0	28.2		50.7	27.4	48.9		25.6	38.0	
1864	17.2		37.2	27.9		50.3	28.2	50.2		26.1	39.0	
1865	17.1		37.2	28.9		51.8	28.3	52.5	37.6	26.7	40.2	
1866	18.2		38.3	28.9		51.9	28.5	54.7	38.3	27.7	40.8	
1867	20.4		38.5	28.9		48.4	28.6	50.1	39.3	27.9	40.4	
1868	21.4		39.9	29.4		54.4	30.3	51.9	39.1	26.4	41.7	
1869	21.6		41.4	31.1		56.7	30.5	52.9	40.7	27.7	42.0	

a) estimates adjusted to exclude the impact of frontier changes.

Table 8: Movement in GDP, Annual Data 1870–1913[a]

1913 = 100

	Australia	Austria	Belgium	Canada	Denmark	Finland	France	Germany
1870	25.6	35.9	42.5	20.1	32.4	27.8	49.4	30.4
1871	24.6	38.5	42.6	20.7	32.5		51.2	30.2
1872	27.3	38.8	45.2	17.4	34.3		55.1	32.3
1873	30.2	37.9	45.5	19.1	34.1		51.7	33.7
1874	31.2	39.6	47.0	23.1	35.1		58.5	36.2
1875	34.5	39.8	46.9	22.3	35.7		61.0	36.4
1876	34.5	40.7	47.5	22.5	36.4		58.6	36.2
1877	35.8	42.1	48.1	23.1	35.4		59.9	36.0
1878	39.2	43.5	49.5	22.7	36.8		58.7	37.7
1879	39.9	43.2	50.0	26.6	38.0		56.9	36.8
1880	42.0	43.8	52.5	29.6	38.9	35.5	60.3	36.5
1881	45.0	45.6	53.2	33.6	39.3		62.1	37.4
1882	42.4	45.9	55.0	33.4	40.7		64.4	38.0
1883	48.7	47.8	55.8	32.8	42.1		63.1	40.1
1884	49.1	49.1	56.3	36.1	42.3		61.6	41.1
1885	52.3	48.8	57.0	40.0	42.6		62.1	42.1
1886	52.8	50.4	57.7	36.1	44.3		62.9	42.4
1887	60.4	53.9	59.9	36.1	45.9		63.1	44.1
1888	58.9	53.8	60.3	38.0	46.2		62.7	45.9
1889	63.9	53.3	63.2	37.1	46.8		63.7	47.2
1890	61.7	56.2	64.6	38.0	49.6	44.4	65.5	48.7
1891	66.5	58.2	64.7	44.3	50.6		66.7	48.6
1892	58.3	59.5	66.3	43.3	51.8		68.6	50.6
1893	55.1	59.9	67.3	42.1	52.8		66.9	53.1
1894	57.0	63.4	68.3	41.9	53.9		71.7	54.4
1895	53.7	65.1	69.9	44.1	56.9		70.2	57.0
1896	57.8	66.1	71.3	48.4	59.0		72.4	59.0
1897	54.6	67.5	72.6	42.0	60.4		71.1	60.7
1898	63.1	71.3	73.8	49.8	61.4		75.0	63.3
1899	63.2	72.8	75.3	47.7	64.0		78.9	65.6
1900	66.9	73.4	77.5	49.9	66.2	69.1	80.3	68.4
1901	65.0	75.7	78.2	54.8	69.0	67.4	77.6	66.8
1902	65.9	76.6	79.8	58.8	70.6	65.3	77.6	68.4
1903	67.3	77.3	81.6	60.5	74.8	71.1	80.3	72.2
1904	70.4	78.5	83.7	61.6	76.4	74.1	84.2	75.1
1905	71.3	82.9	86.1	66.3	77.7	75.0	82.9	76.7
1906	78.0	86.1	87.9	70.1	79.9	77.8	84.2	79.0

Table 8 (Fortsetzung)

1913 = 100

Italy	Japan	Netherlands	Norway	Sweden	Switzerland	U.K.	U.S.A.
53.5	(35.2)	40.6	40.6	30.9	41.3	44.6	17.3
53.1			41.2	32.0		47.0	18.4
52.6			43.8	34.0		47.1	19.8
54.7			44.7	35.9		48.2	20.1
54.7			46.2	36.3		49.0	20.0
56.2			47.6	35.6		50.2	20.7
55.6			49.0	37.8		50.7	21.6
55.5			49.2	37.8		51.2	23.0
55.7			47.7	37.7		51.4	24.4
56.3			48.3	40.0		51.2	25.8
57.2			49.8	40.3		53.6	27.7
54.4			50.2	40.9		55.5	28.9
57.2			50.0	41.0		57.1	30.1
56.9			49.8	43.2		57.5	30.9
57.6			50.8	43.2		57.6	31.5
58.2	45.6		51.4	43.8		57.3	32.1
59.3	49.4		51.7	44.3		58.2	34.3
59.7	51.7		52.3	43.7		60.5	35.7
59.0	49.4		54.6	45.5		63.2	36.6
57.2	52.0		56.5	46.0		66.6	38.7
61.2	56.6		58.0	47.4	58.0	66.9	41.5
61.8	54.0		58.5	49.3		66.9	43.3
59.4	57.6		59.8	50.0		65.3	47.5
61.4	57.8		61.4	51.4		65.3	45.2
60.7	64.6		61.6	52.8		69.7	43.9
62.0	65.6		62.2	55.9		71.9	49.2
63.0	62.0		64.1	57.8		74.9	48.2
60.5	63.2		67.3	60.2		75.9	52.8
64.4	75.2		67.5	61.8		79.6	53.9
65.3	69.7		69.4	63.0		82.9	58.8
69.8	72.7	74.1	70.6	64.6		82.3	60.4
73.4	75.2	74.3	72.5	63.9		82.3	67.2
73.8	71.4	77.1	74.0	66.3		84.4	67.9
74.8	76.3	78.8	73.7	69.7		83.5	71.2
74.9	77.0	79.4	73.6	71.9		84.0	70.3
77.5	75.7	82.2	74.5	73.3		86.5	75.5
79.1	85.5	81.1	77.2	79.8		89.4	84.2

Table 8 (Fortsetzung)

1913 = 100

	Australia	Austria	Belgium	Canada	Denmark	Finland	France	Germany
1907	80.0	91.4	89.2	70.4	82.9	82.6	85.5	82.5
1908	78.3	91.8	90.1	73.4	85.5	82.4	86.8	83.9
1909	82.1	91.5	91.8	81.7	88.8	83.0	88.2	85.6
1910	88.2	92.8	94.2	83.3	91.5	85.3	88.2	88.7
1911	91.3	95.7	96.4	90.5	96.4	88.7	92.1	91.7
1912	95.1	100.5	98.7	92.2	96.4	96.1	100.0	95.7

a) estimates adjusted to exclude the impact of frontier changes.

Table 8 (Fortsetzung)

1913 = 100

Italy	Japan	Netherlands	Norway	Sweden	Switzerland	U.K.	U.S.A.
87.1	88.2	87.1	80.1	83.1		91.1	85.5
87.0	88.8	86.9	82.7	83.4		87.4	78.5
92.4	88.7	89.7	84.9	83.6		89.4	88.1
87.7	90.2	89.3	87.9	88.8		92.2	89.0
93.1	95.0	91.6	90.6	92.6		94.9	91.9
95.3	98.6	98.6	94.7	96.1		96.3	96.2

Table 9: Movement in GDP, Annual Data 1913-49[a]

	Australia	Austria	Belgium	Canada	Denmark	Finland	France	Germany
1914	94.4			93.9	106.3	92.9	94.4	85.2
1915	93.5			96.8	98.9	91.0	86.9	80.9
1916	97.1			101.1	103.1	95.6	83.2	81.7
1917	94.7			103.3	97.0	81.0	80.7	81.8
1918	95.0			104.2	93.8	63.9	76.4	82.0
1919	93.4			109.1	105.9	75.3	75.2	72.3
1920	97.0	66.4	92.5	103.7	110.9	88.7	81.8	78.6
1921	105.9	73.5	94.1	94.3	107.7	92.0	80.5	87.5
1922	110.5	80.1	103.3	101.9	118.6	103.0	93.1	95.2
1923	114.5	79.3	107.0	108.3	131.1	109.1	98.1	79.1
1924	120.5	88.5	110.5	108.1	131.5	115.2	108.2	92.6
1925	122.5	94.5	112.2	112.8	128.5	122.2	109.4	103.0
1926	123.2	96.1	116.0	122.7	136.0	126.7	110.7	105.9
1927	125.7	99.0	120.3	134.3	138.7	137.4	109.4	116.5
1928	123.4	103.6	126.6	146.6	143.4	142.0	115.7	121.6
1929	123.1	105.1	125.5	147.2	153.0	141.2	125.8	121.1
1930	118.1	102.2	124.3	140.9	162.1	138.9	122.0	119.4
1931	113.3	94.0	122.1	125.0	163.9	132.8	117.0	110.3
1932	117.6	84.3	116.6	110.2	159.6	135.2	112.0	102.0
1933	123.3	81.5	119.1	102.9	164.7	144.7	117.0	108.4
1934	127.0	82.2	118.1	115.4	169.7	162.9	117.0	118.3
1935	131.6	83.8	125.4	124.4	173.5	166.8	113.2	127.2
1936	137.1	86.3	126.3	129.9	177.8	178.5	114.5	138.4
1937	143.7	90.9	128.0	142.9	182.1	196.1	120.8	153.4
1938	145.2	102.5	125.1	144.1	186.5	197.5	120.8	169.1
1939	146.2	116.2		154.8	195.4	192.1	125.8	182.7
1940	155.7	113.2		176.6	168.0	169.2	103.8	184.0
1941	173.2	121.3		202.0	151.4	179.5	82.3	195.7
1942	193.1	115.2		239.5	154.8	187.7	73.6	198.4
1943	199.9	118.0		249.2	171.9	204.6	69.8	202.3
1944	193.0	121.0		259.0	189.9	200.8	61.0	207.5
1945	183.4	50.0		253.2	175.6	171.1	66.2	145.3
1946	176.8	58.4		246.4	203.0	193.3	100.6	83.0
1947	181.1	64.4		256.9	214.4	206.1	109.5	101.9
1948	192.8	82.0	132.9	263.3	221.5	219.5	125.8	120.8
1949	205.4	97.5	138.3	269.8	231.5	228.8	134.5	140.7

a) estimates adjusted to exclude the impact of frontier changes.

Table 9 (Fortsetzung)

1913 = 100

Italy	Japan	Netherlands	Norway	Sweden	Switzerland	U.K.	U.S.A.
99.0	97.0	99.1	102.2	100.2		101.0	92.3
110.8	106.1	100.8	106.6	98.5		109.1	94.9
122.5	122.4	105.3	110.0	104.0		111.5	108.0
126.5	126.7	97.7	100.0	92.5		112.5	105.3
127.5	124.0	92.5	96.3	92.0		113.2	114.8
107.8	140.9	115.7	112.6	96.5		100.9	115.8
100.0	132.2	118.3	119.7	102.8		94.8	114.7
98.0	146.9	122.7	109.8	105.9		87.1	112.1
103.9	146.3	127.5	122.6	111.8		91.6	118.3
109.8	146.3	131.9	125.3	116.9		94.5	133.9
111.8	151.2	136.3	124.7	119.3	119.2	98.4	138.0
119.6	156.7	142.8	132.4	130.4	127.8	103.2	141.2
120.6	158.1	146.2	135.3	138.7	134.2	99.4	150.4
117.6	160.6	154.2	140.5	144.9	141.5	107.4	151.9
126.5	172.8	158.5	145.1	145.3	149.3	108.7	153.6
130.4	178.9	166.5	158.6	156.5	154.5	111.9	163.0
123.5	166.1	168.2	170.3	165.5	153.6	111.1	147.4
122.5	171.6	162.6	157.1	153.9	147.2	105.4	136.1
125.5	173.2	157.0	167.6	150.2	142.2	106.2	117.4
125.5	180.5	152.9	171.6	153.7	149.2	109.3	115.0
125.5	199.9	154.3	177.1	163.3	149.5	116.5	123.9
137.3	204.7	158.3	184.7	172.7	148.9	121.0	134.6
137.3	211.2	161.3	196.0	183.7	149.4	126.5	153.3
146.1	261.2	170.0	203.0	186.6	156.5	130.9	160.7
148.0	270.0	171.6	208.1	192.7	162.6	132.5	153.6
158.8	272.3	178.2	218.0	199.4	162.3	133.8	165.6
159.8	256.0	160.0	198.6	190.7	164.0	147.2	178.4
157.8	260.1	162.8	203.4	190.6	162.9	160.6	207.5
155.9	263.5	148.7	195.5	196.6	158.8	164.6	239.5
141.2	262.8	144.6	191.6	199.9	157.4	168.2	276.0
114.7	254.0	97.7	181.6	207.2	161.2	161.6	295.5
89.8		99.1	203.5	220.6		154.5	291.1
117.6		173.2	225.3	232.1		147.8	247.9
138.2	152.8	200.0	251.1	241.6		145.6	243.5
146.1	171.0	221.4	271.1	251.5	204.1	150.2	253.3
156.9	179.0	235.5	276.4	264.9	196.1	155.8	254.7

Table 10: Movement in GDP, Annual Data 1950–79[a]

	Australia	Austria	Belgium	Canada	Denmark	Finland	France	Germany
1950	219.6	109.6	145.9	290.2	248.2	243.0	144.6	161.0
1951	229.0	117.1	154.2	303.2	246.4	265.6	153.0	177.8
1952	231.1	117.2	153.0	329.6	250.7	274.8	158.2	193.5
1953	238.3	122.3	157.9	345.9	265.2	275.1	162.1	209.5
1954	253.1	134.8	164.4	342.1	274.4	300.0	168.9	225.6
1955	266.9	149.7	172.2	374.7	273.4	322.7	176.8	252.8
1956	276.0	160.0	177.2	406.9	278.9	329.1	187.3	270.9
1957	281.6	169.8	180.5	417.3	291.0	334.1	198.5	286.1
1958	295.1	176.0	180.3	426.2	299.1	333.8	204.3	296.3
1959	313.8	181.0	186.0	443.1	319.7	358.0	210.8	318.2
1960	327.4	195.9	196.0	455.6	338.6	393.6	225.9	346.5
1961	334.8	206.8	205.9	469.5	360.2	423.4	238.3	364.2
1962	348.2	212.2	216.8	501.3	380.7	434.5	254.3	380.2
1963	372.3	221.0	226.3	529.1	383.1	449.2	267.8	391.6
1964	398.8	234.7	242.1	562.9	418.6	472.9	285.3	417.8
1965	416.6	241.5	251.1	601.0	437.7	497.9	298.9	441.4
1966	434.0	255.2	258.7	643.3	449.7	508.4	314.5	452.4
1967	455.7	262.8	269.0	665.4	470.3	520.1	329.3	451.6
1968	485.7	274.6	280.4	702.6	490.3	533.3	343.3	480.0
1969	522.0	291.8	298.9	739.2	524.1	584.6	367.3	517.6
1970	550.8	312.6	317.8	758.3	537.8	630.8	388.3	548.6
1971	577.4	330.2	330.1	811.2	550.9	642.4	409.3	566.3
1972	600.7	350.1	347.7	858.8	580.7	690.9	433.5	587.0
1973	628.0	368.5	369.3	923.2	611.2	736.0	456.8	615.8
1974	648.9	384.3	385.8	955.9	605.8	759.4	471.6	619.1
1975	662.9	377.8	378.4	966.6	602.1	763.8	472.4	607.7
1976	682.1	399.6	398.4	1,022.7	649.9	767.7	496.9	639.0
1977	693.8	417.0	401.5	1,047.6	661.6	768.5	510.8	658.4
1978	708.6	421.3	413.4	1,085.6	670.0	786.0	529.2	680.2
1979	730.2	442.6	423.2	1,117.3	693.6	842.8	545.9	711.4

a) Estimates adjusted to exclude the impact of frontier changes.

Table 10 (Fortsetzung)

1913 = 100

Italy	Japan	Netherlands	Norway	Sweden	Switzerland	U.K.	U.S.A.
169.6	194.8	243.0	291.5	279.3	209.5	160.8	276.8
182.5	219.1	247.3	305.0	287.7	226.5	166.6	299.6
190.6	244.5	252.1	315.9	292.6	228.4	166.2	310.6
204.9	262.5	272.8	331.7	302.1	236.5	173.8	322.6
212.4	277.4	291.1	344.5	320.1	249.7	180.5	318.6
226.5	301.1	311.5	351.8	329.8	266.6	186.5	339.8
237.1	323.8	325.4	369.8	340.7	284.2	189.4	346.9
249.7	347.5	335.1	378.3	348.8	295.5	193.1	353.0
261.8	367.8	331.8	383.3	357.0	289.2	193.4	352.0
278.9	401.3	347.4	394.4	375.6	307.5	201.1	373.0
296.5	453.9	378.8	413.0	389.9	329.0	211.6	380.1
320.8	520.0	390.4	433.9	412.2	355.7	218.6	390.0
340.7	556.7	405.9	454.3	429.9	372.7	220.7	412.3
359.9	615.2	420.6	471.5	452.3	390.9	229.3	428.8
369.9	696.4	455.4	495.1	483.6	411.4	241.3	451.3
382.0	732.2	479.3	521.3	503.5	424.5	246.9	478.5
404.9	811.8	492.5	541.0	514.7	435.0	251.9	507.7
433.9	912.8	518.5	574.9	533.1	448.3	258.4	521.5
462.3	1,041.2	551.8	587.9	552.5	464.3	269.1	545.4
490.5	1,167.9	587.2	614.4	578.8	490.5	273.1	560.8
516.6	1,304.8	626.6	626.6	610.4	521.8	279.1	559.7
525.1	1,371.4	653.4	655.3	616.5	543.1	286.7	578.0
541.9	1,499.5	675.7	689.2	629.2	560.4	292.9	610.3
580.0	1,633.7	714.2	717.5	653.3	577.5	314.9	644.0
604.0	1,628.1	739.5	744.9	680.0	585.9	311.2	639.2
582.1	1,650.4	731.8	786.2	697.0	543.2	308.8	633.6
616.2	1,757.1	770.8	839.8	708.1	535.6	321.6	667.4
627.9	1,851.9	789.1	869.8	691.2	548.6	324.8	703.6
644.1	1,960.7	808.6	898.3	700.6	550.4	336.5	735.9
676.0	2,076.4	826.3	926.6	728.8	562.6	339.6	756.2

Annex

The annex indicates the sources I used to measure GDP growth. It is intended to provide some indication of the wealth of the present literature in this field, and of the gaps that remain to be filled.

Australia: 1861–1901, GDP from N. G. Butlin, *Australian Domestic Product, Investment and Foreign Borrowing 1861–1938/39,* Cambridge 1962, pp. 33–4. 1901–51, GDP at 1966/67 prices from M. W. Butlin, *A Preliminary Annual Database 1900/01 to 1973/74,* Discussion Paper 7701, Reserve Bank of Australia, May 1977. All figures adjusted to a calendar year basis.

Austria: 1830–1913 from A. Kausel, *Österreichs Volkseinkommen 1830 bis 1913,* in: Geschichte und Ergebnisse der zentralen amtlichen Statistik in Österreich 1829–1979, Beiträge zur österreichischen Statistik, Heft 550, 1979. 1913–50 gross national product from A. Kausel, N. Nemeth and H. Seidel, *Österreichs Volkseinkommen, 1913–63,* in: Monatsberichte des Österreichischen Institutes für Wirtschaftsforschung, 14th Sonderheft, Vienna, August 1965. 1937–45 from F. Butschek, *Die Österreichische Wirtschaft 1938 bis 1945,* Stuttgart, 1979, p. 65. The figures are corrected for territorial change which has been large (in 1911–13 present day Austria represented only 37.4 per cent of the total output of the Austrian part of the Austro-Hungarian Empire). They refer to the product generated within the present boundaries of Austria.

Belgium: 1846–1913 gross domestic product derived from movements in agricultural and industrial output from J. Gadisseur, *Contribution à l'Etude de la Production Agricole en Belgique de 1846 à 1913,* in: Revue Belge d'Histoire Contemporaine, IV (1973), 1–2, and service output which was assumed to move with employment in services (derived for census years from P. Bairoch, *La Population Active et sa Structure,* Brussels 1968, pp. 87–88). 1913 weights derived from Carbonnelle. 1913–50 gross domestic product estimates derived from C. Carbonnelle, *Recherches Sur l'Evolution de la Production en Belgique de 1900 à 1957,* in: Cahiers Economiques de Bruxelles, No. 3, April 1959, p. 353. Carbonnelle gives G.D.P. figures for only a few benchmark years but gives a commodity production series for many more years. Interpolations were made for the service sector to arrive at a figure for G.D.P. for all the years for which Carbonnelle shows total commodity production. Figures corrected to exclude the effect of the cession by Germany of Eupen and Malmedy in 1925, which added 0.81 per cent to population and was assumed to have added the same proportion to output.

Canada: Gross national product (expenditure) from O. J. Firestone, *Canada's Economic Development 1867–1953,* London 1958, p. 276 for 1867–1926; 1926 to 1950 from *National Income and Expenditure Accounts 1926–1974,* Vol. I, Statistics Canada, 1976. Figures adjusted to offset the acquisition of Newfoundland in 1949 which added 1.3 per cent to G.N.P. and 2.6 to population.

Denmark: 1820–1950 G.D.P. at factor cost (1929 prices) from S. A. Hansen, *Økonomisk vaekst i Danmark,* Vol. II, Institute of Economic History, Copenhagen 1974, pp. 229–32 (figures from 1921 onwards adjusted to offset the acquisition of North Schleswig, which added 5.3 per cent to the population, and 4.5 per cent to G.D.P.).

Finland: 1860–1950 GDP from O. E. Niitamo, *National Accounting and National Statistical Service on the Threshold of the 1980's,* in: Finnish Journal of Business Economics, I, (1980).

France: For the eighteenth century J. Marczewski has presented rough estimates of economic growth based partly on the work of his colleague J. C. Toutain, who showed a 60 per cent increase in agricultural output between the first and eighth decade. Toutain's estimates have been criticised by M. Morineau, *Les Faux-Semblants d'un Demarrage Economique,* Paris 1971 who rejects all evidence of French progress rather in the style of a prosecution attorney. E. Le Roy Ladurie presents a more balanced criticism and also presents an alternative estimate to Toutain which I have used. The sources to 1820 were therefore: 1701–10 to 1820 movement in industry and 1781–90 to 1820 movement in agriculture from J. Marczewski, *Some Aspects of the Economic Growth of France, 1660–1958,* in: Economic Development and Cultural Change, April 1961, p. 375; 1701–10 to 1781–90 agricultural output increase assumed to be 32.5 per cent, the mid point of the range suggested by E. Le Roy Ladurie, *Le Territoire de l'Historien,* Vol. I, Paris 1973, p. 279. 1701–10 to 1781–90 output in services assumed to move parallel with population. 1781–90 to 1820 output in services from J. Marczewski, *The Take-Off Hypothesis and French Experience,* in: W. W. Rostow (ed.), The Economics of the Take-Off into Sustained Growth, New York 1965, p. 136. 1820–96 gross domestic product derived from separate indicators of industrial, agricultural, building, and service output. Industrial production, agriculture and building from M. Levy-Leboyer, *La Croissance Economique en France au XIXe Siecle,* in: Annales, July-August 1968, p. 802 bis. Service output interpolated from J. Marczewski, Take-Off, p. 136. 1896–1950 GDP and 1896 sector weights from J. J. Carre, P. Dubois and E. Malinvaud, *La Croissance Française,* Paris 1972, pp. 35 and 637. Interpolation between 1913 and 1920 based on figures for industrial and agricultural output shown in J. Dessirier, *Indices Compares de la Production Industrielle et Production Agricole en Divers Pays de 1870 a 1928,* in: Bulletin de la Statistique Generale de la France, Etudes Speciales, October-December 1928; service output was assumed stable in this period, and weights for the three sectors were derived from Carre, Dubois and Malinvaud, Croissance. Interpolation between 1939 and 1946 was based on A. Sauvy's report on national income to the Conseil Economique, *Journal Officiel,* 7th April, 1954. (Sauvy's estimates for this period seem reasonable when checked against estimates of wartime agricultural and industrial output. See M. Cepede, *Agriculture et Alimentation en France Durant la IIe Guerre Mondiale,* Paris 1961 and *Annuaire de Statistique Industrielle 1938–1947,* Ministere de l'Industrie et du Commerce, Paris, 1948.) The figures from 1918 onwards were adjusted downwards by 4.6 per cent to offset the impact of the return of Alsace Lorraine, figures for 1861–70 multiplied by 95.92 to offset for inclusion of Alsace Lorraine, and 1860 and earlier by 97.65 to offset both the impact of acquisition of Nice and Savoy in 1861 and the Alsace-Lorraine component.

Germany: 1816–50 GDP estimated from Prussian data in R. H. Tilly, *Capital Formation in Germany in the Nineteenth Century,* in: P. Mathias and M. M. Postan (eds.), Cambridge Economic History of Europe, Vol. VII, Part I, pp. 395, 420 and 441. Using 1850 weights for agriculture, industry and services from Hoffmann, p. 454, Prus-

sian per capita output in agriculture and industry were multiplied by population in Germany as a whole. Output in services was assumed to move with population. 1850–1925 net domestic product (value added by industry) at factor cost from W. G. Hoffmann, F. Grumbach and H. Hesse, *Das Wachstum der deutschen Wirtschaft seit der Mitte des 19. Jahrhunderts,* Berlin 1965, pp. 454–5. This source gives no figures for 1914–24, but starts again in 1925. The pattern of movement in individual years 1914–24 was derived from annual indices of industrial and agricultural output in Dessirier, using Hoffmann's weights for these sectors and adjusting them to fit his sectoral output benchmarks for 1913 and 1925. Service output was interpolated between Hoffmann's 1913 and 1925 figures for this sector. 1925–39 GDP from *Bevölkerung und Wirtschaft 1872–1972,* Statistical Office, Wiesbaden 1972, p. 250. 1939–44 GNP from E. F. Denison and W. C. Haraldson, *The Gross National Product of Germany 1936–1944, Special Paper 1* (mimeographed), in: J. K. Galbraith (ed.), The Effects of Strategic Bombing on the German War Economy, U.S. Strategic Bombing Survey 1945. 1946 from *Wirtschaftsproblemen der Besatzungszonen,* Berlin 1948, p. 135; 1945 was assumed to lie midway between 1944 and 1946. 1947–50 from *Statistics of National Product and Expenditure No. 2, 1938 and 1947 to 1955,* O.E.E.C., Paris 1957, p. 63. The estimates are fully corrected for territorial change which was extremely complicated in Germany. It can be summarised in simplified form as follows (in terms of ratio of old to new territory 1870 96.15 per cent; 1918 108.39 per cent; 1946 155.35 per cent. (See A. Maddison, Phases of Capitalist Development, in: Banca Nazionale del Lavoro Quarterly Review, June 1977, p. 133–4 for full detail.)

Italy: 1861–1950 gross domestic product at 1938 prices from P. Ercolani, *Documentazione statistica di base,* in: G. Fua (ed.), La Sviluppo Economico in Italia, vol. III, pp. 410–12, Milan 1975. The figures refer to output in the present territory of Italy ("confini attuali", see p. 388). Figures in an earlier official study, *Annali di Statistica,* Serie VIII, vol. 9, Instituto Centrale di Statistica, Rome 1957 show a gain in output due to territorial change of 3.2 per cent after the first world war and a loss of 1.5 per cent after the second world war (corresponding population changes were a gain of 4.1 per cent and a loss of 1.4 per cent respectively).

Japan: 1885–1930, gross domestic product at 1934–36 prices from K. Ohkawa, N. Takamatsu and Y. Yamamoto, *National Income,* Vol. I of *Estimates of Long-Term Economic Statistics o Japan since 1868,* Toyo Keizai Shinposha, Tokyo 1974, p. 227. Rough estimate for 1870 was derived by assuming that per capita product rose by 1 per cent a year from 1870 to 1885. This is smaller than the later period, but 1870–85 saw major upheavals in which economic growth was probably slow. 1930–42, gross national product at 1934–36 prices from *National Income White Paper* (in Japanese), 1963 edition, p. 178 adjusted (from 1946 to a calendar year basis. 1952 onwards from *National Accounts of OECD Countries 1950–78,* Vol. I, pp. 28–9. In the above sources, Okinawa is included up to 1945, and excluded from 1946 to 1972. An upward adjustment of 0.66 per cent was made for 1946 to offset the impact of territorial change, and 1973 was adjusted down by 0.92 per cent of offset the impact of Okinawa's return.

Netherlands: For 1700 it was assumed that Dutch GDP per head was a little more than 50 per cent higher than that of the U.K. This rough assumption is based on comparative evidence of economic structure and relative levels of international trade, investment and government finance in the two countries as shown mainly in Jan de Vries, *The Dutch Rural Economy in the Golden Age, 1500–1700,* Yale 1974, and P. Deane and W. A. Cole, *British Economic Growth 1688–1959,* Cambridge 1964. In 1700 about two thirds of the U.K. labour force was in agriculture, and in the Netherlands the proportion was about one third. I assume productivity was higher in industry and services than in agriculture in both countries and the evidence suggests strongly that Dutch productivity was higher in each sector. Dutch agriculture was more specialised with a large internal trade carried by canal, exports of dairy products, a quarter of its grain was imported from Eastern Europe and cattle were imported on a large scale from Denmark. Its industry was highly diversified with a great deal of international trade, and the Dutch performing sophisticated finishing processes (bleaching, printing, dyeing) for English woollens and German linens. Activity in international banking, insurance, shipping, warehousing was on a much larger scale per capita than in the U.K. At the end of the seventeenth century the Dutch merchant fleet was about 50 per cent larger than the British but population was a fifth of that in the U.K. (See R. Davis, *The Rise of the English Shipping Industriy,* London 1962, p. 27 for the size of British fleets and W. Vogel, *Zur Grösse der europäischen Handelsflotten im 15., 16. und 17. Jahrhundert,* in: Festschrift D. Schäfer, Forschungen und Versuche zur Geschichte des Mittelalters und der Neuzeit, Jena, 1915, p. 331, for Dutch shipping.) Gregory King estimated Dutch per capita income as only 4 per cent higher than that of England in 1695 (see G. E. Barnett, *Two Tracts by Gregory King,* Baltimore 1936, p. 55) but he overestimated Dutch population by 18 per cent. Assuming that this error was independent of his output estimate (which is not clear) this would raise King's differential to about 23 per cent in favour of the Netherlands as against England. Our own estimates for the U.K. (see below) imply that U.K. per capita income in 1700 was about 4.5 per cent lower than that in England and Wales. Adjusting King again for this would produce a differential of 29 per cent in favour of the Netherlands as against the U.K. However, King estimates English consumption levels to be one third higher than the Netherlands (even after adjusting for his population error). This seems implausible. Hence, the evidence of Gregory King, though it points to a lower Dutch advantage than I suggest is not too persuasive. (H. C. Bos, *Economic Growth of the Netherlands,* IARIW Portoroz 1959 (mimeographed) presented a rough estimate of Dutch per capita income in 1688 compared with 1910 which is not different from my estimate, though the approach is quite different.)

In the eighteenth century the Dutch economy stagnated. The process is described in detail without any aggregate quantification by Johan de Vries, *De economische Achteruitgang der Republiek in de Achttiende Eeuw,* Leiden 1968. From 1700 to 1760 I have assumed that Dutch per capita GDP fell by 10 per cent and then stagnated. Per capita GNP probably did not decline because of the increase in foreign investment and the receipts from it. These receipts, and GDP, were quite adversely affected during the Napoleonic wars and French occupation. I have not made any direct estimate of 1820–70 growth, but this emerges as a by-product from the above and from estimates backcast from 1970 to 1870 from the following sources. 1870–1900 GDP from

S. Kuznets, *Economic Growth of Nations,* Harvard 1971, pp. 12 and 16. 1900–17, 1921–39, and 1948–50 net domestic product and 1917–20 national income at constant market prices derived from *1899–1959 Zestig Jaren Statistiek in Tijdreeksen,* Centraal Bureau voor de Statistiek, Zeist 1959, p. 102. 1939–47 real product in international units interpolated from C. Clark, *Conditions of Economic Progress,* 3rd ed., London 1957, p. 166–7.

Norway: Gross domestic product at market prices. 1865–1950 from *National Accounts 1865–1960,* Central Bureau of Statistics, Oslo 1965, pp. 348–59 (gross fixed investment was adjusted downwards by a third to eliminate repairs and maintenance). 1939–44 movement in national income (exluding shipping and whaling operations carried out from Allied bases 1940–44) from O. Aukrust and P. J. Bjerve, *Hva Krigen Kostet Norge,* Oslo 1945, p. 45. 1945 assumed to be midway between 1944 and 1946.

Sweden: 1861–1950 gross domestic-product from O. Krantz and C. A. Nilsson, *Swedish National Product 1861–1970: New Aspects on Methods and Measurement,* Kristianstad 1975, p. 171.

Switzerland: 1890–1944 real product in international units from C. Clark, *Conditions of Economic Progress,* 3rd edition, London 1957, pp. 188–9. The link 1938–48 is from *Europe and the World Economy,* OEEC, Paris 1960. 1948–76 from *Séries Revisées de la Comptabilité Nationale Suisse 1948–1970,* Federal Statistical Office, Berne 1977, pp. 26–7. The rough estimate for 1870 was derived by backward extrapolation of the 1890–1913 movement in output per head. There is a graphical indication of the growth of Swiss real product in F. Kneschaurek, *Probleme der langfristigen Marktprognose,* in: Aussenwirtschaft, December 1959, p. 336 for 1900–65. This shows faster growth than C. Clark to 1938. U. Zwingli and E. Ducret, *Das Sozialprodukt als Wertmesser des langfristigen Wirtschaftswachstums,* in: Schweizerische Zeitschrift für Volkswirtschaft und Statistik, March-June 1964, shows slower growth for 1910–38 than C. Clark.

U.K.: 1700–1800 England and Wales from P. Deane and W. A. Cole, *British Economic Growth 1688–1959,* Cambridge 1964, p. 78 (excluding government) and 1801–1831 for Great Britain from p. 282. The Deane and Cole estimates were adjusted to a U.K. basis, assuming Irish output per head in 1830 to be half of that in Great Britain (as Deane herself hypothesises in the source mentioned below) and to have been stagnant from 1800–1830, assuming that Scottish and Irish output per head in 1800 were threequarters of that in England and Wales in 1800, and that output per head increases by a quarter in these two areas from 1700 to 1800 (as compared with a growth of 47 per cent in England and Wales). 1830–1855 gross national product at factor cost from P. Deane, *New Estimates of Gross National Product for the United Kingdom 1830–1914,* in: The Review of Income and Wealth, June 1968, p. 106, linked to 1855–1950 gross domestic product at factor cost (compromise estimate) from C. H. Feinstein, *National Income Expenditure and Output of the United Kingdom 1855–1965,* Cambridge 1972, pp. T 18–20. Figures from 1920 onwards are increased by 3.8 per cent to offset the exclusion of output in the area which became the Irish Republic.

U.S.A.: G.D.P., 1820–40 at 1840 prices derived from P. A. David, *The Growth of Real Product in the United States before 1840: New Evidence, Controlled Conjectures,* in: Journal of Economic History, June 1967. The method assumes that 1820–40 agricultural output moved parallel with total population, derives the agricultural productivity movement from this and further assumes that agricultural and non-agricultural productivity grew at the same pace. Agricultural productivity in 1840 is taken as 51 per cent of non-agricultural. 1840–1889 movement of G.N.P. in 1860 prices (The movement in our estimates for the U.S.A. between 1840 and 1889 is very similar to those of T. S. Berry, *Revised Annual Estimates of American Gross National Product: Preliminary Annual Estimates of Four Major Components of Demand,* Virginia 1978, which is not surprising as they are both benchmarked on Gallman. Before 1840 Berry's estimates show even faster growth than David's.) derived from R. E. Gallman, *Gross National Product in the United States 1834–1909,* in: Output, Employment and Productivity in the United States after 1800, N.B.E.R., New York 1966, p. 26. Gallman does not actually give figures for 1840, 1850, 1860, 1870 and 1889. These were extrapolated from neighbouring years. The movement in individual years 1870–1889 was derived by using the index of output in mining manufacturing and construction in W. A. Lewis, *Growth and Fluctuations 1870–1913,* London 1978, p. 273, the index of farm production from F. Strauss and L. H. Bean, *Gross Farm Income and Indices of Farm Production and Prices in the United States 1869–1937,* Technical Bulletin 703, U.S. Dept. of Agriculture, Washington 1940, p. 126, table 61 (Laspeyre's index), and interpolating the movement in services from the residual derived from Gallman. 1889 weights (agriculture 28.1, industry 26.7, other 45.2 per cent) at 1929 prices were derived from *The National Income and Product Accounts of the United States, 1929–1974,* p. 186, and the 1889–1929 product movement by sector as shown in Kendrick, pp. 302–3 as cited below. 1889–1929, gross domestic product from J. W. Kendrick, *Productivity Trends in the United States,* National Bureau of Economic Research, Princeton 1961, p. 298–9. 1929–79 GDP from *The National Income and Product Accounts of the United States: An introduction to the Revised Estimates for 1929–80,* in: Survey of Current Business, December 1980, Figures corrected to exclude the impact of the accession of Alaska and Hawaii in 1960. These two states added 0.5 per cent to total product, but part was already included and the explicit addition was only 0.2 per cent, see *Survey of Current Business,* July 1962, p. 5.

Carl-Ludwig Holtfrerich

The Growth of Net Domestic Product in Germany 1850–1913*

I.

In 1965, Walther G. Hoffmann published his path-breaking collection of time series on the growth of the German economy since 1850.[1] Subsequently, the data have been used by economists to test empirically theories of economic growth[2] and by economic historians as a quantitative framework for describing more exactly the process of industrialization in Germany.[3] Hoffmann's figures on aggregate output, its components and factor inputs thus served as a basis for evaluation of different models of economic growth and of traditional interpretations of Germany's industrialization process, especially for the period 1850–1913. The data themselves, however, their sources, their compilation and their use in estimation procedures have not yet been subjected to a comprehensive critical analysis. This may have to do with the immense effort, which went into collecting and processing the data, especially so for the period before the First World War. At that time national income accounting had not yet been developed and therefore statistical offices failed to collect data with a view to that concept. It probably exceeds the working capacity of an individual scholar to undertake a thorough close examination of Hoffmann's numerous time series, especially for the period 1850–1913, for which most aggregate data were produced by estimation procedures selected by Hoffmann.

My contribution here has a more narrow focus and does not present the results of a new investigation into the sources. Its limited aim is, first, to take a critical look at

* I would like to thank my Frankfurt colleague, Prof. Heinz Grohmann, for a critical discussion of statistical-methodological questions.

1. Hoffmann, Walther G. et al., *Das Wachstum der deutschen Wirtschaft seit der Mitte des 19. Jahrhunderts,* Berlin 1965.
2. E.g. Gahlen, Bernhard, *Die Überprüfung produktionstheoretischer Hypothesen für Deutschland 1850–1913. Eine kritische Untersuchung,* Tübingen 1968.
   Gahlen, Bernhard, *Der Informationsgehalt der neoklassischen Wachstumstheorie für die Wirtschaftspolitik,* Tübingen 1972.
3. E.g. André, Doris, *Indikatoren des technischen Fortschritts. Eine Analyse der Wirtschaftsentwicklung in Deutschland von 1850 bis 1913,* Göttingen 1971.
   Schremmer, Eckart, *Wie groß war der "technische Fortschritt" während der Industriellen Revolution in Deutschland, 1850–1913,* in: Vierteljahrschrift für Sozial- und Wirtschaftsgeschichte, 60 (1973), pp. 433–458. Aubin, Hermann and Zorn, Wolfgang (eds.), *Handbuch der deutschen Wirtschafts- und Sozialgeschichte,* vol. 2: *Das 19. und 20. Jahrhundert,* Stuttgart 1976, especially the articles by Knut Borchardt.

the estimation procedure, by which Hoffmann aggregated his time series on the growth of Germany's real net domestic product at factor cost from data series on production of different branches of the economy, and, secondly, to recalculate the growth of the German net domestic product from 1850 to 1913 using an improved method. The difference between Hoffmann's and my results will then give an idea of the magnitude in which growth rates of Germany's net domestic product are determined by the aggregation procedure, i.e. by the assumptions underlying each method.

II.

Hoffmann presents data on the development of Germany's national product using the three standard approaches provided by national accounting: the output approach, the income approach, and the expenditure approach.[4] The result of the income approach is a time series on net national income in *current* prices; this does not allow an assessment of economic growth in *real* terms. In contrast to this, using the expenditure and the output approaches[5] Hoffmann computed time-series on the development of real net national product and real net domestic product. The results of the output approach are the preferred data on which to base a quantitative assessment of economic growth, because they are derived from observations of production activity in the different branches of the economy which are then aggregated into an index of production for the economy as a whole. Hoffmann's Table 101 presents the index thus constructed for the development of the German economy's real net domestic product at factor cost.[6] This index is usually the basis for the quantification of Germany's economic growth since 1850.

In detail, the index is constructed in the following manner: The total economy is grouped into nine branches: 1. agriculture, forestry and fisheries; 2. mining and salt works; 3. industry and crafts; 4. transport; 5. commerce, banking, insurance and catering trade; 6. domestic service; 7. other services without military services; 8. military services; 9. non-agricultural housing. For each branch Hoffmann has compiled data on production of the main goods and services. The time series thus produced are valued at 1913 prices and transformed into indices of production (1913 = 100). Where necessary, these indices were then aggregated into indices of production for the above mentioned nine branches of the economy. Normally the 1913 value-added share of each product or product group was used as a weight in the aggregation procedure; a product's share in employment in later and earlier years was also sometimes used to adjust these weights. The indices of production in each branch of the economy are thus principally based on price and value-added structures in 1913[7] which are partly themselves estimates from data found for the interwar years. Where weights were adjusted using employment shares in different years this

4. Hoffmann, *Wachstum*, pp. 165–170. See also: Stobbe, Alfred, *Volkswirtschaftliches Rechnungswesen*, 5th Ed., Berlin 1980, esp. pp. 146–151.
5. Hoffmann, *Wachstum*, pp. 451–455, 827–828.
6. Hoffmann, *Wachstum*, p. 451–452.
7. Hoffmann, *Wachstum*, p. 7.

was done on the assumption that "the structure of net production value per person employed ..., as [first] computed for 1936, can be assumed to be constant during the whole period from 1850 to 1959".[8]

The requirement to hold prices and values constant in order to obtain an index of production[9] makes it understandable that Hoffmann assumed constant price and value-added structures. It must be criticized, however, that constant weights are used over so long a period which by definition of the industrialization process is characterized by great changes in the structure of production and prices. Therefore, Hoffmann's index is bound to produce a bias in the estimate of economic growth which must be expected to be higher the greater the distance between the year, for which production is estimated and the year (mostly 1913), from which the weights are taken.

The above criticism also applies to the index which Hoffmann constructed for Germany's real net domestic product a factor cost, which was calculated on the basis of the indices of the nine different branches of the economy. He used data from the interwar years to estimate the share of value-added of each of the nine branches and applied these as constant weights in aggregating the sector indices to an index of the whole economy's value-added in constant prices (1913).[10] This procedure has two weaknesses. 1. Are the production indices of each branch also representative for the development of value-added in each branch? Hoffmann was able to produce an index of value-added, i.e. production minus intermediate goods, depreciation, inventory changes, indirect taxes,[11] only for the primary sector. 2. The above criticism of Hoffmann's calculation method for the branch indices also applies to his use of constant weights in computing the aggregate index. This is the point of departure for my following attempt to confront Hoffmann's procedure with a different method of aggregating the branch indices for the period 1850–1913 which takes into account changes in the economy's value-added structure and uses weights currently adjusted to the actual value-added shares in each year. This new procedure, of course, does not solve the problem connected with Hoffmann's use of constant weights to produce the branch indices themselves.

III.

In connection with the income approach to national product, Hoffmann's book contains time series on the development of the value-added (labor and capital income) of different branches. From these data I have calculated the share of each of the nine branches of the economy in total value-added in current prices. Table 1 presents the amount of value-added in current prices in each branch. In order to weaken the effect Hoffmann's choice of the base year (1913 = 100) has on the index of growth in the aggregation procedure, I have calculated annual growth factors $\frac{I_t}{I_{t-1}}$ from Hoffmann's branch indices.

8. Hoffmann, *Wachstum*, p. 389.
9. Yamane, Taro, *Statistics. An Introductory Analysis*, New York 1964, pp. 304–312.
10. Hoffmann, *Wachstum*, p. 453.
11. Hoffmann, *Wachstum*, p. 331–334.

For each year from 1851 to 1913 I have then aggregated the growth factors of each of the nine branches to produce a growth factor for the whole economy according to the following formula:

$$\frac{I_t^{(1)}}{I_{t-1}^{(1)}} \cdot VS_{t-1}^{(1)} + \frac{I_t^{(2)}}{I_{t-1}^{(2)}} \cdot VS_{t-1}^{(2)} + \ldots \frac{I_t^{(9)}}{I_{t-1}^{(9)}} \cdot VS_{t-1}^{(9)} = GF_t$$

I = index value of production in branches 1 to 9, as given by Hoffmann
VS = share of total value-added of each branch 1 to 9
GF = growth factor of the whole economy

The annual growth factors thus calculated are presented in Table 2. Annual growth rates in percent result when the data are transformed into $(GF-1) \cdot 100$.

Technically the growth factors could also easily be transformed into an index for the period 1850–1913 similar to Hoffmann's (1913 = 100). This would, however, not result in an index in the conventional sense because it would not be based on a constant weighting structure as required for indices of prices or production. In a strict sense, only each growth factor in itself constitutes an index of production for the current year in relation to the preceding year (= 1). A time series of index values cumulated from the annual growth factors would be a concatenation of the series of annual indices. Such an index of production does not allow the quantification of average annual growth rates over a very long period, such as from 1850–1913, because the weighting structures at the beginning of the series are too different from those at the end. But Hoffmann's index of production is also a doubtful basis for calculating the average annual growth rate over the 63 years before the First World War; it is true that it is computed with a constant weighting structure (1913), but the weighting shares lose in validity the further away in time from the base year they are applied to the aggregation of the branch indices to the index for overall production activity.

The growth rates, however, given in Table 2, should indicate annual growth of Germany's net domestic product more reliably than those derived from the Hoffmann index precisely because the weights are adjusted annually to the current branch structure of value-added. Since this structure did not change dramatically over a period of, say, one decade, in contrast to the longer period from 1850 to 1913, it is justified to calculate from Table 2 average annual growth factors—the geometric mean of the growth factors—over a period of ten years or so. The differences between the average annual growth rates during such periods derived from the data in Table 2, on the one hand, and from Hoffmann's index, on the other, are shown in Table 3.

The divergences tend to diminish in the course of the period from 1850 to 1913. This is what had to be expected since the current weighting structures tend to approach the one used by Hoffmann (1913 value-added structure). The differences are greatest during the so-called take-off period of Germany's industrialization up to 1874.[12]

12. Rostow, Walt W., *The Stages of Economic Growth. A Non-Communist Manifesto,* Cambridge 1960, p. 38. Rostow, Walt W., *The World Economy. History and Prospect,* Austin, Tex.-London 1978, p. 401.
Hoffmann, Walther G., *The Take-off in Germany,* in: Rostow, Walt W. (ed.), *The Economics of Take-off into Sustained Growth,* London 1963, pp. 93–118.

Table 1: Value-added in Current Prices in the Nine Branches of the German Economy 1850–1913 in Million Marks

	1 Agriculture; Forestry, Fisheries	2 Mining, Salt Works	3 Industry, Crafts	4 Transport	5 Commerce, Banking, Insurance, Catering Trade	6 Domestic Service	7 Other Services without Military Services	8 Military Services	9 Non-agricultural Housing
1850	1,753	76.2	1,513.3	89.7	271.5	293	458	53	223
1851	2,050	83.2	1,566.3	102.4	285.5	307	469	54	229
1852	2,480	86.2	1,551.5	112.2	299.2	335	470	55	245
1853	2,560	98.2	1,700.7	120.0	324.1	366	471	55	258
1854	3,101	122.5	1,649.7	141.0	356.8	417	475	56	261
1855	2,774	135.4	1,887.0	158.2	374.6	451	476	57	266
1856	3,373	143.7	1,939.4	165.3	376.9	444	481	58	268
1857	3,071	156.1	2,084.6	188.9	370.3	396	497	58	273
1858	2,707	157.7	2,080.9	194.8	364.4	384	510	60	280
1859	2,782	142.4	2,108.5	185.2	368.1	381	524	62	286
1860	3,382	136.8	2,188.8	210.0	388.4	404	531	73	293
1861	3,305	135.8	2,241.7	220.7	407.5	429	535	77	299
1862	3,485	148.0	2,265.6	248.5	414.4	432	539	74	308
1863	3,622	162.2	2,335.4	256.9	420.4	423	548	71	327
1864	3,579	177.2	2,360.9	281.6	423.0	415	553	73	350
1865	3,371	191.1	2,357.4	313.9	429.9	421	559	73	370
1866	3,551	195.6	2,452.9	330.5	451.4	437	599	93	390
1867	3,821	208.8	2,454.5	320.4	486.7	491	639	88	409
1868	4,545	219.9	2,633.6	358.8	529.5	521	681	89	430
1869	3,980	228.3	2,830.0	384.0	550.7	504	691	90	443
1870	3,833	231.3	3,065.6	414.4	594.2	518	703	115	454
1871	4,142	282.9	3,315.1	431.6	638.0	541	713	230	462
1872	4,722	358.6	3,909.7	511.4	716.7	571	772	122	479
1873	5,022	403.4	4,490.6	558.1	791.0	617	834	129	510
1874	5,487	381.4	4,483.2	606.1	840.4	654	897	125	562
1875	4,865	352.8	4,526.3	644.0	830.9	609	1,000	139	622
1876	5,129	316.9	4,440.3	646.9	823.9	601	1,101	130	666
1877	5,323	274.8	3,993.9	660.5	822.3	612	1,111	133	698
1878	5,102	277.8	3,879.2	669.2	857.9	619	1,121	136	730
1879	4,706	262.8	3,916.9	674.0	878.4	628	1,143	136	757
1880	5,116	290.4	4,058.7	729.7	900.9	633	1,148	137	774
1881	5,117	300.5	4,144.3	767.7	927.2	617	1,176	144	790
1882	4,899	337.7	4,312.9	824.0	964.4	636	1,196	145	808
1883	5,263	345.9	4,460.6	869.2	999.5	655	1,223	145	830
1884	5,275	349.4	4,651.9	872.8	1,014.7	636	1,240	148	855

1885	5,116	354.0	4,839.0	879.3	1,047.9	644	1,257	151	882
1886	5,070	356.0	5,136.5	894.2	1,070.5	635	1,285	155	862
1887	5,260	364.4	5,493.1	954.7	1,119.5	641	1,344	166	936
1888	5,267	386.4	6,055.3	1,036.5	1,189.4	656	1,409	170	973
1889	5,426	446.9	6,618.2	1,092.5	1,251.9	673	1,470	173	1,015
1890	6,124	531.5	7,034.4	1,123.0	1,334.1	686	1,539	180	1,068
1891	5,741	548.1	7,046.7	1,144.2	1,401.2	708	1,599	187	1,122
1892	6,181	530.8	6,997.5	1,155.4	1,445.7	720	1,654	192	1,176
1893	6,033	513.0	6,990.1	1,212.7	1,484.9	723	1,717	205	1,225
1894	5,970	520.9	7,057.7	1,248.7	1,527.4	726	1,758	215	1,270
1895	5,837	525.3	7,333.1	1,286.5	1,606.6	746	1,806	219	1,311
1896	5,959	581.0	8,009.5	1,342.1	1,710.5	765	1,851	222	1,354
1897	6,669	654.9	8,649.5	1,451.1	1,804.5	769	1,900	225	1,398
1898	7,353	726.4	9,359.8	1,573.0	1,921.8	775	1,952	206	1,447
1899	6,892	835.6	10,291.3	1,685.5	2,040.0	780	2,009	214	1,514
1900	6,939	968.7	11,110.8	1,826.6	2,193.4	781	2,110	227	1,581
1901	6,817	971.5	10,608.3	1,788.0	2,253.2	778	2,219	233	1,658
1902	7,361	916.4	10,532.5	1,822.6	2,336.1	779	2,249	233	1,731
1903	7,515	962.4	11,143.9	1,959.1	2,503.7	810	2,339	238	1,810
1904	7,788	1,023.3	11,810.4	1,986.1	2,671.2	842	2,426	257	1,889
1905	8,585	1,079.2	12,644.6	2,140.7	2,836.1	883	2,507	294	1,964
1906	8,754	1,217.6	13,966.9	2,332.8	3,068.6	933	2,612	352	2,051
1907	8,859	1,396.6	15,001.7	2,496.8	3,257.7	966	2,856	361	2,145
1908	9,145	1,433.3	14,413.4	2,337.0	3,330.2	974	2,970	303	2,241
1909	9,594	1,392.1	14,515.8	2,460.1	3,455.2	985	3,077	315	2,314
1910	10,070	1,446.2	15,513.4	2,610.5	3,625.4	992	3,372	314	2,416
1911	10,285	1,519.1	16,607.1	2,679.7	3,827.9	1,023	3,682	306	2,508
1912	11,144	1,694.6	17,900.8	2,998.9	4,096.6	1,072	3,857	335	2,605
1913	11,270	1,882.2	18,561.3	3,146.0	4,296.5	1,061	4,000	346	2,687

Source: Hoffmann, *Wachstum*

(1) Value-added (Table 65, Column 9).
(2) Labor income (Table 120, Column 2) + capital income*.
(3) Labor income (Table 120, Column 3) + capital income*.
(4) Value-added as computed from value-added in 1913 prices (Table 91, Column 9) multiplied by the price index of transport services (Table 148, Column 9).
(5) Labor income (Table 120, Column 5) + capital income*.
(6) Labor income (Table 120, Column 6).
(7) Labor income (Table 120, Column 7).
(8) Labor income (Table 120, Column 8).
(9) Capital income (Table 122, Column 8).

* Hoffman gives capital income in branches 2, 3 and 5 only in summary form. For my calculations I divided the sum roughly as follows: 7% branch 2, 87% branch 3 and 6% branch 5. This corresponds to the capital income shares of these branches in 1913 (Hoffmann, *Wachstum*, Table 102, Column 2). Since the overwhelming portion falls to branch 3 and, furthermore, since capital income in these three branches is of minor value compared to labor income, it should be of insignificant importance that possible shifts in the current share of capital income were not taken into account.

Table 2: Annual Growth Factors of Germany's Net Domestic Product at Factor Cost 1851–1913*

1851	0.9980	1872	1.0765	1893	1.0495
1852	1.0192	1873	1.0373	1894	1.0263
1853	0.9956	1874	1.0813	1895	1.0500
1854	1.0219	1875	1.0064	1896	1.0351
1855	0.9905	1876	0.9963	1897	1.0377
1856	1.0873	1877	0.9928	1898	1.0404
1857	1.0565	1878	1.0485	1899	1.0371
1858	0.9960	1879	0.9794	1900	1.0459
1859	1.0023	1880	0.9935	1901	0.9785
1860	1.0632	1881	1.0255	1902	1.0227
1861	0.9872	1882	1.0168	1903	1.0581
1862	1.0483	1883	1.0534	1904	1.0415
1863	1.0797	1884	1.0271	1905	1.0238
1864	1.0356	1885	1.0235	1906	1.0314
1865	1.0105	1886	1.0071	1907	1.0468
1866	1.0137	1887	1.0434	1908	1.0146
1867	1.0013	1888	1.0432	1909	1.0211
1868	1.0644	1889	1.0333	1910	1.0390
1869	1.0067	1890	1.0343	1911	1.0359
1870	1.0033	1891	1.0006	1912	1.0413
1871	1.0377	1892	1.0399	1913	1.0461

* Each in constant prices of the previous period using current value-added shares as weights.

Table 3: Comparison of Average Annual Growth Rates for Different Periods between 1850 and 1913*

	Net Domestic Product			Population
	according to Hoffmann, Table 101	according to Table 2	Difference	(Hoffmann, Table 1)
	%	%	%	%
1850–1857	2.13	2.36	0.23	0.48
1857–1863	2.56	2.88	0.32	1.00
1863–1874	2.94	3.31	0.37	0.73
1874–1883	1.14	1.22	0.08	1.02
1883–1890	2.81	3.02	0.21	0.97
1890–1900	3.46	3.62	0.16	1.30
1900–1907	2.71	2.87	0.16	1.46
1907–1913	3.26	3.29	0.03	1.29

* The periods correspond roughly to business cycles.

The annual average growth rates derived from Table 2 exceed those derived from Hoffmann's index by .2 and .3 percentage points during the years up to 1863, and by even .4 percentage points in the period 1863–1874. These differences are substantial, for they correct Hoffmann's annual average growth rates by between 11 and 13 percent upwards. The cumulation effect of such an increase in the growth rates for almost a quarter of a century is great and important for the assessment of Germany's economic growth in this early period of industrialization. Its relative impact is even more striking when annual growth is expressed in per capita terms, the rates of which roughly result when subtracting the growth rates of population (also in Table 3) from those of the net domestic product.

The differences between annual average growth rates of net domestic product calculated in the two ways narrow in the years 1874 to 1907 to a margin of .1 to .2 percentage points. The margin practically disappears for the above mentioned reason during the last period from 1907 to 1913.

It is, however, noteworthy that for all periods observed Hoffmann's growth rates are lower than those derived from Table 2. The differences of up to .4 percentage points indicate the magnitude, in which the growth rates of the German economy determined by Hoffmann, especially during the third quarter of the 19th century, are biased by his weighting method, namely by the use of constant value-added shares (1913) over the whole period back to 1850.

Zusammenfassung: Das Wachstum des Nettoinlandsprodukts in Deutschland, 1850–1913

Walther G. Hoffmanns Daten zum Wachstum der deutschen Wirtschaft seit 1850 sind bisher in vielfältiger Weise von Wachstumstheoretikern und Wirtschaftshistorikern zur Überprüfung von Wachstumstheorien und wirtschaftshistorischen Interpretationen des Industrialisierungsprozesses in Deutschland herangezogen worden. Die Daten selbst, ihre Quellen, ihre Zusammenstellung und die dabei benutzten Annahmen und Schätzverfahren haben bisher jedoch noch keine umfassende kritische Bearbeitung erfahren. In diesem Beitrag wird die Methode, die Hoffmann für die Aggregation der Produktionsindizes von neun Sektoren der Wirtschaft zu einer Zeitreihe für das Wachstum des realen Nettoinlandsprodukts zu Faktorkosten in Deutschland 1850–1913 verwendet hat, kritisch vorgestellt. Sodann wird der Hoffmannschen Zeitreihe eine nach einem anderen Verfahren geschätzte gegenübergestellt, um die Größenordnung festzustellen, in der die Wachstumsrate des realen Nettoinlandsprodukts zu Faktorkosten in Deutschland in jener Periode von jeweils gewählten statistischen Verfahren der Indexberechnung abhängt. Während Hoffmann die Struktur der Wertschöpfung seiner neun Wirtschaftssektoren aus dem Jahr 1913 als konstante Gewichtung für die Aggregation der Sektorindizes zum Index für die Produktion der Gesamtwirtschaft in Deutschland benutzt, verwendet der Autor in seinem Berechnungsverfahren eine jährlich über die Gesamtperiode 1850–1913 angepaßte Wertschöpfungsstruktur für die Gewichtung der Wachstumsraten in den einzelnen Sektoren zwecks Aggregation zur jährlichen Wachstumsrate der Gesamtwirtschaft.

Im Ergebnis liegen die vom Autor berechneten Wachstumsraten des deutschen Nettoinlandsprodukt höher als die von Hoffmann ermittelten. Die Unterschiede nehmen bis 1913 jedoch tendenziell ab, da sich die Gewichtungstrukturen beider Verfahren im Zeitablauf einander annähern. Die Unterschiede sind für die Periode des sog. take-off der deutschen Industrialisierung bis 1874 am größten und machen in dieser Periode im mehrjährigen Durchschnitt bis zu 0,4 Prozentpunkte aus. Dadurch werden die Hoffmannschen jährlichen Wachstumsraten um bis zu 13% nach oben korrigiert.

Gabriel Tortella

National Income Estimation by Means of Monetary Variables, the Case of Spain, 1772–1972. Some Preliminary Results

The reason why we are trying to carry out this kind of exercise is the same which has induced other researchers[1] to attempt it for other countries, namely the lack of satisfactory sources for national income estimates. It is expected, however, that in the not too distant future our research on Spanish output and productivity in the nineteenth and twentieth centuries will have yielded, among other things, more direct and reliable national income estimates for the nineteenth century, and at least some refinements upon those series now extant of Spanish national income in the twentieth century. This could seem to make the present project redundant. In our view, however, the project offers a series of advantages which make it worthwhile. In the first place, it will provide us with a first estimate in a relatively short time; this preliminary estimate should serve to orient us in research and as a possible test of some of our other estimates. Furthermore, the relative abundance of data for the twentieth century will permit us to contrast the method, as we will presently see, and possibly to discriminate between the several extant estimates. Finally, the result of our work will be a test of the method itself, and could suggest new ideas for further research.

The method of estimation is conceptually simple. Starting from the well known Fisher identity, we solve for PT ($\equiv$ Y $\equiv$ Gross National Product). Our basic equation would be

$$Y = MV, \tag{1}$$

where M = Money supply, and V = Income velocity. By using the equation in this form we are trying to take advantage of two facts: one, that we have a continuous series of money supply from 1874 (plus some spot estimates for earlier years); and two, that a considerable body of literature, plus our own calculations with the available data on money and income suggest a remarkable stability of V.[2]

1. Hawke, G. R., *Income Estimation from Monetary Data: Further Explorations*, in: Review of Income and Wealth, 21 (1975), no. 3; Leff, Nathaniel, *A Technique for Estimating Income Trends from Currency Data and an Application to Nineteenth-Century Brazil*, in: Review of Income and Wealth, 18 (1972), no. 4.
2. For a brief and incomplete survey of the literature on this topic see Tortella, Gabriel, *Estimación de la Renta Nacional española a partir de datos monetarios. Consideraciones preliminares (1789–1956)*, Typescript April 1981.

Table 1: Money, Income, and Income Velocity, 1865–1972

	(1) Money Supply[a]	(2) National Income[a]	(3) Income Velocity
1865	1 51o	5 o46	3.3414
1879	1 792	5 21o	2.9o74
1882	1 968	5 992	3.o447
1888	2 199	6 7o8	3.o5o5
1894	1 994	6 669	3.3445
19o1	3 229	1o 152	3.144o
19o2	3 o63	1o 4o9	3.3983
19o3	3 141	1o 75o	3.4225
19o4	3 o74	11 125	3.6191
19o5	2 945	11 2o1	3.8o34
19o6	2 884	11 324	3.9265
19o7	2 875	11 672	4.o598
19o8	2 785	11 926	4.2822
19o9	2 9o4	12 381	4.229o
191o	2 926	12 o38	4.1141
1911	2 973	12 745	4.2869
1912	3 129	12 638	4.o39o
1913	3 2o8	13 o86	4.o792
1914	3 32o	14 382	4.3319
1915	3 849	16 4o7	4.2627
1916	4 345	2o o47	4.6138
1917	5 37o	25 471	4.7432
1918	6 856	29 323	4.277o
1919	7 742	33 855	4.3729
192o	8 727	32 863	3.7657
1921	8 579	26 925	3.1385
1922	8 414	25 66o	3.o497
1923	8 49o	26 916	3.1731
1924	8 927	28 927	3.24o4
1925	9 o1o	31 35o	3.4795
1926	8 8o2	31 1o2	3.5335
1927	9 327	31 244	3.3498
1928	9 652	31 oo2	3.212o
1929	9 839	31 844	3.2365

Table 1 (Fortsetzung)

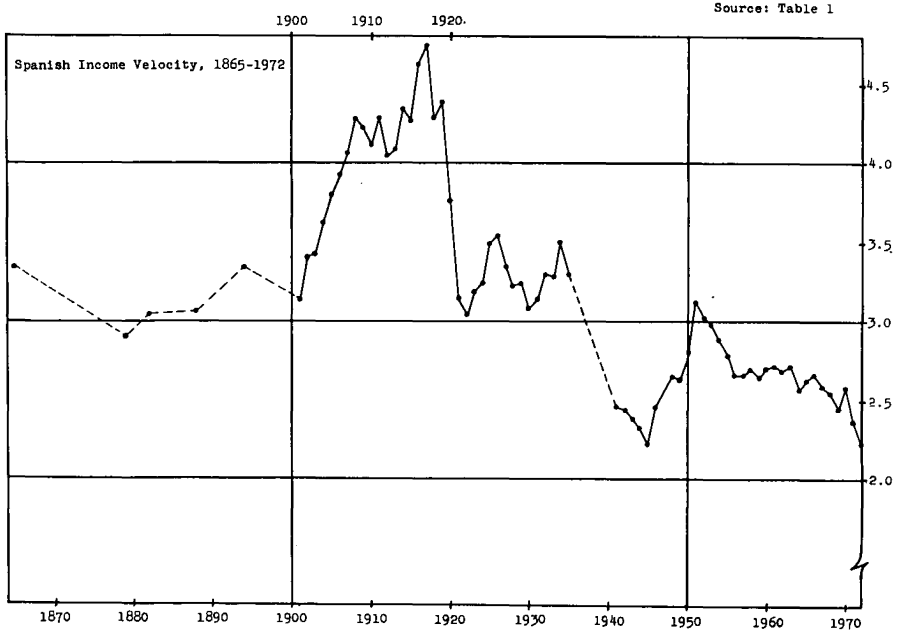
	(1)	(2)	(3)
193o	1o 226	31 5o3	3.o8o7
1931	1o 156	31 922	3.1432
1932	9 986	32 921	3.2967
1933	9 863	32 324	3.2773
1934	9 946	34 892	3.5o81
1935	1o 4oo	34 358	3.3o37
1941	22 98o	56 562	2.4614
1942	26 786	65 535	2.4466
1943	28 776	68 771	2.3899
1944	32 352	74 788	2.3117
1945	36 o72	79 737	2.21o5
1946	45 191	11o 9o8	2.4542
1947	51 67o	132 675	2.5677
1948	53 259	141 o52	2.6484
1949	57 798	151 42o	2.6198
195o	66 o44	182 o36	2.7563
1951	77 535	241 174	3.11o1
1952	85 277	256 7o2	3.o1o2
1953	91 691	272 635	2.9734
1954	1o2 514	294 816	2.8759
1955	117 695	327 693	2.7843
1956	141 212	376 746	2.6679
1957	164 758	439 516	2.6676
1958	187 719	5o8 456	2.7o86
1959	198 883	523 o67	2.63oo
196o	197 829	532 7o1	2.6927
1961	223 916	6o9 5o6	2.722o
1962	265 367	7o9 623	2.6741
1963	31o 416	841 29o	2.71o2
1964	368 55o	946 228	2.5674
1965	426 557	1 117 82o	2.62o6
1966	477 971	1 274 6o1	2.6667
1967	543 o39	1 4oo 759	2.5795
1968	6o9 378	1 552 134	2.5471
1969	698 765	1 7o7 747	2.444o

Table 1 (Fortsetzung)

	(1)	(2)	(3)
1970	739 994	1 907 506	2.5777
1971	915 144	2 160 481	2.3608
1972	1 132 668	2 520 537	2.2253

a Millions of current pesetas

Sources: Money: 1865, Tortella Casares, Gabriel, La economía española, 1830-1900, in: Tortella Casares, Gabriel, et al. (eds.), Revolución burguesa, oligarquía y constitucionalismo (1834-1923), Barcelona 1981, p. 124. For the rest of the series, Bustelo, and Tortella, Monetary Inflation, Table I.
Income: 1865-1894, Prados de la Escosura, Análisis, pp. 165-168, 211-212, esp. Table E-2. (The figure for 1865 has been interpolated linearly). 1901-1972, Alcaide, Revisión, pp. 1138 f.



A continuous money supply series from 1874 to 1972 has been published by Bustelo and Tortella.[3] This series comes from a variety of sources and can undoubtedly be improved. The 1918–1935 segment has been corrected by Pablo Martín Aceña in his yet unfinished doctoral dissertation, and the 1940–1954 segment should also be revised. In this paper we have been unable to incorporate these improvements; this is one of the factors which make it provisional. Though unrefined, however, the series is adequate for our present purposes.

Coupling the Bustelo-Tortella monetary series with the available national income estimates we obtain the first historical series for Spanish income velocity hitherto published (Table 1).

This velocity series elicits a few comments. In the first place, its stability is remarkable. Over more than a century its range has lain between 4.74 (1917) and 2.21 (1945). In fact, this stability is surprising in view of, among other things, the downward trends displayed in the Doblin[4] and other series. The Spanish series also exhibits a downward trend in the long run; but it is a very slow trend, and with a strong reversal in the years 1901–1917.

In the second place, however, the shorter-term fluctuations can be explained by taking account of the peculiarities of Spanish monetary and economic history. Restrictive monetary policies and the loss of gold in the last quarter of the nineteenth century checked the growth of M and kept V fairly stable. The fall between 1894 and 1901 was due to the rapid expansion of paper money which accompanied the War of Cuban Independence. The war was followed by a very strict stabilization plan which restricted budget expenditures and banknote circulation. This explains the constant growth of V until 1908, when restrictive policies were eased. The next spurt of growth in V took place during the First World War and was due to real rather than monetary causes. Spain remained neutral during the war, and had an export boom which provoked scarcities and steep price rises: prices running ahead of money brought about increases in V. The reverse process took place in the following years: prices declined faster than money and V dropped drastically between 1918 and 1922; it hovered at around its 'normal' level (3.00–3.50) until the Spanish Civil War. The trough reached by V during the mid-1940's was probably due to the low levels of income which characterized the first years of the Franco era, and the increase in 1946–51 to the gradual economic recovery towards prewar economic levels. The relatively mild decline which ensued must be attributed to the 'normal' decrease in V which is typical of the early and middle stages of growth.[5]

In the third place, the relative stability of V over the long run, and the relative ease with which we can explain shorter-run fluctuations are encoraging signs that the series are reliable. This is especially good news with respect to the nineteenth-century income figures, which are based upon Mulhall's estimates. The provisional accepta-

3. Bustelo, Francisco, and Tortella, Gabriel, *Monetary Inflation in Spain 1800–1970*, in: Journal of European Economic History, 5 (1976), no. 1.
4. Doblin, Ernest, *The Ratio of Income to Money Supply: An Inter-National Survey*, in: Review of Economics and Statistics, 33 (1951), no. 1.
5. Anderson, Paul S., *Behavior of Monetary Velocity*, in: New England Economic Review (Federal Reserve Bank of Boston), March-April 1977.

bility of the Mulhall-Prados[6] income figures is buttressed by a series of circumstantial facts: first, they seem to tally well with the monetary series; second, they show continuity with the Alcaide[7] income series starting in 1901; and third, Mulhall's figures for other countries have been vindicated by later research.

In the fourth place, while these figures and conclusions augur well for our ability to reach our ends for the period from 1865, that from the end of the eighteenth century to 1865 appears more problematic. It is very unlikely that we may obtain a yearly series of money supply for that time span. Even decennial figures appear highly improbable. The best we could realistically hope for would be a few scattered estimates permitting reasonable interpolations. This attained, we could make some simple assumptions about velocity. One of these assumptions, probably the best, would be a linear or exponential extrapolation of the trend in our 1865–1972 series. Other possible assumptions could be a fixed V with maximum and minimum intervals or bands, and the adoption of known velocities for other countries in comparable growth stages.

If not even this spotty series were available, then a second (or third) best solution would be just a simple benchmark figure which, in the Friedman-Leff manner, would give us an estimate of the long-term growth rate of income.[8]

For this, from equation (1) we obtain:

$$\dot{y} = \dot{m} + \dot{v}, \tag{2}$$

where lower-case, dotted letters symbolize percentage rates of growth of the higher-case variables.

Our benchmark money figure combined with, say, our 1865 figure, would give us $\dot{m}$, while $\dot{v}$ would be estimated according to the assumptions mentioned previously. In any case, $\dot{v}$ would be either negative or zero, so that

$$\dot{y} \leq \dot{m}.$$

This assumption of a decreasing or, at most, constant V is based upon the experience of many other countries in their early stages of development,[9] and will serve us to discriminate between different possible estimates. For instance, Canga Argüelles's[10] estimate of a gold and silver currency stock for 1772 of 4,886 million reales (accepted by Sardá[11] with little questioning) is a gross overestimate, as our reasoning will show.

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6. Prados de la Escosura, Leandro, *Análisis económico del Comercio Exterior de España en los siglos XVIII y XIX,* Doctoral Thesis, Universidad Complutense de Madrid 1981.
7. Alcaide Inchausti, Julio, *Una revisión urgente de la serie Renta Nacional espanola en el siglo XX,* in: Datos básicos para la Historia Financiera de España (1850–1975), vol. I, Madrid 1976.
8. Friedman, Milton, *Money and Economic Development,* New York 1973; Friedman, Milton, *Monetary Data and National Income Estimates,* in: Economic Development and Cultural Change, (April 1961); Leff, *Technique.*
9. See Doblin, *Ratio;* Anderson, *Behavior;* Leff, *Technique;* Cohen, Jon S., *Italy 1861–1914,* in: Cameron, Rondo (ed.), Banking and Economic Development. Some Lessons of History, New York 1972.
10. Canga Argüelles, José, *Diccionario de Hacienda,* 2 vols., Madrid 1833–34.
11. Sardá, Juan, *La Política Monetaria y las Fluctuaciones de la economía española en el siglo XIX,* Madrid 1948.

A simple interpolation of two estimates of national income by Grupo '75[12] for 1755 and by Arthur Young[13] for 1792 shows that Spanish national income in 1772 was around 3,700 million reales (no space here to give details about the problems involved in these calculations; our reasoning admits very wide margins of error). This would make the money supply larger than national income and, consequently, V less than one (around .75 in fact). Such a small V at such early date is unbelievable. For Canga's figure to be correct while V standing at around 3.5 (a very low bound), national income would have had to be five times larger than our estimate. Among other things, this would imply that income should have grown between 1772 and 1865 at a rate below 0.1 percent and therefore that per capita income should have decreased at a rate of perhaps −0.3 percent between the two dates (this is in current money; the decline would be larger if we allowed for inflation). Such long-term depression is clearly out of the question: Canga's estimate should be rejected in spite of his being a respected source of macroeconomic information from his writing days in the early nineteenth century (I am leaving aside here his highly questionable estimation procedure).

To sum up, our method seems fruitful for our research, both as a way to check the trustworthiness of existing income and/or money estimates, and to extrapolate and interpolate a series. The problems, naturally, are less tractable for the first part of our period.

Zusammenfassung: Die Schätzung des Volkseinkommens anhand monetärer Variablen am Beispiel Spaniens, 1772–1972

Hiermit werden einige Aspekte des Forschungsprojektes über "Einkommen, Output und Produktivität in Spanien vom achtzehnten Jahrhundert bis in die Gegenwart" vorgestellt. Eine Gruppe von Wirtschaftshistorikern arbeitet an diesem Projekt, das von der spanischen Zentralbank gefördert wird.

In diesem Beitrag wird versucht, die möglichen wie auch die bereits erreichten Resultate darzulegen, die bei der Aufstellung einer Zeitreihe über das spanische Volkseinkommen auf der Grundlage von monetären Variablen zu erzielen sind. Monetäre Angaben sind recht leicht zusammenzustellen und liegen jährlich bereits seit 1874 vor.

Milton Friedman hat dieses Schätzverfahren erstmals angewandt. Es geht von der grundlegenden Voraussetzung aus, daß die Geldumlaufgeschwindigkeit (der Koeffizient von Volkseinkommen zu Geldmenge) eine ziemlich stabile Größe ist. Und tatsächlich wird diese Annahme durch empirische Angaben aus einer Vielzahl von Län-

12. Grupo '75, *La economía del Antiguo Régimen. La "Renta Nacional" de la Corona de Castilla*, Universidad Autónoma de Madrid, Departamento de Historia Contemporánea, Madrid 1977.
13. Young, Arthur, *Travels during the years 1787, 1788 and 1789 in France for which is Added the Register of a Tour into Spain*, Dublin 1793 (cited in Prados de la Escosura, *Análisis*, *p.* 91).

dern bestätigt: Bei nur geringen Abweichungen von Jahr zu Jahr weist die Umlaufgeschwindigkeit eine langfristige Tendenz zur Verlangsamung auf. In weit fortgeschrittenen Volkswirtschaften kehrt sich dieser Trend jedoch um, d.h., die Umlaufgeschwindigkeit hat die Tendenz, sich zu erhöhen, und auch dieses nur mit geringen Schwankungen.

Die Umlaufgeschwindigkeit in Spanien scheint sich in dieses Muster einzufügen. Unsere Zahlen belegen, daß die Umlaufgeschwindigkeit hier einen Trend zur Verminderung aufweist. In den Zeitspannen von 1901 bis 1908, von 1914 bis 1917 und von 1946 bis 1951 jedoch kehrte sich als Folge von Kriegseinflüssen dieser allgemeine Trend um: Der kubanische Unabhängigkeitskrieg, der Erste Weltkrieg sowie der spanische Bürgerkrieg waren für diese Trendumschwünge verantwortlich.

Doch sieht man von diesen Störungen einmal ab, so erweist die relative Stabilität der Umlaufgeschwindigkeit, daß die vorgesehene Schätzmethode durchaus anwendbar ist. Am Ende des Artikels werden einige Probleme umrissen, die dabei auftauchen, wenn man die Methode auf das frühe neunzehnte Jahrhundert anwenden will; denn für diesen Zeitraum sind Schätzungen der Geldmenge nur schwer zu erstellen.

Jean Gadisseur

Output per Worker and its Evolution in Belgian Industry, 1846–1910

Owing to its crucial role in the process of industrialization,—not only by its technical, but also economic and social implications—the threefold relationship capital-technical change-labour is of extreme importance in the explanation of the economic development of Belgium during the XIXth Century.

The present study aims simply to estimate annual rates of increase in output per worker in the main industries and sectors of industrial activity. It is a preliminary step for a much larger study, which should embrace four aspects of the evolution of industrial productivity:

- the technical aspect, including technological and organizational changes as well as progress in skills;
- the micro-level approach, focused on the substitution of capital for labour at the level of the firm;
- such macro elements as the evolution of comparative costs and prices, the distribution of returns between capital and labour;
- finally socio-demographic factors ranging from health—the physical ability to work—to working hours.

1. The available data

1.1. The Input of Manpower

The numbers of workers and other employees engaged in each sub-division of industry has been derived and calculated from four sources:

a) the Industrial Censuses of 1846, 1880, 1896 and 1910;
b) Censuses of Population which classify the population by occupations and professions;
c) official mining statistics which contain annual estimates for the extractive, metals and glass industries;
d) other sources, including reports of Chambers of Commerce, official estimates and studies of particular industries.

The figures available for some branches of industry look sometimes very different. But differences can usually be accounted for by a reference to the definitions and rules utilized by any given source to deal with seasonal employment, unemployment and home workers. The Industrial Census of 1880 has often been criticized because its coverage is not exhaustive and it is clear that for several branches of industrial activity this census does underestimate the work force. Population censuses must also

be used carefully because it is difficult to find a corresponding industrial division to their classifications of the work force into occupations and professions. Mining statistics are reasonably satisfactory. Although the categories used in this source do not correspond exactly with such integrated industries as iron and steel. A detailed discussion of the problems encountered and solutions adopted would be out of place in a short article.[1]

The choices of particular figures or new estimates were made according to a statistical criticism of the data, including tests for coherence across sectors and through time. Final estimates are those presented in Table 1.

Table 1: The Allocation of Labour by Branches of Industry

	1846	1880	1896	1910
Coal	43,488	102,930	119,246	143,701
Metal Mines	8,203	3,810	2,163	455
Quarries		26,007	38,624	39,873
Milling	11,384	11,900	11,374	13,134
Rice		278	145	102
Sugar	1,785	11,870	11,237	8,420
Sugar Refining	696	1,237	1,349	1,786
Glucose		105	176	267
Cocoa	45	335	1,099	2,577
Coffee	234	340	360	601
Chicory	128	1,720	1,640	1,964
Margarine			360	522
Beer	9,558	15,130	20,074	24,397
Alcohol	2,205	2,460	2,077	2,406
Tobacco	7,805	14,530	12,034	15,471
Wool-Preparation	4,800	3,302	2,325	2,688
Wool-Spinning	5,100	11,023	12,942	13,625
Wool-Weaving	20,100	28,158	17,982	10,849
Linen-Preparation	7,000	7,173	10,000	14,000
Linen-Spinning	25,600	14,204	17,668	20,062
Linen-Weaving	25,000	26,500	21,389	12,886
Jute			2,321	5,741
Hemp	1,910	2,765	4,044	3,811
Cotton-Spinning	6,984	7,153	8,073	14,736
Cotton-Weaving	15,267	18,935	11,929	25,012
Saw Mills	7,160	7,582	8,443	10,400
Woodwork	25,702	28,401	39,557	44,260

1. For further details on these estimates readers should consult the author and the reference under footnote 2.

Table 1 (Fortsetzung)

	1846	1880	1896	1910
Cabinet Making	3,705	12,629	17,812	23,573
Paper and Cardboard	2,262	7,130	9,575	12,434
Printing	3,591	6,645	14,810	21,308
Leather and Skins	3,113	5,173	5,047	6,774
Leather-Working	12,273	26,861	26,519	29,643
Rubber	15	245	1,235	2,146
Soda and Derivatives	132	987	903	1,639
Vegetable Oils	2,293	2,500	2,879	2,800
Wax and Polish	288	539	852	788
Coke		2,358	2,415	3,737
Coal Briquettes			1,334	1,999
Glass and Crystal	3,729	11,131	23,333	26,182
Pig Iron (Blast Furnaces)	3,288	3,452	3,305	4,214
Crude Iron (Puddled or Converted)	1,646	8,180	4,455	1,064
Finished Iron	1,547	7,689	4,512	2,087
Crude Steel	26	2,156	6,018	13,186
Finished Steel	26	1,678	5,218	10,694
Iron Foundries	1,596	6,693	7,785	9,937
Zinc Manufacture	1,205	3,277	4,970	7,745
Zinc Laminating		704	509	734
Lead Manufacture	134	278	527	727
Desilvering Lead		72	200	1,090
Copper	585	1,355	2,252	3,817
Machinery	6,815	21,390	37,778	55,025
Weapons	8,065	11,204	13,423	11,539
Precision Instruments		262	830	888

1.2. Production Statistics

The basic figures for production were produced by a former research.[2] The series used concern estimates of physical outputs produced in the different industries and cover one half to two thirds of total industrial activity. Most industries are represented with the exception of the construction industry. (Although the quarrying of stone is included under extractive industry). Using those estimates indices for total industry and eight sub-groups were computed: extractive industry, food, textiles, ani-

2. J. Gadisseur, *Le produit physique de l'économie belge, 1831-1913—Présentation critique des données statistiques.* Doctoral Dissertation, Liege, 1980. The dissertation will be published in *Histoire Quantitative et Dévelopment de la Belgique, 1831-1913,* under the auspices of *Le Centre d'histoire quantitative* of the University of Liège directed by Professor Pierre Lebrun and under the patronage of the Académie Royale de Belgique.

mal and vegetable products (including wood, leather, paper, printing group 1), chemicals (including coking plants and glass group 2), iron and steel, non-ferrous metals and finally engineering (machines, weapons, etc ...). The indices are of a Laspeyres type with fixed reference points and are base weighted. Four different sets of indices were computed, with weights and bases corresponding respectively to the years 1846, 1880, 1896 and 1910.

2. *The Method*

2.1. Output per Worker in Industrial Branches of Industry

For each of the 53 individual industries outputs taken into consideration are three-years averages centred upon the Industrial Censuses of 1846, 1880, 1896 and 1910. These averages were divided by the corresponding work force so that four levels of output per worker were obtained. Since those outputs per worker were of abstract significance every time the estimates of output are represented by indices, and since sub-periods between censuses are of unequal length, annual rates of increase were computed so that comparison between branches and through time would become possible. Those annual rates are presented in Table 2. In order to facilitate interpretation of those figures, Table 3 presents the corresponding average rates of increase in total output for the same sub-periods and branches.

Table 2: Annual Average Rates of Increase in Output per Worker (%)

	1846 1880	1880 1896	1896 1910	1846 1910
Coal	0.98	0.65	−0.55	0.56
Metal Mines	0.93	0.56	5.61	1.84
Quarries		−0.75	0.83	−0.02
Milling		2.30	0.88	1.63
Rice		4.75	0.38	2.69
Sugar	3.10	7.19	1.11	3.66
Sugar Refining	1.45	5.98	0.07	2.26
Glucose		5.88	−1.08	2.57
Cocoa	−1.22	−0.22	2.95	−0.07
Coffee	0.04	0.00	−0.13	−0.01
Chicory	−0.99	1.80	−1.97	−0.51
Margarine			0.92	0.92
Beer	0.32	0.35	0.30	0.32
Alcohol	2.43	1.31	0.34	1.69
Tobacco	0.58	1.50	0.78	0.85
Wool-Preparation	9.44	0.55	−0.75	4.88
Wool-Spinning	2.76	1.56	0.70	2.00
Wool-Weaving	5.34	5.42	4.56	5.19

Table 2 (Fortsetzung)

	1846 1880	1880 1896	1896 1910	1846 1910
Linen-Preparation	2.94	0.15	0.80	1.76
Linen-Spinning	3.10	1.29	0.83	2.14
Linen-Weaving	−0.11	1.85	5.39	1.56
Jute			−2.35	−2.35
Hemp	4.73	0.34	1.28	2.86
Cotton-Spinning	3.64	1.11	1.39	2.51
Cotton-Weaving	3.25	4.87	0.13	2.96
Saw Mills	0.01	0.01	0.15	0.04
Woodwork	0.83	0.02	1.42	0.75
Cabinet Making	−0.44	−0.29	6.29	1.03
Paper and Cardboard	−0.12	0.70	1.70	0.48
Printing		−0.38	3.23	1.29
Leather and Skins	0.79	0.94	1.74	1.04
Leather-Working	−0.16	0.46	2.81	0.64
Rubber		−3.65	7.10	1.23
Soda and Derivatives	−0.51	4.74	0.07	0.91
Vegetable Oils	0.20	0.71	2.20	0.76
Wax and Polish	−0.07	−0.23	3.64	0.69
Coke		1.16	0.02	0.62
Coal Briquettes			2.82	2.82
Glass und Crystal	1.71	−0.09	1.03	1.11
Pig Iron (Blast Furnaces)	3.08	3.56	3.09	3.20
Crude Iron (Puddled or Converted)	1.10	3.17	2.89	2.01
Finished Iron	0.96	3.51	2.62	1.95
Crude Steel		2.61	3.38	2.97
Finished Steel		2.41	3.22	2.79
Iron Foundries	0.53	6.07	3.69	2.58
Zinc Manufacture	2.85	1.09	0.39	1.87
Zinc Laminating	−12.23	3.62	0.05	−5.85
Lead Manufacture	7.73	0.62	4.39	5.18
Desilvering Lead			3.44	3.44
Copper	1.65	0.31	0.72	1.11
Machinery	4.58	−1.50	3.64	2.82
Weapons	1.76	0.70	2.96	1.75
Precision Instruments		−7.73	6.07	−1.53

Table 3: Average Annual Rates of Increase in Production (%)

	1846 1880	1880 1896	1896 1910	1846 1910
Coal	3.43	1.58	0.78	2.94
Metal Mines	−1.32	−2.93	−5.52	−1.79
Quarries		1.73	1.06	2.94
Milling		2.01	1.92	1.62
Rice		0.57	−2,11	2.67
Sugar	9.01	6.82	−0.95	7.04
Sugar Refining	3.18	6.55	2.10	3.43
Glucose		9.35	1.91	8.33
Cocoa	4.79	7.48	9.41	4.96
Coffee	1.14	0.36	3.59	1.46
Chicory	6.88	1.50	−0.70	3.76
Margarine			3.63	3.39
Beer	1.69	2.13	1.71	1.53
Alcohol	2.76	0.25	1.40	1.75
Tobacco	2.43	0.31	2.61	1.91
Wool-Preparation	8.24	−1.63	0.29	3.18
Wool-Spinning	5.11	2.58	1.07	2.80
Wool-Weaving	6.39	2.51	0.86	3.28
Linen-Preparation	3.01	2.25	3.25	2.32
Linen-Spinning	1.33	2.68	1.75	1.43
Linen-Weaving	0.06	0.50	1.65	0.01
Jute			4.17	2.98
Hemp	5.88	2.76	0.85	4.20
Cotton-Spinning	3.71	1.88	5.84	3.25
Cotton-Weaving	3.91	1.89	5.56	3.21
Saw Mills	0.18	0.68	1.65	0.49
Woodwork	1.12	2.11	2.23	1.35
Cabinet Making	3.22	1.88	8.44	3.58
Paper and Cardboard	3.31	2.57	3.61	2.79
Printing		4.74	5.95	6.09
Leather and Skins	2.31	0.78	3.91	1.96
Leather-Working	2.17	0.37	3.63	1.82
Rubber		6.60	11.41	8.66
Soda and Derivatives	5.55	4.16	4.43	6.16
Vegetable Oils	0.45	1.61	2.00	1.06
Wax and Polish	1.79	2.67	3.07	2.36
Coke		1.31	3.18	2.15
Coal Briquettes			5.83	4.42
Glass and Crystal	5.03	4.64	1.87	4.17
Pig Iron (Blast Furnaces)	3.23	3.27	4.90	4.25
Crude Iron (Puddled or Converted)	5.98	−0.67	−7.11	1.50
Finished Iron	5.83	0.12	−2.88	2.56

Table 3 (Fortsetzung)

	1846 1880	1880 1896	1896 1910	1846 1910
Crude Steel		9.41	9.34	14.11
Finished Steel		9.93	8.65	13.42
Iron Foundries	4.86	7.07	5.52	5.47
Zinc Manufacture	5.92	3.76	3.62	5.03
Zinc Laminating	6.44	1.54	2.70	−4.30
Lead Manufacture	10.07	4.72	6.81	7.91
Desilvering Lead			16.76	11.75
Copper	4.20	3.55	4.58	4.27
Machinery	8.16	2.06	6.46	7.43
Weapons	2.75	1.84	1.85	2.47
Precision Instruments		−0.84	6.58	3.34

2.2. Output per Worker in 8 Broad Sectors of Industry and for Industry as a whole
For those global group indices, the method of calculation is basically the same as described above (Section 2.1.). Because estimates do not start in 1846 for all branches of industry, precautions were to be taken in order to avoid a bias in the estimation of annual rates of growth in output per worker at the aggregate levels. For each sub-period the average levels of output per worker were calculated by dividing the levels of production given by the global or sectoral indices with weights and base corresponding to the beginning of the sub-period by the relevant labour forces. Thus the range of products taken into consideration varies from sub-period to sub-period and coverage is, for example, more complete for 1896–1910 than for 1846–1880.

Table 4: Average Annual Rates of Increase in Output per Worker (%)

	1846 1880	1880 1896	1896 1910	1846 1910
Extractive Industry	1.03	0.34	−0.16	0.60
Food	1.57	2.94	0.63	1.70
Textiles	4.01	2.64	1.74	3.17
Group 1	0.20	0.13	2.87	0.76
Group 2	1.29	0.21	1.71	1.11
Iron and Steel	0.93	4.07	3.21	2.20
Non-ferrous metals	3.10	1.05	1.00	2.12
Mechanical Engineering	3.74	−0.92	3.56	2.52
Total Industry	2.31	1.25	1.70	1.91

Table 5: Average Annual Rates of Increase in Output (%)

	1846 1880	1880 1896	1896 1910	1846 1910
Extractive Industry	3.46	1.53	0.86	2.91
Food	2.25	2.34	1.69	1.94
Textiles	2.22	1.80	2.67	2.22
Group 1	1.94	1.76	4.33	2.10
Group 2	3.49	3.97	2.92	3.92
Iron and Steel	5.64	3.96	5.25	5.38
Non-ferrous metals	5.48	3.63	4.76	4.77
Mechanical Engineering	5.58	1.94	5.49	5.55
Total industry	2.83	2.00	3.01	2.51

Table 4 displays annual rates of increase in output per worker for 8 sectors of industry and for total industrial output, while in Table 5 the corresponding rates of growth of output are set out. The rates for the total period are weighted geometric averages of the rates for sub-periods.

3. The Results

Since this research is still at a prelimary stage a complete interpretation of its results would be premature. But some observations, principally methodological in character, might be attempted at this point.

3.1. The Consistency of the Basic Data

Most of the rates of increase in labour productivity as set out in Table 2 are reassuring because they generally correspond with our qualitative and historical information on changes in technology and in legislation affecting the industry concerned. For example, the growth of productivity in coal mining was increasingly restrained by the technical difficulties involved in exploiting a depleting natural resource and by the reduction of working hours in 1910. The estimates for milling pick up the concentration and mechanization of that industry after 1880, as a response to imports of American wheat. Our figures are also congruent with what is known to historians about arms manufacturing which remained a craft industry until the late 19th century. They also accord with changes in the soda industry from the Leblanc to the ammonia process which occured mainly between 1880–96.

Unfortunately not all the estimates are readily explicable in this way. Several "unnatural" rates of productivity change appear in the data—for example in zinc lamination, for the jute industry and for precision instruments. Some exceptional rates can be explained by the introduction of new technology (for example, the mechanization of washing, weaving and carding wool) but it will require a careful technologi-

cal study industry by industry before all the statistics can be accepted or rejected. In several cases the movements probably reflect variations in the quality of output over time (e.g. for rubber) or incorrect and uncertain data. But on the whole and particularly for the broad amalgamated sectors of industry the statistics are plausible.

3.2. Chronology

Unfortunately the timing of the Industrial Censuses did not always correspond with turning points in the growth of the Belgian economy. 1846 and 1896 seem fairly well placed—the first at the end of the Industrial Revolution and the second at the beginning of the upswing following the Great Depression of 1874–95. But 1880 falls in the middle of the Great Depression. Thus the first period 1846–80 includes the years of vigorous growth 1848–73 and a significant part of the ensuing depression. While the second period, 1880–96, which covers the darkest years of crisis, also includes a span of years which witnessed a relative upswing in production. Periodization has been imposed by the sources, which makes historical interpretation of the figures problematical.

3.3. The Rhythm of Progress

The rate of increase in labour productivity from 1846–80 which witnessed the diffusion of the technology of the First Industrial Revolution, was clearly faster than over the subsequent period (1880–96)—a phase when progress slowed down and when the decline in the rate of growth of money wages hardly encouraged investment aiming at substitution of capital for labour. Nevertheless a number of branches of industry continued with investment designed to save on capital, on energy or raw material inputs or designed to raise the quality of the product and then often led to improvements in labour productivity. The deceleration in labour productivity growth can be connected to the slowing down of the evolution of composition in global industrial output: the depression affected more deeply the most dynamic activities, that is those industries which enjoyed the highest growth rates and also the highest outputs per worker.[3]

Labour productivity which accelerated again after 1896 can be connected to what is mistakenly called the Second Industrial Revolution which is really a phase of technological renewal which manifested its effects through the application of new forms of power, such as the internal combustion engine and electricity to industries untouched by the industrial revolution as well as further technological improvements to industries already mechanized (through such inputs as steel, gas turbines, industrial electricity, mass production techniques, etc...)

Belgian industry can be grossly divided into four broad groups classified in terms of differences in the rates of increase in output per worker:

a) Extractive industry, textiles, non-ferrous metals atteined first fairly high growth rates in output per worker and then progressively slowed down. This deceleration was due to the precocity of their mechanization. Production per worker seems

3. J. Gadisseur, *Croissance, structure et cycles dans la production industrielle belge, 1831-1913*, (forthcoming) in *Vorträge für Wirtschaftsgeschichte*. This paper shows that the pace of structural change slowed at the same time as the growth of production and prompts one to regard the Great Depression 1874–95 as a "structural malaise".

hardly affected by the Great Depression but it is possible that the problems experienced from 1874 pushed industrialists into a search for economies by cutting employment in these industries, in spite diminishing wages.

b) Food processing and the iron and steel industry experienced maximum growth of output per worker during the period 1880–96. For the food industry this upswing was connected to the expansion of the home market from 1886 and American grain imports from 1880. After 1896 the progress slowed down considerably. Improvements in the productivity of the iron and steel industry which had proceeded rather slowly from 1846–80 changed dramatically thereafter and continued (albeit at a slower rate) after 1896. The long term evolution of iron and steel can be explained basically by reference to such innovations as the Bessemer Converter 1856, the Martin-Siemens process 1868 and the Gilchrist Thomas process in 1879, as well as developments in metallurgical industries using steel.

c) Traditional industries, dominated by leather, wood and printing, (group 1) displayed weak rates of progress throughout the periods 1846–80 and 1880–96. The Great Depression restrained the application of new technology in these industries, so that an important increase in the output per worker did not appear before the end of the Century.

d) Mechanical engineering and the industries of group 2 (chemicals, glass, coke, etc...) experienced rapid progress at the beginning and at the end of the period—interphased with a clear deceleration in 1880–96. Low wages certainly played a role in the evolution followed by these industries, otherwise hardly affected by the depression. For mechanical engineering the technological change that marked the Depression (the transition from iron to steel and the emergence of electricity and the internal combustion engine with its difficult but necessary adaptations) complements movements in wages in the explanation for long swings of rapid and slower growth.

4. Towards a Conclusion

Conclusions from a preparatory study and preliminary calculations can only be tentative and are simply reflections of a critical, methodological and economic nature.

We must first of all underline the risks involved in diachronic and intersectoral comparisons even when those comparisons are based on a careful evaluation of the data. Attention to the rules of statistical method carries certain guarantees but in the last resort only consistency with the full historical record can allow firm judgements to be drawn.

From the methodological point of view it is obvious that the study of technical and economic progress in the history of industry cannot be limited to an examination of the quantitative aspects of production. The variables of the production functions are the costs and values; technique, organization of production—and the choices they are subject to—are their structural elements, however changing over time. Those functions and their evolution are to be estimated—"historiometrically" if econometrics should fail.

From an economic view the figures do trace significant variations in the evolution of output per worker over the long run in the major branches and sectors of Belgian

industry. The Great Depression 1874–95 emerges from the data in its many facets (in costs of raw materials, changes in rates of growth, emergence and diffusion of techniques of production). The Great Depression is confirmed as more of a structural discontinuity than a mere conjunctural episode in the economic history of Belgium.

Zusammenfassung: Entwicklung der Arbeitsproduktivität in der belgischen Industrie von 1846 bis 1910

In diesem Beitrag soll versucht werden, die jährlichen Wachstumsraten der Arbeitsproduktivität in der belgischen Industrie für die Zeitspanne von 1846 bis 1910 zu messen. Grundlagen dafür bilden die physischen Produktionsindices der belgischen Industrie von 1831 bis 1913 sowie vier Schätzwerte über die Verteilung der Beschäftigten auf die verschiedenen Industriezweige. Sie basieren auf Angaben aus den Jahren 1846, 1880, 1896 und 1910, in denen Betriebszählungen durchgeführt wurden. Die Wachstumsrate der Produktivität insgesamt wurde nach acht Industriezweigen und 53 Untergruppen aufgegliedert. Mit ihnen ist der Großteil des Bergbaus und der Industrie erfaßt.

In dieser Studie wird zum erstenmal eine umfassende Statistik über die Arbeitsproduktivität in der belgischen Industrie während des 19. Jahrhunderts vorgelegt. Wenngleich diese Ergebnisse auch nur als vorläufig zu gelten haben, so lassen sich doch methodologische wie auch ökonomische Schlußfolgerungen daraus ziehen. So weisen die Daten zum Beispiel nach, daß sich die Arbeitsproduktivität in den wichtigsten Industriezweigen recht unterschiedlich entwickelte, und zwar entsprechend der jeweiligen technischen Entwicklung. Sodann belegen die Daten, daß sich die Große Depression von 1875 bis 1895 als „strukturelle Diskontinuität" in der Geschichte der belgischen Industrie zeigte.

Rainer Fremdling

Foreign Trade Patterns, Technical Change, Cost and Productivity in the West European Iron Industries, 1820–1870*

I

My major research topic has been the development of the primary iron industry in Belgium, France and Germany from the 1820's to the 1860's. Let me briefly define which part of the sector I am talking about: It is the primary iron industry with its two stages of production. First, there is pig iron, which is smelted from the iron ore in a blast furnace. Second, there is bar iron or wrought iron. This is refined from pig iron by using either charcoal or hard-coal.

During the four decades from the 1820's onwards, the iron industries of Belgium, France and Germany experienced the same fundamental change Britain had undergone in the 18th century, namely the substitution of mineral fuel for charcoal, that is, the process of puddling, rolling and coke smelting diffused. But neither in Britain nor on the Continent did this transition, however radical, spread fast or straightforward. Rather both traditional methods of iron production alone and conbinations of the old and new technology remained economically viable for quite a long time,[1] whereas the new techniques of smelting and refining iron hat to be improved considerably and to be adapted to the particular environments of the Continental countries before they gained clear-cut cost advantages over modified traditional techniques. Thus, it is misleading to confer distinct economic superiority on the finally most advanced technology from the beginning on, in retrospection.[2] This point has to be emphasized because of a widespread misjudgment in the literature on technical change in historical perspective ("Technikgeschichte"). That is, rashly lumping together technical advances with major improvements in economic efficiency.

David Landes might be quoted as a prominent advocate of this approach. In assessing the different technological levels between Britain and Continental Europe after the end of the Napoleonic wars he states:[3]
"In view of the enormous economic superiority of these innovations one would expect the rest to have followed automatically".

* For helpful comments I wish to thank Richard H. Tilly.

1. Cf. Table A 1 of the appendix.
2. On this very common pitfall, namely the confusion of technical advance with economic superiority, in the writing of economic history see the elaborated comment by Rosenberg, Nathan, *Perspectives on Technology,* Cambridge 1976, especially chapter 11 "Factors affecting the diffusion of technology", pp. 189–210.
3. Landes, David S., *The Unbound Prometheus,* Cambridge 1972, p. 126.

I have tried to avoid this bias of the technological historiography and to describe and analyse the processes of modernization in the primary iron industries by comparing levels of prices and costs among different countries and regions over time. In a market economy with sufficient competition, costs and prices reflect the endowment with resources and the level of productivity. On this yardstick, technological achievements only become apparent when they are economically significant. Thus, the potential economic relevance of an innovation in the long run is not identical with its cost-saving contributions at the time of its first appearance, which were usually rather modest. It is however difficult to obtain reliable data on costs and prices which are representative of an entire country. Available data on costs and prices often only refer to certain regions and enterprises. Furthermore, differences in prices due to differences in quality of the product complicate comparisons.
In this article, I want to set forth two aspects:

1. structural changes in international trade, and
2. productivity changes over time. Hence I do not intend to present direct evidence here which would refute views as expressed by Landes.[4]

II

Let me now set forth the conclusiveness of structural changes, which took place in the international trade flows and in the tariff policy accordingly, focussing on France and Germany.[5] The changing pattern of trade flows among nations and the corresponding tariff policy are useful indicators to detect the international competitive position of the specific iron industry over time.

In Britain, the transition from charcoal to coke or hard-coal as a fuel for smelting and refining iron had been achieved already in the 18th century, whereas on the Continent, charcoal techniques dominated until far into the 19th century. Around 1820, the British iron industry was not only free from any real competition on her domestic market, but it was more and more able to export much of her output abroad. From the 1820's to 1870, exports of all iron products rose dramatically from one quarter to roughly 60% of the total pig iron production.[6] For the most part of the period in question, British producers were the cheapest suppliers of iron internationally.

The French tariff policy reflects very clearly the cost and price advantage of British suppliers in the early 19th century. In 1822, France established nearly prohibitive du-

4. On this see my forthcoming manuscript on *Untersuchungen zur Modernisierung der Eisenindustrie 1820–1860 — Zur Einführung des Koksschmelzens und des Puddelverfahrens in Belgien, Frankreich und Deutschland.*
5. Belgium as the first country to catch up with British technology deserves a special attention. In this paper, however, I refer to her rather occasionally, but Belgium will be analysed more thoroughly in my current research, see footnote 4 above.
6. Hyde, Charles K., *Technological Change and the British Iron Industry, 1700–1870,* Princeton 1977, pp. 144, 172; British producers in general became increasingly dependant on exports during this time, on this see Crouzet, François, *Toward an Export Economy:* British Exports during the Industrial Revolution, in: Explorations in Economic History, 17 (1980), pp. 48–93; and Davis, Ralph, *The Industrial Revolution and British Overseas Trade,* Leicester 1979.

ties especially against British iron. This law remained unchanged in principle until the mid-1850's, and then it was replaced by the Cobden-Chevalier-treaty. Such a highly effective and long-lived customs law deserves a closer look into its genesis.[7]

In 1814, the tariff on bar iron was set up in the following way: Swedish bar iron reached French ports for 350 Francs per ton. Since French bar iron was sold there at least at 500 Francs, the duty was fixed at 150 Francs, i. e. ad valorem more than 40%. The fact, that the reference price was Swedish iron, reflects that Sweden was still considered the dominating supplier of iron on the international market. Obviously, the French were not yet aware that in the meantime Britain had become the supplier at lowest prices on the world market. In spite of this high protective duty of 1814, British bar iron was dumped in large quantities on the French market. In 1820 and 1821, nearly 80% of all bar iron imports came from Britain. 1819 is the only year before 1822 for which a French output figure can be compared to imports: The ratio between imports and production made up 0.14. These imports must have been perceptible for French producers.

So the new tariff of 1822 was solely directed against British imports. Numerous petitions of iron masters had convinced the government of the necessity to increase the duty on iron. The following calculation was made up: British bar iron was sold at 400 Francs per ton, including the already existing tariff. French bar iron could not be sold cheaper than 500 Francs per ton, so the existing tariff of 150 Francs was raised to 250 Francs. This measure was solely taken against British puddled and rolled bar iron, whereas Swedish hammered charcoal bar iron still bore the duty of 1814. British bar iron now suffered a duty of 100% ad valorem.[8] This discriminatory duty had immediate effects on British bar iron exports to France: While in 1821 still one third of all British bar iron exports had gone to France, this share dropped dramatically in the following years. Not even the 8% of 1822 could be matched in the years to come.[9]

In short, the wall of protectionism kept British bar iron imports down. And any importation of pig iron, which might have been worked up to bar iron along the coast should be blocked likewise. So the duty on British pig iron was raised adequately, namely from 20 to 90 Francs per ton.[10] Thereafter only foundries imported British pig iron.[11] These tariffs, both on bar iron and on pig iron, were not lowered markedly

7. Detailed documentation based on records in the "Archives Nationales" is to be found in Fremdling, Rainer, *Britische Exporte und französische Schutzzollpolitik, Zur Entstehung und Auswirkung der Eisenzölle von 1822,* in: Scripta Mercaturae, 14 (1980), pp. 55–70.
8. According to the calculation of a government official the ad valorem duty, including the "décime" (tith), was raised from 70 to more than 120 percent, Archives Nationales F 12 2529, Report of the 18.8.1821; see also Amé, M., *Étude sur les tarifs de douanes et sur les traités de commerce,* Paris 1876, p. 145.
9. See Tables A 1 and A 2 of the appendix.
10. Before the new duty was introduced bar iron produced from imported pig iron had to bear a duty of 30 Francs. An input-output-coefficient of 1.5 was assumed. The additional pig iron duty of 70 Francs multiplied by 1.5 was about the 100 Francs increase on the bar iron duty. On details of this calculation see the report mentioned in footnote 8.
11. Continental producers could hardly attain the quality of British foundry pig iron for certain purposes. This was e. g. clearly expressed in the minutes of the *Enquête sur les fers,* Paris 1829, pp. 103–110, 151.

before the 1850's, and finally by the Cobden-Chevalier-treaty in 1861. But even then, they still made up between 30 and 40% ad valorem on bar iron, and between 20 and 30% on pig iron.[12]

Table 1: French Iron Production, Imports and Exports, 1825–1870, thousands of metric tons and ratios, annual averages

Years	Pig Iron Production (P)	Imports (M)	Exports (X)	$\frac{X - M}{X + M}$	$\frac{M - X}{P}$
1824/30	220.9	8.8	0.9	-0.81	0.04
1831/40	293.6	13.4	0.4	-0.94	0.04
1841/50	447.2	49.9	0.4	-0.98	0.11
1851/60	780.0	70.7 (+ 19.4)[a]	0.8	-0.98 (-0.98)[a]	0.09 (0.11)[a]
1861/70	1,191.5	79.1 (+ 73.1)[a]	0.7	-0.98 (-0.99)[a]	0.07 (0.13)[a]

Years	Bar Iron[1] Production (P)	Imports (M)	Exports (X)	$\frac{X - M}{X + M}$	$\frac{M - X}{P}$
1825/30	148.6	6.9	0.5	-0.86	0.04
1831/40	195.2	5.6	0.5	-0.84	0.03
1841/50	301.7	6.7	0.8	-0.80	0.02
1851/60	480.0	18.1 (+ 1.9)[a]	2.1 (+5.1)[a]	-0.79 (-0.47)[a]	0.03 (0.03)[a]
1861/70	767.0	12.2 (+16.4)[a]	2.5 (+28.9)[a]	-0.66 (0.05)[a]	0.01 (-0.004)[a]

1 including rails

a The "commerce spécial" is a category in which imports allowed under the system of "admission temporaire" are not included. It can be corrected by means of the following formula: S = commerce spécial; G = commerce général $(M_G - M_S) - (X_G - X_S)$.

Sources: See appendix.

12. Cf. Boiteau, Paul, *Les traités de commerce, Texte de tous les traités en vigueur notamment des traités conclus avec l'Angleterre, la Belgique, la Prusse (Zollverein) et l'Italie*, Paris 1863, p. 10; duties on bar iron and rails were reduced to 70 and 60 Francs per metric ton, and on pig iron to 25 and 20 Francs, in 1860 and 1864 respectively.

Table 1 demonstrates which impact the French tariff policy had on imports and exports. The ratios in the last column show the relation of net imports to production. The export-import-ratios were calculated after a suggestion of Bela Balassa.[13] They reflect the "revealed comparative advantage", and indicate differences in costs and other factors determining international trade, e.g. tariffs and transportation costs. The value of these ratios could fluctuate between plus and minus 1. A high positive value reveals a comparative advantage, the opposite is true of negative values.

These ratios clearly show that France had considerable comparative disadvantages concerning pig iron over the whole time-span. The high import duties, however, kept the level of imports in relation to production during the 1820's and 1830's extremely low. But the refining branch south of the Belgian-French border had been a consumer of Belgian pig iron for a long time, and this Belgian pig iron could be imported at less than half of the rate for British iron.[14] So northern France continued buying Belgian pig iron, and bought even more since the 1840's. This coke pig iron was worked up to bar iron in modern puddling and rolling mills.[15] The imports amounted to around 10% of the indigenous production, and they remained high. But from 1855 on, Belgian pig iron had to bear the same duty as the British product. From that time on, British exports surpassed those of Belgium by far, a striking evidence that British suppliers were still producers at the lowest costs internationally.

Throughout the period the level of bar iron imports to France remained very low compared to that of the French production. The export-import ratios reveal a clear comparative disadvantage well into the 1850's. However, the system of "admission temporaire" provided an incentive to exports for works in the south and centre of France. This virtual premium on exports helped improve the French international trade position considerably.[16] In the 1860's, France even became net-exporter of rails and bar iron.

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13. Balassa, Bela, *Trade Liberalisation and "Revealed" Comparative Advantage,* in: Manchester School of Economic and Social Studies, (1965), pp. 102f. and pass.; see also Dumke, Rolf H., *The Political Economy of German Unification: Tariffs, Trade and Politics of the Zollverein Era,* Diss. University of Wisconsin, Madison 1976, pp. 151, 186.
14. On Belgian pig iron a duty of between 40 and 60 Francs per metric ton was levied, Archives Nationales F 12 2513, Question des fers, Report of 1841.
15. There are reports that in the early 1840's Belgian rolling masters founded rolling mills south ot the Belgian border in France to work up Belgian pig iron to bar iron and rails, Stainier, Emile, *Histoire commerciale de la métallurgie dans le district de Charleroi de 1829 à 1867,* Charleroi 1873[2], pp. 45f.
16. The system of "admission temporaire" worked in the following way: E.g. exporters of rails to Spain got a certificate to import free of duty an equivalent of pig iron. In general the exporter of rails—let us say an iron master in the south of France—did not use this certificate ("aquits-à-caution") to import pig iron himself but he sold it to an importer of pig iron in the north of France. On this see Lexis, W., *Die französischen Ausfuhrprämien im Zusammenhang mit der Tarifgeschichte und Handelsentwicklung Frankreichs seit der Restauration,* Bonn 1870, pp. 400ff.; Ministère de l'agriculture, du commerce et des travaux publics, *Enquête sur l'application du décret du 15 février 1862, relatif à l'importation en franchise temporaire des métaux,* Paris 1867, pp. 25ff.; Levasseur, E., *Histoire du commerce de la France,* vol. 2, Paris 1912, pp. 304ff.

In the next section, I want to discuss the tariff policy of Prussia/Germany. The Prussian tariff of 1818 was later adopted by the Zollverein.[17] It exercised a great influence on determining the route over which the new iron techniques penetrated into the western parts of Germany, namely the Rhineland and Westphalia.[18]

The tariff on bar iron was fixed at 60 Marks per ton.[19] From 1825 to 1830, the first years for which Prussian data on foreign trade are available, this tariff rate meant an ad valorem duty of 40 to 21%. The French tariff on British iron at the same price was four times as high.[20] At first sight it is astonishing that there was no duty levied on pig iron imports. It was treated as a raw material, which could enter the country free of duty according to the conception of the 1818 Prussian tariff system. At the time when the Prussian tariff was established, British coke pig iron did not play any role on the German market. And the free importation of pig iron was granted because Prussian refineries should work up charcoal pig iron from other German states.[21] Thus, the Prussian tariff policy was comparatively liberal. And it could afford to be so, as during the 1820's and the early 1830's, Germany's indigenous producers were not seriously challenged by British exports. Only in slump years, when British prices were extremely low, British bar iron and some pig iron penetrated into traditionally iron-producing regions of Germany. But by and large the domestic charcoal iron industry produced at costs low enough to meet British competitors on its internal markets. The low level of British iron exports to Germany at this time was partly due to the structure of demand in Germany. Traditional consumers of iron still preferred traditionally produced charcoal iron.[22]

The special set-up of the tariff, however, brought about a rather peculiar modernization process of the German iron industry. This became palpable when the railway construction in Germany increased the demand for cheap mass-produced iron, which happened since the mid-1830's. Until the early 1840's, the new railway demand was mainly satisfied by British producers. But in the second stage the German primary iron industry modernized quickly: German iron masters were soon capable of producing puddled and rolled iron. They used imported coke pig iron from Britain, and since 1844 increasingly from Belgium, too, and worked it up to bar iron or rails in their modern iron works. Usually these new rolling mills did not have any blast furnace to smelt their own pig iron. So they remained dependent on pig iron imports.

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17. See Ohnishi, Takeo, *Zolltarifpolitik Preußens bis zur Gründung des Deutschen Zollvereins*, Diss. Göttingen 1973, p. 1; Dumke, *Political Economy*, pp. 247ff.; Treue, Wilhelm, *Wirtschaftszustände und Wirtschaftspolitik in Preußen 1815–1825*, Stuttgart 1937, pp. 114–159.
18. On the iron duties see Sering, Max, *Geschichte der preussisch-deutschen Eisenzölle von 1818 bis zur Gegenwart*, Leipzig 1882.
19. Sering, *Eisenzölle*, p. 20 and Anhang 2.
20. Based on bar iron prices in Liverpool and pig iron prices in Glasgow, the freight rate was assumed at 16 Mark per metric ton to French ports and at 21 Mark to the Prussian boarder on the Rhine. On the prices see Griffiths, Samual, *Guide to the Iron Trade of Great Britain*, new ed., n.p. 1967, pp. 288f.; Meade, Richard, *The Coal and Iron Industries of the United Kingdom*, London 1882, p. 741.
21. Oechelhäuser, Wilhelm, *Der Zollverein, Seine Verfassung, sein handelspolitisches System und die Entwicklung der Tarifsätze seit 1818*, Frankfurt a.M. 1851, pp. 58f.
22. At that time the finishing branches of the iron industry were still dominated by small, rural works.

That is why the import substitution process on the level of bar iron and rails was accompanied by a dramatic increase of imported pig iron since the early 1840's.[23]

This development in the refining branches challenged the producers of charcoal pig iron seriously. Just a bit of the incremental demand for railway construction was directed to them, and even worse, their traditional customers of bar iron were learning how to use puddled bars. And these had either been imported or more and more of them had been produced in Germany from imported coke pig iron. In the early 1840's, this development coincided with very low prices on the world market.

To protect the smelting branch of the iron industry the Zollverein introduced a tariff on pig iron, which amounted to 20 Marks per ton. As a compensation for the increased input prices iron masters with their modern rolling mills now had to bear, the duty on bar iron was raised accordingly, namely from 60 Marks to 90 Marks per ton.[24]

In 1844, this specific tariff meant 70% ad valorem on bar iron, and nearly 30% on pig iron, based on British prices before the German border on the Rhine. The comparable French duties were two or three times as high.[25]

The 1844 tariff granted Belgium special treatment. Belgian iron exporters had to bear only half of the pig iron duty and half of the incremental duty on bar iron. After 1844, therefore, Belgian coke pig iron succeeded at the expense of British iron, and now rolling mills on the right bank of the Rhine also used Belgian instead of Scottish pig iron. For some years, Belgium's exports to Germany even surpassed those from Britain. So the Belgian success on exports markets proved Britain's world domination there to be vulnerable.[26]

After 1854, Belgium lost her privilege, and even then she still exported large quantities into the Zollverein. The fact that Belgian producers maintained a strong position on the French and German market even after they had lost their preferential treatment indicates that Belgium's productive capacity had grown considerably.[27] At least since the mid-1850's, Belgium produced iron at costs not much higher than in Britain. But for all that, Belgian costs actually *were* a bit higher, which may be con-

23. This argument has been developed more thoroughly in Fremdling, Rainer, *Railroads and German Economic Growth: A Leading Sector Analysis with a Comparison to the United States and Great Britain,* in: Journal of Economic History, 37 (1977), pp. 583–604, and Fremdling, Rainer, *Britische Exporte und die Modernisierung der deutschen Eisenindustrie während der Frühindustrialisierung,* in: Vierteljahrschrift für Sozial- und Wirtschaftsgeschichte, 68 (1981), pp. 305–324.
24. An input-output-coefficient of 1.5 was assumed. The pig iron duty of 20 Mark per metric ton multiplied by 1.5 matched the increase of the bar iron duty. See Sering, *Eisenzölle,* pp. 65 ff., 74.
25. See footnote 20.
26. Sydow, Helmut, *Die Handelsbeziehungen zwischen Belgien und dem Zollverein 1830–1885,* vol. 1, Cologne 1979, pp. 79 ff.; Oechelhäuser, Wilhelm, *Denkschrift über den Vertrag des Zollvereins mit Belgien und die Lage der vereinsländischen Eisenindustrie,* Frankfurt a. M. 1851, pp. 6 f. and pass.
27. The precise figures of Belgian exports broken down to receiving countries are to be found in: Le Ministère de l'Intérieur, *Tableau général du commerce de la Belgique avec les pays étrangers, pendant l'anneé* 1,831 ff.

cluded from larger British import shares both in Germany and in France during the late 1850's and 1860's.

Table 2: German[1] Iron Production, Imports and Exports, 1825–1870, thousands of metric tons and ratios, annual averages

Years	Pig Iron Production (P)	Imports (M)	Exports (X)	$\frac{X - M}{X + M}$	$\frac{M - X}{P}$
1825/30	56.8	3.8	3.5	-0.03	0.004
1831/33	71.0	5.0	1.9	-0.45	0.04
1834/40	149.0	14.2	1.8	-0.77	0.08
1841/50	196.4	75.2	1.8	-0.95	0.37
1851/60	411.5	150.5	5.3	-0.93	0.35
1861/70	1,022.5	154.0	41.5	-0.58	0.11

Years	Bar Iron[2] Production (P)	Imports (M)	Exports (X)	$\frac{X - M}{X + M}$	$\frac{M - X}{P}$
1825/30	34.1	3.7	1.8	-0.35	0.06
1831/33	40.7	5.3	3.4	-0.22	0.05
1834/40	66.0	13.1	2.3	-0.71	0.16
1841/50	128.4	35.2	2.2	-0.88	0.26
1851/60	257.6	20.1	6.1	-0.53	0.05
1861/70	528.5	13.9	28.8	0.35	-0.03

1 until 1833 Prussia; from then on the Zollverein

2 including rails

Sources: See appendix.

Table 2 reflects the shifts in the foreign trade position of Prussia or the Zollverein. In the 1820's, the export-import-ratios for pig iron reveal no clear-cut comparative disadvantage yet, but from the 1830's until the late 1850's, the ratios become unfavourable. In the 1860's, Germany could improve her trade position by exporting large quantities of bar iron, though the level of imports still remained quite high. The extraordinary importance of imports compared to the domestic production is shown in

the last column of Table 2. These high ratios indicate that the development of the refining branch, the puddling and rolling mills, could not have been achieved without Britain and Belgium delivering the necessary inputs. In this way the refining branch with its bar iron and rail production modernized earlier and faster than the smelting branch. The ratios for bar iron indicate that the comparative disadvantage became more pronounced until the 1840's. The high net-imports in the late 1830's and in the 1840's were mainly caused by the extraordinary demand for railway construction. But from then on, the foreign trade position of Germany improved considerably. The process of import substitution was completed when Germany became a net-exporter of rails and bar iron in the 1860's.

Looking back at the development of the German and French primary iron industry one may briefly note some similarities or differences: In Prussia/Germany the modernization started later, but was carried through more rapidly than in France. By the late 1850's, both countries had reached a similar technical level. This level can be defined as the degree to which mineral fuel was used for smelting and refining iron.[28] In both countries, the second stage of primary iron production modernized sooner and much faster than the first. Each of them became a net-exporter of bar iron and rails in the 1860's. In both countries, pig iron imports still played a major role in the 1860's, thus providing the refinery branches and foundries with cheap inputs at sufficient quantities. A principal difference lay in the tariff policy and the resultant role of imports over the period: In France, high tariffs allowed a delayed, long-drawn and rather smooth transition making more use of internal resources. In Germany, lower tariffs led to a fast and rather abrupt change drawing considerably on external intermediate products.[29] It seems that by the 1860's both countries had acquired productivity gains high enough for them to lower their tariffs on primary iron products. At this point, they simply could afford a liberalization, e.g. that of the Cobden-Chevalier-treaty.[30]

The shifting international trade positions of west European countries are mirrored in the British foreign trade statistics. The bulk of the data is not presented here, but is confined to the shifts in British exports of bar iron and pig iron. Table 3 presents ratios of bar iron to pig iron, and they clearly indicate that right from the 1820's onwards, Britain began losing her absolute advantage in the refining stage of the primary iron industry much faster than in the smelting stage. In exporting huge amounts of pig iron she even supported the catching-up process in other countries.

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28. During the most part of the period in question both countries ranged far behind Belgium. See Table A 1 of the appendix.
29. France exploited much longer the wealth of the charcoal iron producing regions, the wood.
30. Mark per metric ton:
    Pig iron: D 1865 = 15 M, 1868 = 10 M, 1870 = 5 M;
    F 1855 = 32 M, 1861 = 20 M, 1864 = 18 M;
    Bar iron: D 1865 = 50 M, 1870 = 35 M;
    F 1855 = 80 M, 1861 = 54 M; 1864 = 48 M.
    Sering, *Eisenzölle*, Anhang 2;
    Archives Nationales F 12 2513, Etudes sur les résultats ...;
    Boiteau, *Traités*, p. 10.

Table 3: British Iron Exports, 1821–1870, thousands of metric tons and ratios, annual average

Years	Pig Iron (1) total	to Germany + Holland	Bar Iron[1] (2) total	to Germany + Holland	Ratio (2) / (1)[2] total	to Germany + Holland
1821/25	4.5	o.2	3o.5	2.2	8.5	13.8
1826/3o	8.5	1.2	49.3	5.8	7.3	6.o
1831/35	21.6	2.1	76.4	9.1	4.4	5.4
1836/4o	44.5	1o.3	112.8	14.9	3.2	1.8
1841/45	1o3.7	45.3	183.o	52.5	2.2	1.4
1846/5o	165.o	43.7	3o4.3	36.3	2.3	1.o
1851/55	276.4	72.4	575.7	41.o	2.6	o.7
1856/6o	366.1	136.3	742.2	64.o	2.5	o.6
1861/65	47o.o	157.2	627.5	48.8	1.7	o.4
1866/7o	626.5	187.8	874.6	46.8	1.7	o.3

1 including rails

2 for bar iron a multiplier of 1.25 was used to obtain pig iron equivalents

Sources: See appendix.

III

In the last section of this paper, I want to present some comparable data on costs and prices mainly for 1860 or 1861. Further, I intend to measure productivity gains over time by using price ratios of the major input and the output.

Table 4 gives data on variable costs. The cost structure within the iron industry is relevant for the approach in which productivity levels are measured across countries or over time periods. As already Donald N. McCloskey[31] has written in his study on the British iron and steel industry, this sector is characterized by "material-intensity and capital-lightness", notwithstanding common belief. Productivity measurement in this industry has to take into account the peculiar structure of inputs.

"'Productivity' is customarily defined as output per man or output per composite unit of men and machines, setting aside inputs of material from other industries. Although this definition is appropriate for measuring productivity in the nation as a whole, it is not for measuring it in one industry alone, whatever the end in view. It is inappropriate if the measure is meant to reflect the increased national income generated by technological change or improved efficiency in the industry, for these events

31. McCloskey, Donald, N., *Economic Maturity and Entrepreneurial Decline, British Iron and Steel, 1870–1913*, Cambridge Mass. 1973, p. 74.

release for alternative employment the labor and capital embodied in materials used by the industry as well as the labor and capital used directly. And it is also inappropriate if the measure is meant to reflect the responsiveness of entrepreneurs to market pressures to minimize costs, for these pressures induce entrepreneurs to save materials as well as labor and capital directly employed in the industry. Measures of productivity change for single industries should include material inputs."

The shares which costs of fuel and iron ore took, clearly reveal that material inputs made up most of the costs of pig iron production by far. But there are striking variations among different countries, regions or enterprises in the shares of costs of fuel or

Table 4: Pig Iron Costs, percent and Mark (M) per metric ton

Year		Country	(1) Fuel in % of (3)	(2) Iron Ore in % of (3)	(3) Variable Costs	
(1)	1841	Blair Scotland (GB)	32.2	46.7	29.9 M	
(2)	1843	Champagne (F)	68.2	14.2	113.o M	charcoal pig iron (includes "frais généraux")
(3)	1847	Dowlais South-Wales (GB)	24.3	61.4	56.2 M	
(4)	1846/ 1847	S.A.Marcinelle et Couillet (GB)	29.3	42.9	79.o M	
(5)	1847	S.A.Espérance Seraing (B)	32.1	3o.2	7o.2 M	
(6)	1848	S.A. Cockerill	42.8	44.1	75.9 M	pig for castings
		Seraing (B)	43.3	41.6	48.3 M	forge pig
(7)	186o	S.A. Cockerill Seraing (B)	3o.3-31.4	53-54	56-54 M	
(8)	186o	Alais	54.1	33.9	54.6 M	pig for rails
		Dépt. Gard (F)	54.2-57.2	38.o-37.7	83.7-89.o M	pig for "fer marchand"
(9)	1861/ 1862	Hochdahl Düsseldorf (D)	27.7	57.8	71.6 M	
(1o)	1862	Siegerland Westphalia(D)	59.7	36.9	67.o M	charcoal pig iron
(11)	1867	France Average (F)	62.9	16.4	52.o-56.o M	
(12)	1867	Cleveland (GB)	46.2	32.9	48.8 M	

1 Franc = o.8 Mark = o.8 Shilling; GB = Great Britain, F = France, B = Belgium, D = Germany.

Sources: See appendix.

ore. Besides my British data in Table 4, which vary considerably, one can draw on Robert Allen's data.[32] In the 1850's, fuel costs made up 44% of riable costs in Cleveland, 22% in Scotland, and 18% in South Wales, whereas the fuel shares of Cockerill and Hochdahl amounted to around 30%, and the extremely high French values were around 60%. The last figure was matched or even surpassed by traditional charcoal blast furnaces.

All these data, and I could add more on different regions and periods, support the statement, that one cannot assume a world, which followed a Cobb-Douglas-production-function for the period in question. The data do not fit into a system with constant factor shares and the same corresponding elasticities of production across countries and over time. Hence, this theoretically easy way to combine output-input-ratios to indices of total factor productivity cannot be pursued. This procedure would have been complicated on empirical grounds anyway: During the time-span from the 1820's to the 1860's, it is extremely difficult to get reliable and representative time series on physical input-output-quantities and ratios as e.g. the coke rate.[33] The information is rather sparse and fragile, and could easily lead to errors in measurement.

I suppose, a safer way to measure productivity gains over time might be to use price series of output and inputs. Within the framework of neoclassical theory, as it was put forward by Donald N. McCloskey and others, this approach might be equivalent to the use of physical input-output-quantities.[34] Even in periods, when sufficient competition is not always granted, prices could be used to estimate productivity over time.

"One way to apply the reasoning is to compare the prices of products at different dates. The price of a finished product, heavy steel rails, say, rose and fell because of changes in the prices of inputs, changes in productivity, and changes in the degree of monopoly power. The price of the most important input, pig iron, is readily available. The observed ratio of the rail price to the pig iron price will reflect productivity and the degree of monopoly power. ... The trend in the ratios is an estimate of the trend of productivity in railmaking ..."[35]

Following this reasoning I estimated the growth rates in Table 5. At first I refer to the pig iron production. As it is commonly assumed that ore requirements are not subject to productivity improvements,[36] I only used the other major input, the fuel, to detect productivity changes over time.[37] Due to the lack of data I had to calculate the

32. Allen, Robert, C., International Competition in Iron and Steel, 1850–1913, in: Journal of Economic History, 39 (1979), p. 921.
33. I.e. the amount of coke needed to produce one ton of pig iron. For Britain Riden has recently emphasized that it was extremely difficult if not impossible at all to get consistent time series on physical consumption of raw materials, Riden, Philip J., *The Iron Industry*, in: Church, Roy (ed.), The Dynamics of Victorian Business, London 1980, pp. 71 ff.
34. McCloskey, *Economic Maturity*, pp. 29, 86; Temin, Peter, *Iron and Steel in Nineteenth-Century America*, Cambridge Mass. 1964, p. 187.
35. McCloskey, *Economic Maturity*, pp. 24 f.
36. McCloskey, *Economic Maturity*, pp. 77 f.; Allen, Robert C., *The Peculiar Productivity History of American Blast Furnaces, 1840–1913*, in: Journal of Economic History, 37 (1977), p. 608.
37. E.g. Labour costs usually were below 10 percent, Isard, Walter, *Some Locational Factors in the Iron and Steel Industry since the Early Nineteenth Century*, in: Journal of Political Economy, 56 (1948), p. 203, footnote 4.

Table 5a: Ratios of Coke Pig Iron Prices to Fuel Prices, annual growth rates

Country	Period				
	1833-187o	1834-187o	1839-187o	1845-187o	185o-187o
GB	- 2.77^{++}			- 1.64^{++}	- 1.13^{++}
B				- 3.28^{++}	- 3.68^{++}
F Dépt. Nord			- 3.44^{++}	- 3.86^{++}	- 3.4o^{++}
F Dépt. Loire		- 1.1^{++}	- 1.96^{++}	- 1.92^{++}	- 1.42^{++}
D U. Silesia					- 2.63^{++}
D Ruhr					- 1.58[a]

Table 5 b Ratios of Bar Iron Prices to Pig Iron Prices, annual growth rates

GB	+			-	-
B				- (Rails -o.6^{+})	- (Rails-)
F Dépt. Nord			+ o.45^{+}	+ (Rails +)[b]	+ (Rails + o.46^{+})
F Dépt. Loire		+	+	+ (Rails -1.23^{++})[b]	- (Rails -1.54^{++})
D Ruhr					-

a nearly significant (5 %), b 1847 - 187o

The growth rates are derived from estimated values of a linear trend function; in cases where the linear trend function was not significant (++ 1 %; + 5 %) only the sign of the slope is given.

Sources: See appendix.

growth rates for different comparable time periods. With the exception of the Département Loire and the Ruhr area the ratios of pig iron to fuel prices show the expected picture: Continental countries or regions achieved considerably higher productivity gains between 1845 (or 1850) and 1870 than Britain.

Thus, the shifting foreign trade position between Britain and Continental countries, with these countries lowering their import duties mainly in the 1860's, corresponds very well with the fact described here, that Continental iron producers were able to reduce the cost differences in producing pig iron. Britain remained producer at lowest costs, however.

Obviously, Continental iron masters had been forced to economize on fuel rather early, whereas British producers had been used to drawing on cheap readily available fuel. This is explicitly stated in the Report on Coal:[38]

"It is certain that until recently there has been both an enormous waste of fuel in the production of heat, and a considerable waste of heat when produced, in all furnaces in which it has been necessary to obtain an elevated temperature." In the minutes to this report, Isaac Lowthian Bell, an authority on the iron industry, said:[39] "If you go back 40 years ... the small coal ... was so complete a drug in the market that immense quantities were wasted; ... the consequence was that an immense quantitiy of coal was left under ground, and the portion which was separated by the screens was allowed to accumulate at the pit head, and there it took fire and was lost."

In this case it seems that Continental iron masters enjoyed the advantage of backwardness. At a time when Britain could still draw on her immense supplies of cheap fuel Continental producers were much more forced to apply fuel-saving devices. Thus, the Continent rapidly adopted the hot blast, which had been developed in Scotland, but which was applied in other British iron producing regions rather hesitantly.[40] And there were innovations on the Continent to use the waste gases of the blast furnace to heat the hot blast and subsequently puddling furnaces as well. Not by accident was the utilization of waste gases developed within the field of traditional charcoal iron industry, which was much more under pressure to economize on fuel.[41]

I have mentioned above that the Ruhr area and the Département Loire had exceptionally low growth rates concerning the ratios for pig iron. In order to explain why the Département Loire in the south of France merely achieved significantly lower productivity gains than the Département Nord, specific enterprises in both regions

38. *Report of the Commissioners Appointed to Inquire into Serveral Matters Relating to Coal in the United Kingdom,* in: Parliamentary Papers, XVIII (1871), p. 96.
39. *Report from the Select Committee on Coal; with the Proceedings of the Committee, Minutes of Evidence,* in: Parliamentary Papers, X (1873), p. 237.
40. The introduction of the hot blast led to drastic reductions in fuel consumption. Thus its cost-saving function was highest where fuel costs were highest. Within Britain this was true of Scotland compared to South-Wales and internationally it was true of Continental countries compared to Britain. Hyde, *Technological Change,* pp. 146–159; Bell, Isaac Lowthian, *The Iron Trade of the United Kingdom Compared with of the other chief Iron-Making Nations,* London 1886, p. 100.
41. E.g. in Württemberg (southern Germany), where since 1830 Faber du Faur had developed several devices to use waste gases. Beck, Ludwig, *Die Geschichte des Eisens in technischer und kulturgeschichtlicher Beziehung, 1801–1860,* Braunschweig 1899, pp. 412ff., 434f.

ought to be scrutinized and compared. But let me simply try an informed guess here: It is conspicuous that the Département Loire considerably increased its productivity of rail-making, as measured in Table 5. My explanation for this seeming inconsistency is that pig iron prices here do not reflect the considerable improvements in the quality of the pig iron produced. I assume that over time in this region the amount of pig iron necessary to produce a certain quantity of rails had dropped considerably. I know this for sure concerning a comparable region, the Département Aveyron. There the quantity of pig iron needed to produce rails dropped dramatically, whereas the prices of pig iron fell only slightly.[42] This argument gives a hint of the limitations of measuring productivity changes over time by using price data. Certainly, this approach is biased when quality changes are not taken into account.

The case of the Ruhr area requires a different explanation. The most striking evidence here seems to be the lateness of introducing coke blast furnaces into this region. The first one was successfully put into blast only in 1849.[43] Given the fact that the Ruhr area had drawn considerably on cheap foreign coke pig iron for quite a time it seems plausible that entrepeneurs could afford to wait for the blast furnace to have developed a high practice standard. And only then did the Ruhr iron masters enter the pig iron market and erect a lot of *modern* blast furnaces of their own. Hence, the works of Hochdahl, which were considered to be representative of the price and qualitiy of forge pig iron, could experience only slight decreases in costs during the 1860's: Having taken up the production of pig iron in 1861 at a highly modern standard they could hardly develop further in the 1860's.[44]

Let me now turn to the refining sector. The overwhelming cost factor to produce bar iron or rails is pig iron, which amounted to usually more than 50%.[45] If we exclude rail prices the trend functions on the ratios of bar iron to pig iron prices are not significant. By this measure the refining branch does not show any traceable productivity gains, neither in Britain nor on the Continent.[46] But the fact that bar iron prices moved parallel to pig iron prices intimates that there must have been certain productivity gains in the refining branch, too.

42. E.g. in the Département Aveyron the extraordinary amount of 1.75 tons of pig iron was needed to produce one ton of bar iron in 1834. The average price for pig iron was 70 Mark per metric ton between 1834 and 1840, and 72 Mark between 1861 and 1870, compiled from the various issues of the French mineral statistics: Source, see the note on France of Table 5. As suggested by François Crouzet in the discussion of this paper the Département Loire had already developed the best practice standard very early, therefore the possibility of productivity gains in the years to come could not exceed those of the pacemaker i.e. Britian.
43. Lange-Kothe, Irmgard, *Die ersten Kokshochöfen in Deutschland, besonders im Rheinland und in Westfalen*, in: Stahl und Eisen, 85 (1965), pp. 1053–1061.
44. On the costs of the Hochdahl iron works see *Reichs-Enquete für die Eisenindustrie*, n.p. or d., p. 254; as another example, where the coke rate did not show any decrease from 1854 to 1870, the "Eisenhütte Berge-Borbeck" is presented by Fischer, Wolfram, *Herz des Reviers*, Essen 1965, pp. 100f.
45. Conseil supérieur de l'agriculture, du commerce et de l'industrie, *Enquête, Traité de commerce avec l'Angleterre, Industrie métallurgique*, vol. 1, Paris 1860, p. 643f.; Glamorgan Record Office Cardiff, Dowlais Works, D/DG Sect. C Box 4.
46. Concerning Britain see Hyde, Technological Change, pp. 166, 176.

As the technology of puddling and rolling was rather easy to adopt it was applied everywhere in the relevant Continental countries quite successfully already in the 1820's. Since these techniques could be used to work up charcoal pig iron as well (it was often mixed with coke pig iron) the modern mineral fuel techniques spread much faster through in this stage than the coke blast furnace.[47] Hence, it seems plau-

Table 6: Pig Iron Prices at the Works, Mark (M) per metric ton, 1860 or 1861

D	(1)	Düren (left bank of the Rhine near Aachen)	75 M 85.3 M (charcoal pig)
	(2)	Dortmund (eastern Ruhr)	81.7 M
	(3)	Oberhausen (western Ruhr)	76.3 M
	(4)	Düsseldorf (Hochdahl)	85.1 M
	(5)	Georgs-Marien-Hütte (south of Osnabrück)	84.4 M
	(6)	Upper-Silesia	66-72 M
		"	9o M (charcoal pig)
B	(7)	Seraing (S.A. Cockerill)	6o-64 M
	(8)	National Average	63.6-65.1 M
		"	1o2.5-1o5.9 M (charcoal pig)
F	(9)	Dépt. Haute Marne	99 M (charcoal pig)
	(1o)	Dépt. Nord	96-1o1 M
	(11)	Dépt. Loire	81-84 M
	(12)	Dépt. Aveyron	8o M
	(13)	Dépt. Saône-et-Loire	76-77 M
	(14)	Dépt. Moselle	74-75 M
		"	124-128 M (charcoal pig)
GB	(15)	Glasgow	48.5-52.9 M
	(16)	South Wales	69.o-83.1 M

Import Duties: D 2o M p t
B 16 M p t
F 32 M p t (2o M from 1861 onwards)

Costs of transportation to Continental ports, around: 16 M p t

Sources: See appendix.

47. France is a good example, for the 1820's see *Enquête sur les fers*, pass.

sible that already during the mid-1840's the costs for working up pig iron were not significantly different from those in Britain. And still existing productivity differences, e. i. of the puddlers, which are reported by contemporary observers, were compensated for by adequate reductions in wages on the Continent.

To conclude the tentative reasoning on the data presented in Table 5 a major shortcoming should be mentioned: The whole charcoal iron industry was missed out, although this branch was still very important in the mid-century. For example in the years of 1848 to 1850, in France only 41% of the pig iron were smelted with coke as a fuel and in Prussia only 23%.[48] Therefore, a thorough analysis of the primary iron sector from the 1820 to the 1860's has to pay due regard to this traditonal branch.

But notwithstanding all developments on the Continent, it is worth repeating that even around 1860 Britain had in general maintained her position as lowest cost producer, both of pig iron and of bar iron. Comparing prices (as shown in Table 6) it is, however, pretty clear that the still existing import duties and transportation costs allowed indigenous producers in France, Belgium and Germany to satisfy the demand in most parts of their *home* countries at prices equal to the British prices or even lower.

Appendix

Sources on Table 1:

On the production figures see the notes on Table A 1. On the foreign trade figures see Administration des Douanes, *Tableau général du commerce de la France avec ses colonies et les puissances étrangères, pendant l'année...*, Paris..., Years 1825–1870.

Sources on Table 2:

On the production figures see Marchand, *Säkularstatistik,* pp. 88, 115, 129. On the foreign trade figures see Ferber, C. W., *Beiträge zur Kenntniß des gewerblichen und commerciellen Zustandes der preußischen Monarchie,* Berlin 1829, pp. 29ff.; Ferber, C. W., *Neue Beiträge...*, 1832, p. 23; Dieterici, C. F. W., *Statistische Uebersicht der wichtigsten Gegenstände des Verkehrs und Verbrauchs im preußischen Staate und im deutschen Zollverbande, in dem Zeitraume von 1831 bis 1836,* Berlin 1838, p. 95; Sering, Max, *Geschichte der preussisch-deutschen Eisenzölle von 1818 bis zur Gegenwart,* Leipzig 1882, pp. 290f.

Sources on Table 3:

The iron export data are to be found in the respective yearly volume of the Parliamentary Papers. Cf. 1825 XXI; 1829 XVII; 1830–31 X; 1831–32 XXXIV; 1833 XXXIII; 1835 XLVIII; 1839 XLVI; 1840 XLIV; 1842 XXXIX; 1843 LII; 1844 XLV; 1845 XLVI; 1846 XLIV; 1847–48 LVIII; 1849 L; 1851 LIII; 1854 LXVI; 1854–55 LI; 1856 LVI; 1857 XXXV; 1857–58 LIV; 1859 XXVIII; 1860 LXIV; 1861 LX; 1862

48. Cf. Table A 1 of the appendix.

LVI; 1863 LXV; 1864 LVII; 1865 LII; 1866 LXVIII; 1867 LXVI; 1867–68 LXVII; 1868–69 LVIII; 1870 LXIII; 1871 LXIII P. II. Exports to Ireland, the Channel Islands (Guernsey, Jersey, Alderney) and the Isle of Man were subtracted from the total.

Sources on Table 4:

(1) Hyde, Charles K., *Technological Change and the British Iron Industry, 1700–1870,* Princeton 1977, p. 153;
(2) Archives Nationales Paris, F 12 2223, Fonderies de Dammarie to Le Directeur Général des Forêts, 16.–11.–1843;
(3) Glamorgan Record Office Cardiff, Dowlais Works, D/DG Sect. C Box 4;
(4) – (6) Valerius, Benoit, *Theoretisch-praktisches Handbuch der Roheisen-Fabrikation* (German by C. Hartmann), Freiberg 1851, pp. 474–478;
(7) Conseil supérieur de l'agriculture, du commerce et de l'industrie, *Enquête, Traité de commerce avec l'Angleterre, Industrie métallurgique,* vol. 1, Paris 1860, pp. 640 f.
(8) Archives Nationales Paris, F 12 2884, Rapport... sur le prix de revient de la fonte et du fer dans les usines du Département du Gard par M. Dupont, pp. 17 f.;
(9) *Reichs-Enquete für die Eisenindustrie 1878,* n.p. or d., p. 254;
(10) Wedding, Hermann, *Die Resultate des Bessemer'schen Processes für die Darstellung von Stahl und Aussichten desselben für die rheinische und westfälische Eisen- resp. Stahlindustrie,* in: Zeitschrift für das Berg-, Hütten- und Salinenwesen, 11 (1863), p. B. 265;
(11) Ministère de l'agriculture, du commerce et des travaux publics, *Enquête sur l'application du décret du 15 février 1862, relatif à l'importation en franchise temporaire des métaux,* Paris 1867, p. 215;
(12) *Report of the Commissioners appointed to inquire into the several matters relating to Coal in the United Kingdom,* vol. 1, in: Parliamentary Papers, 18 (1871), p. 151.

Sources on Table 5:

GREAT BRITAIN, coke pig iron at Glasgow: Meade, Richard, *The Coal and Iron Industries of the United Kingdom,* London 1882, p. 741; Sering, *Geschichte,* p. 302. Hard coal, Annual average price of all exports: Mitchell, B. R. and Deane, Phyllis, *Abstract of British Historical Statistics,* Cambridge 1962, p. 483. Bar Iron at Liverpool: Griffiths, Samual, *Guide to the Iron Trade of Great Britain,* new ed., n.p. 1967, pp. 288 f.

BELGIUM, coke pig iron, national average: Reuss, Conrad et al., *Le Progrès Économique en Sidérurgie, Belgique, Luxembourg, Pays-Bas, 1830–1955,* Louvain 1960, p. 396. Hard coal: Stainier, Emile, *Histoire commerciale de la métallurgie dans le district de Charleroi de 1829 à 1867,* sec. ed. Charleroi 1873, Appendix VI; Commission Centrale de Statistique, *Exposé de la situation du Royaume de 1861 à 1875,* Brussels 1885, vol. II, p. 646. Bar Iron (i.e. "fers finis") and Rails: Reuss et al., *Progrès,* p. 400.

FRANCE, coke pig iron, bar iron ("gros fer, fer marchand"), rails: Compiled from the various issues of the French mineral statistics, Direction générale des ponts et chaussées et des mines, *Compte rendu des travaux des ingénieurs des mines pendant l'année...* (1833–1835), Paris 1834–1836; Ministère du commerce et des travaux publics, Direction générale des ponts et chaussées et des mines, *Résumé des travaux statistiques ...* (1835–1836), Paris 1836–1837; Ministère des travaux publies et du commerce, *Résumé des travaux statistiques de l'administration des mines en ...* (1837–1846), Paris 1838–1847; Ministère de l'agriculture, du commerce et des travaux publics, Direction des mines, *Résumé des travaux statistiques de l'administration des mines en ...* (1847–1872), Paris 1854–1877. Hard coal: Ministère des travaux publics, *Statistique de l'industrie minérale et des appareils à vapeur en France et en Algérie* pour l'année 1893, Paris 1894, diagramme 1.

GERMANY, RUHR, coke pig iron: Däbritz, Walther, *Entstehung und Aufbau des rheinisch-westfälischen Industriebezirks,* in: Matschoß, Conrad (ed.), Beiträge zur Geschichte der Technik und Industrie, 15, Berlin 1925, p. 1906. Hard coal: Holtfrerich, Carl-Ludwig, *Quantitative Wirtschaftsgeschichte des Ruhrkohlenbergbaus im 19. Jahrhundert,* Dortmund 1973, pp. 22f. Bar iron: Holtfrerich, *Quantitative Wirtschaftsgeschichte,* pp. 145f.

UPPER SILESIA: Jacobs, Alfred and Richter, H., *Die Großhandelspreise in Deutschland von 1792 bis 1934,* Berlin 1935, pp. 62f.

Sources on Table 6:

(1) Zeitschrift für das Berg-, Hütten- und Salinenwesen, 9 (1861), p. 14.
(2/3) Zeitschrift für das Berg-, Hütten- und Salinenwesen, 10 (1862), p. 170.
(4) *Reichs-Enquete,* p. 254.
(5) *Reichs-Enquete,* p. 272.
(6) Zeitschrift für das Berg-, Hütten- und Salinenwesen, 10 (1862), p. 167.
(7) See note (7) on Table 4.
(8) Reuss, et al., *Progrès,* p. 396.
(9)–(14) Ministère de l'agriculture, du commerce et des travaux publics, Direction des mines, *Résumé des travaux statistiques de l'administration des mines en 1860 à 1864,* Paris 1867.
(15) See note on Table 5.
(16) Archives Nationales, Paris, F 12 2513, copy from the Mining Journal.

Table A 1: Iron Production in Belgium (B), France (F) and Prussia (P), 1836-1870, thousands of metric tons and percentages

Year		Pig Iron Production 1000 tons	by coke or mixed fuel %	Bar Iron Production 1000 tons	by hard coal %
1836	B	101.4-115.8	67.5-71.5		
	F	308.4	15.0	210.6	47.3
	P	88.7		50.5	32.1
1837	B	118.1	72.1		
	F	331.7	15.9	224.6	51.0
	P	99.5	9.6	58.7	31.8
1842	B	81.3	90.8		
	F	399.5	25.6	284.8	61.1
	P	101.0	18.0	79.3	39.5
1847	B	248.4	89.5	80.9	
	F	591.6	42.6	376.7	74.3
	P	137.9		158.5	70.2
1848/1850	B	151.5	89.8	65.9	
	F	430.8	40.9	255.3	71.4
	P	126.7	22.7	117.8	59.3
1851/1860	B	274.3	95.7	143.1	
	F	780.0	58.6	480.0	79.9
	P	305.5	38.3	239.8	85.4
1861/1870	B	442.2	99.2	358.8	
	F	1191.5	84.1	767.0	90.6
	P	819.9	91.5		

Notes and sources on Table A 1: The bar iron production includes rails. For Belgium this category represents total wrought iron production. The years were chosen according to information available for Prussia. On France and partly Belgium more information is published in the cited sources.

Belgium: 1836, 1837, 1842, own estimate based on the number of furnaces in blast. For the calculation methods see Fremdling, Rainer, *Untersuchungen zur Modernisierung der Eisenindustrie in Westeuropa 1820-1860,* manuscript 1982.

For the other years, Statistique générale de la Belgique, *Exposé de la situation du Royaume, 1841-1850, 1851-1860, 1861-1875,* Brussels 1852, 1865, 1885.

France: All years are covered, in: Ministère de l'agriculture, du commerce et des travaux publics, Direction des mines, *Résumé des travaux statistiques de l'administration des mines en ... (1847-1872),* Paris 1854, 1861, 1867, 1874, 1877.

Prussia: On pig iron production see Marchand, Hans, *Säkularstatistik der deutschen Eisenindustrie,* Essen 1939, pp. 39, 88; on the production by charcoal for 1837, 1842, 1849 see Oechelhäuser, Wilhelm, *Vergleichende Statistik der Eisen-Industrie aller Länder und Erörterung ihrer ökonomischen Lage im Zollverein,* Berlin 1852, p. 35; for 1848 see Althans, E., *Zusammenstellung der statistischen Ergebnisse des Bergwerks-, Hütten- und Salinenbetriebes in dem preußischen Staate während der zehn Jahre von*

Table A 2: French Iron Imports, 1815–1828, thousands of metric tons and percentages

Year	Bar Iron (fer en barres) tons	from Great Britain %	Belgium %	Sweden/Norway %
1815	6.9			
1816	4.0			
1817	13.8			
1818	10.1			
1819	10.7			
1820	8.9	76.8	10.1	?
1821	13.8	79.2	4.9	?
1822	5.1	48.5	8.1	37.1
1823	4.5	33.7	6.7	53.9
1824	5.8	17.7	3.0	67.1
1825	6.1	?	?	?
1826	9.6	?	?	?
1827	7.3	6.7	0.7	74.3
1828	6.6	15.9	0.3	72.3
	Pig Iron (fonte brute)			
1815	0.9			
1816	2.3			
1817	2.8			
1818	3.4			
1819	2.7			
1820	5.4			
1821	7.7	35.6	42.0	-
1822	8.3	30.7	41.5	-
1823	7.8	41.7	39.0	-
1824	7.2	24.9	47.4	-
1825	7.4	?	?	-
1826	11.4	?	?	-
1827	7.8	28.6	46.1	-
1828	8.8	29.9	44.2	-

All figures are related to the "commerce spécial", i.e. imports entering the French market for consumption.

1852 bis 1861, in: Zeitschrift für das Berg-, Hütten- und Salinenwesen in dem preußischen Staate, Suppl. to vol. 10 (1863) p. 85; for 1850 see Oechelhäuser, Wilhelm, *Die Eisenindustrie des Zollvereins in ihrer neueren Entwicklung,* Duisburg 1855, p. 14; for 1851–1870 see Marchand, *Säkularstatistik,* p. 39.

On bar iron production see Marchand, *Säkularstatistik,* p. 88; on the production by hard coal for 1836 see Marchand, *Säkularstatistik,* p. 37; for 1837, 1842, 1847–1860 see Althans, *Zusammenstellung,* p. 101.

Sources on Table A 2:

Ministère du Commerce et des Manufactures, *Enquête sur les fers,* Paris 1829, pp. 21, 23; Douanes Royales de France, *Tableau des quantités et de la valeur approximative des marchandises étrangères importées en France pour la consommation pendant l'année...,* Paris..., Years 1820–1824; Administration des Douanes, *Tableau général du commerce de la France avec ses colonies et les puissances étrangères, pendant l'année...,* Paris..., Years 1825–1828; Archives Nationales, F 12 2513.

Table A 3: British Iron Exports to France, 1815–1828

Year	Bar Iron		Pig Iron	
	1000 of metric tons	as percentage of total exports	1000 of metric tons	as percentage of total exports
1815	0.09	0.5	-	-
1816	1.1	5.3	-	-
1817	11.8	34.3	0.8	19.9
1818	8.8	20.8	0.9	27.8
1819	5.3	22.3	0.2	16.6
1820	7.7	21.1	1.4	52.0
1821	11.4	33.7	3.1	68.1
1822	2.6	7.6	3.4	66.1
1823	2.4	7.1	4.1	53.1
1824	1.4	5.5	0.9	43.7
1825	1.5	5.9	1.1	37.7
1826	2.7	8.0	3.9	58.3
1827	1.7	3.8	2.7	37.8
1828	2.1	4.1	2.2	28.4

Exports to Ireland, the Isle of Man and to the Channel Islands were subtracted from total exports.

Source: *Parliamentary Papers,* 1819, vol. XVI; 1825, vol. XXI; 1829, vol. XVII.

Zusammenfassung: Außenhandelsstruktur, technischer Wandel, Kosten und Produktivität in der Eisenindustrie Westeuropas, 1720–1870

Dieser Aufsatz ist Teil eines umfassenderen Projektes, in dem die Diffusion des Koksschmelzens und des Puddelverfahrens in Belgien, Frankreich und Deutschland von den 1820er Jahren bis in die 1860er Jahre untersucht wird. Großbritannien als wirtschaftlich führendes Land in der Eisenindustrie ist darin vorrangig in seiner Modellfunktion sowie als Exporteur primärer Eisenprodukte (Roh- und Stabeisen) einbezogen. Wesentliches Anliegen der Arbeit ist, den Diffusionsprozeß aus *ökonomischen* Erwägungen zu erklären. Damit soll der gängige Fehler vermieden werden, technische Fortschritte verkürzt mit wirtschaftlichen gleichzusetzen. Traditionelle Verfahren oder teilweise modernisierte Techniken waren nämlich lange Zeit den jeweils „modernsten" Techniken unter *wirtschaftlichen* Gesichtspunkten (d. h. hinsichtlich der Produktionskosten) durchaus ebenbürtig.

Aus der umfangreicheren Themenstellung werden hier zwei Teilbereiche herausgegriffen, und zwar:

1. Strukturwandlungen des Außenhandels,
2. Produktivitätsentwicklungen im Vergleich von Regionen bzw. Ländern.

Die Strukturwandlungen des Außenhandels (Punkt 1) wurden zwischen Frankreich und Deutschland verglichen. Als ausgeprägte Unterschiede erwiesen sich dabei die Zollpolitik und die Rolle von Importen. In Frankreich ermöglichten hohe Zolltarife einen verzögerten, langgezogenen Übergang zur Steinkohlentechnologie, wobei man stärker auf vorhandene inländische Ressourcen zurückgriff. In Deutschland dagegen bewirkten die niedrigen Zolltarife einen schnellen und eher abrupten Wechsel, wobei in beträchtlichem Ausmaß Zwischenprodukte (Roheisen) von außerhalb eingesetzt wurden. In den späten 1850er Jahren hatten beide Länder in der primären Eisenindustrie ungefähr den gleichen technischen Standard erreicht. Die Produktionskosten waren dann so weit gesenkt, daß man sich die niedrigen Zolltarife im Rahmen des Cobden-Chevalier-Vertrages leisten konnte.

Unter Punkt 2 wurde versucht, die Produktivitätsentwicklung bei der Herstellung von Roheisen und Stabeisen zu messen, indem die Outputpreise dem Preis des wichtigsten Inputs (nämlich Steinkohle für das Roheisen und Roheisen für das Stabeisen) im Trend gegenübergestellt wurden. In der Roheisenerzeugung zeigten die kontinentaleuropäischen Länder in der Zeit zwischen 1845/1850 und 1870 deutlich höhere Produktivitätsfortschritte als Großbritannien. In der Stabeisenherstellung dagegen, d. h. beim Puddel- und Walzprozeß, wiesen alle Länder kaum Produktivitätsfortschritte auf. All diese Kosten- und Preisvergleiche zeigen aber, daß Großbritannien in den 1860er Jahren immer noch der Anbieter zu niedrigsten Preisen war, wenngleich kontinentaleuropäische Eisenproduzenten inzwischen so weit aufgeholt hatten, daß sie unter dem Schutz der noch immer existierenden Zolltarife und der Transportkosten ihr Eisen in ihren Ländern ebenso billig, wenn nicht gar billiger anzubieten vermochten.

Rainer Metz

"Long Waves" in English and German Economic Historical Series from the Middle of the Sixteenth to the Middle of the Twentieth Century*.

I. State of research and scientific interest

Upswings and downswings taking irregular courses, exhibiting both different rates of variation and changing directions, and which moreover manifest themselves in economic time-series, and thus indicate phases of prosperity and depression of capitalist economies, at least for the last 150–200 years, constitute the empirical background on which the current discussion about the phenomenon of "long waves" is taking place.[1] It is chiefly in recent discussions that the attempt has been made to integrate these long wave cyclical fluctuations into an approach which starts from the study of all relevant economic and social factors. This approach tries to find out, to what extent economic, political, and social events are dependent on such fluctuations.[2]

Although such an approach implies the conviction that it is worth while dealing with "long waves", it should not be overlooked, however, that this conception has departed a long way from a view which regards ups and downs as the regular course of all economic and historical events.[3] The hypothesis of a fundamentally cyclical course inherent in the system, which is basic to the classic theory,[4] seems to be of mi-

* I owe much gratitude to my esteemed teacher Prof. Dr. Franz Irsigler for his engaged help and useful contributions to the discussion while I was composing this paper.

1. For the current discussion see *Petzina, D.; van Roon, G.:* Konjunktur, Krise, Gesellschaft. Wirtschaftliche Wechsellagen und soziale Entwicklung im 19. und 20. Jahrhundert. (Geschichte und Gesellschaft. Bochumer Historische Studien, Bd. 25) Stuttgart 1981; and *Schröder, W. H.; Spree, R.:* Historische Konjunkturforschung. Stuttgart 1980.
2. See Petzina's comments on this approach: "Lange Wellen" und "Wechsellagen": Die derzeitige Diskussion. In: *Petzina/Roon:* Konjunktur, Krise, Gesellschaft (supra, n. 1), p. 17; as to the problems attached to such a view see *Schröder/Spree:* Historische Konjunkturforschung (supra, n. 1). Important impulses were given by *Hans Rosenberg's* book: Große Depression und Bismarckzeit. Berlin 1967, who attributed a twofold function to the long oscillations of the economic development. One of these functions was to be "reales Erkenntnisobjekt, ..., ebenso Ergebnis wie Anlaß von spezifischen Wirkungszusammenhängen; loc. cit., p. 19.
3. The evident trend phases constitute the actual object of investigation; the question whether they necessarily recur as cyclical fluctuations, or not, is of secondary importance.
4. This paper cannot claim to analyze the history of scientific dogmas; it must be pointed out, however, that *Kondratieff, van Gelderen* and others were of the opinion that the reasons for

nor importance in such an approach. Therefore the question whether there is a possibility of identifying long-term cycles with the aid of a statistical procedure independent of the object that is to be analyzed, appears to have become less significant.[5]

It is not very surprising in this context that the serious problems of an empirical test and conceptualization of "long waves", which have not yet been solved, have nearly always been ignored.[6] Two important points should, however, not be left out of account:

- "Long waves" as they are discussed nowadays are regarded as a cyclical phenomenon and as actual indicators of the course of economic processes.[7]
- Serious methodical objections have been made against all attempts of finding empirical proofs of long-term cycles; for this reason, the empirical evidence of "long waves" is still regarded as an unsolved problem.[8]

This paper is conceived as a contribution to the discussion about the problems of a methodical-statistical proof of the existence of "long waves", and it introduces methods which to some extent have been completely newly developed to solve this problem.[9] Whereas the exact determination of the trend has been the main problem of the treatises which have hitherto dealt with this topic, because only trend-free time series can be tested with regard to their cyclical structure, a method for the elimination of

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the existence of "long waves" are necessarily inherent in the capitalist way of production and that there is no capitalist production which does not exhibit such a wavy course. See e.g. the very instructive comments by *Ekland, Klas:* Long Waves in the Development of Capitalism. In: Kyklos 33 (1980), pp. 383–419; or *Duijn, J. J. van:* De lange golf in de economie. Kan innovatie ons uit het dal helpen? Assen 1979, pp. 27–38.

5. Stier, however, holds the opinion that "die Frage nach geeigneten statistischen Verfahren eigentlich am Anfang aller Untersuchungen stehen muß", see *Stier, W.:* Zur Rolle und Funktion statistischer Verfahren in der empirischen Wirtschaftsforschung und der Wirtschaftsgeschichte. In: *Petzina/Roon:* Konjunktur, Krise, Gesellschaft (supra, n. 1) p. 297.
6. This is true of all treatises which take the existence of "long waves" for granted, but do not analyze empirical series statistically. See e.g. *Spree, R.:* Was kommt nach den langen Wellen? In: *Schröder/Spree:* Historische Konjunkturforschung (supra, n. 1), p. 305.
7. This fact is illustrated in Petzina's survey of research, *Petzina, D.:* "Lange Wellen" und "Wechsellagen" (supra, n. 2). The approaches which put the trend periods at the centre of interest differ very much from this one. *W. W. Rostow* is probably the most exposed representative of this view, see his survey: Kondratieff, Schumpeter and Kuznets: Trend Periods Revisited. In: Journal of Economic History 35 (1975), cf. *Spree's* comments: Wachstumstrend und Konjunkturzyklen in der deutschen Wirtschaft von 1820–1913. Göttingen 1978, esp. pp. 32–97.
8. See the fundamental comments by *Stier, W.:* Zur Rolle und Funktion (supra, n. 5); and *Stier:* Die "langen Wellen" in der Konjunktur. Einige statistische Bemerkungen. In: Wirtschaftsdienst 1976 XII, p. 637 ff.; *Nullau's* article is also very instructive; *Nullau, B.:* Die Kondratieff-Wellen—Ein Slutzky Effekt? In: Wirtschaftsdienst 1976/IV. p. 177 ff.; cf. the methodical literature in n. 42.
9. The filter-methods developed by *Prof. Stier* and his team collaborators are mainly dealt with in this paper. The development of these methods is described in: *Stier, W.:* Konstruktion und Einsatz von Digitalfiltern zur Analyse und Prognose ökonomischer Zeitreihen. Opladen 1978; *Stier, W.:* Über eine Klasse von einfachen FIR-Tiefpass-Selektionsfiltern. In: Allg. Stat. Archiv, Heft 3, 1978. I would like to express my gratitude to Prof. Stier and Dr. Schulte for their useful help and support.

the trend is introduced in this paper which achieves the necessary exact determination of the trend.[10] Clear hints as to the existence of "long waves" can only be gained with the aid of spectral analysis which is based on trend-free series.[11]

The more important question concerning the shape and position of these long-term cycles within their historical dimension of time can only be solved if these clear hints are available. To represent the problem of proving the existence of "long waves" in such a way, is the only possibility of making a critical analysis of the postulated cyclical phenomena. The results of the analysis will show to what extent traditional conceptions which have sought to explain the phenomenon of "long waves" ought to be put in a new light and also, how the present state of research ought to be revised, or at least partly revised. The statistical methods introduced in this paper cannot, however, claim to be conclusive and, therefore, we hope that from the statistical standpoint the last word has not yet been spoken on this problem.[12]

The current discussion[13] about long-term cycles is marked by extremely controversial views.[14] In addition to the older treatises[15] on "long waves", which in most cases made use of the historical-descriptive method, in subsequent years, diverse models

10. The fundamental work is *Schulte, H.:* Statistisch-methodische Untersuchungen zum Problem langer Wellen. = Schriften zur wirtschaftswissenschaftlichen Forschung, Bd. 135, Meisenheim 1981, and *Schulte:* Ein neuer statistischer Ansatz zur Identifizierung von Wellenbewegungen in der langfristigen Wirtschaftsentwicklung. In: *Petzina/Roon:* Konjunktur, Krise ... (supra, n. 1), pp. 300–322.
11. As far as I know, an analysis which makes use of modern filter methods has only been made once in: *Metz, R.; Spree, R.:* Kuznets-Zyklen im Wachstum der deutschen Wirtschaft während des 19. und frühen 20. Jahrhunderts. In: *Petzina/Roon:* Konjunktur, Krise ... (supra, n. 1) p. 343 ff. The recently published treatises which have been concerned with this problem are in most cases confined to a spectral analytical proof of "long waves". See e.g. *Bossier, F.; Huge, P.:* An Empirical Examination of Long Cycles from Belgian Data. In: *Petzina/Roon:* Konjunktur, Krise... (supra, n. 1), pp. 331–342.
12. The empirical results will show that quite a lot of filter types are still needed to provide operable procedures for important scientific concepts.
13. Important aspects of this discussion can be found in the omnibus volumes publ. by *Petzina/Roon:* Konjunktur, Krise... (supra, n. 1) and *Schröder/Spree:* Historische Konjunkturforschung; also in *Delbeke's* short but instructive article *Delbeke, Jos.:* Recent Long-Wave Theories. A critical survey. In: Futures, Aug. 81, p. 246 ff.
14. On the one hand there is the opinion that it would be better "die 'langen Wellen' des Wirtschaftswachstums und der Konjunktur endlich zu begraben", see *Spree, R.:* Was kommt nach den "langen Wellen" (supra, n. 6), p. 314; on the other hand it is argued that "there certainly exists a prima facie case for the existence of Kondratieff cycles worthy of further investigation", Research Working Group upon Cyclical Rhythms and Secular Trends: Cyclical Rhythms and Secular Trends of the Capitalist World-Economy: Some premises, hypotheses and questions. In: Review, II (4), p. 487; cit. according to *Gordon, D. D.:* Stages of Accumulation and Long Economic Cycles. In: *Hopkins, T. K.; Wallerstein, I.:* Processes in the World-System. Beverly Hills, Calif. forthcoming.
15. See e.g. *Parvus, H. A.:* Die Handelskrisis und die Gewerkschaften. München 1901; *van Geldern, I.; Fedder, I.:* 'Springvloed, Beschuwingen over industrielle outwikkelning en prijsbewegung. In: Die Nieuwe Tijd 18 (1913); *Wolff, S. de:* Prosperitäts- u. Depressionsperioden. In: Festschrift K. Kautsky. Jena 1924, but also Spiethoff, Schumpeter and Kuznets.

have been designed which have regarded long-waved fluctuations as the essential and intrinsic course of capitalist economies.[16]

All these authors have aimed at proving those factors within the socio-economic process that cause the regular change from prosperity into stagnation, and vice versa. It is typical of all these models that they try to explain this phenomenon with the aid of a very small number of variables, which in turn are either defined as economic endogenous or exogenous factors.[17] The essential point is, however, that both the empirical evidence of "long waves" and their specific length are assumed as a matter of fact, and as being determinable through experience. This circumstance is rather astonishing, considering the great number of serious objections to the procedures which have hitherto been used.

The main reasons why it is so difficult to give empirically exact proofs of "long waves" are the following: In order to prove "long waves" as a cyclical phenomenon it is absolutely necessary to dispose of very long series which ought to be several times as long as the postulated length of the cycles. In reality, it is, however, hardly possible to compile numerical expressions of identical phenomena over such long periods of time. That is either because the necessary sources are not available, or the economic variables have changed so much in meaning that the identity of the phenomena measured cannot be secured, regardless of the fact that methods of measuring and of collecting data permanently change.[18]

Even if one does not take these data-problems into consideration, and surmises, for example, that time series meet these requirements to a certain extent,[19] the statistical proof presupposes an appropriate transformation of the scientific concept into a workable statistical proposition.[20] All attempts which have hitherto been made have

16. See *Delbeke's* survey: Recent Long-Wave Theories (supra, n. 13) and the article written by *H. van der Wee* and *J. Delbeke* in this book.
17. In this context, the meaning of basic innovations, capital-accumulation, over-investment, technological development, industrial concentration are discussed, although there is no common agreement on the decisive interrelationship between the variables.
18. These data problems especially arise, when the 20th century is the object of analysis, cf. the fundamental remarks on this problem by *Borchardt, K.:* Wandlungen des Konjunkturphänomens in den letzten hundert Jahren. = Bayerische Akademie der Wissenschaften, Sitzungsberichte Jhg. 1976, Heft 1. All relevant books point to the difficulties which arise, if one tries to compile statistical long-term series, cf. *Mitchell, B. R.:* Statistischer Anhang 1700–1914. In: *C. M. Cipolla; K. Borchardt* (Hrsg.): Europäische Wirtschaftsgeschichte, Bd. 4, Stuttgart/New York 1977; also see *van der Wee, H.:* European Historical Statistics and Economic Growth. In: Explorations in Economic History 13 (1976), pp. 347–351.
19. Especially with regard to grain prices of the pre industrial period, these requirements are in most cases fulfilled. If, however, series of price indices are used, considerable problems arise. See e.g. *van der Wee, H.:* Prices and Wages as Development Variables: A Comparison between England and the Southern Netherlands 1400–1700. In: Acta Historiae Neerlandicae 10 (1978), pp. 58–78.
20. The problems attached to such a transformation are discussed in statistics as so-called "adequacy problems"; see *Menges, G.:* Ätialität und Adäquation. Dem Andenken an Heinrich Hartwig (1907–1981). In: Statistische Hefte 22 (1981) Heft 2, pp. 144–149; *Bott, D.;* Adäquationsprozeß und Entscheidungsproblem. In: Statistische Hefte 22 (1981) Heft 1, pp. 2–24, general statements on these problems also in *Metz, R.:* Theoretische Aspekte der stati-

failed in achieving this adequate transformation, and as has been pointed out already, it should have been a matter of the statistician's scientific honesty to declare that the hypothesis formulated cannot, or cannot yet be proved for purely statistical reasons,[21] for if one considers "long waves" as a cyclical phenomenon, as most of the older treatises do, to eliminate the trend as a non-cyclical course from the series, beforehand, cannot be avoided.[22] Even a spectral-analytical proof of cycles of the "Kondratieff-type" can only be achieved, if the series which is to be analyzed has a completely stationary, i.e. trend-free course. The procedures which have hitherto beed used to eliminate the trend from the series were either only capable of determining the trend in such a way that if there existed any "long waves" they were eliminated, or as it happened with polynomial approximation, their way of operation could not be numerically tested.[23]

In this context the following aspects are of great importance:

1. There is no generally accepted model to give a sufficient description of a cyclical course of this length, which may be caused either by endogenous, or exogenous factors. In consequence, the respective length of a cycle cannot be theoretically deduced.
2. The reduction of a model to a very small number of explanatory variables is unsatisfactory, both from a theoretical point of view, and within the historical context. Concerning the models to which these objections do not apply, or only partly apply, the fluctuations of the trend are at the centre of interest. This is for example true of Rostow's model, which exceeds all other models in its historical complexity;[24] Rostow has made the attempt to explain the historical trend-periods as the result of different combinations of variable factors.

   It is commonly agreed that it is formally impossible to test, with the aid of empirical methods, whether the trend-periods have a cyclical course. Such a view of the problem consequently excludes the question of cyclicity of trend-periods because it cannot be checked.[25]

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stischen Analyse langfristiger Konjunkturschwankungen. In: *Petzina/Roon:* Konjunktur, Krise ... (supra, n. 1) and the literature given there.

21. This opinion is held by *Stier, W.:* Die "langen Wellen" in der Konjunktur (supra, n. 8), p. 637.
22. This adequate trend-elimination is the necessary prerequisite of any proof of "long waves"; apart from the above mentioned methodical literature, see *König, H.; Wolters, J.:* Zum Problem langfristiger Wachstumszyklen: Eine Spektralanalyse der englischen Entwicklung von 1700–1913. In: Zeitschrift f.d.ges. Staatswissenschaft 128 (1972), pp. 72–96.
23. This principally applies to all procedures which are neither linear, nor time-invariant. Although these procedures achieve an elimination of the trend, their effect both on the different oscillations (frequencies) and thus also on the "long waves" cannot be tested. See e.g. *Schulte, H.:* Ein neuer statistischer Ansatz (supra, n. 10) p. 303, and *König/Wolters:* Eine Spektralanalyse (supra, n. 22), p. 94.
24. Rostow gives a comprehensive description of this approach, *Rostow, W. W.:* The World Economy. History & Prospect. Austin, London 1978. Comments on this approach are given by *Holtfrerich, C.-L.:* Wachstum I: Wachstum der Volkswirtschaften, in: Handwörterbuch der Wirtschaftswissenschaften, 17./18. Lfg. Stuttgart 1979, p. 413ff., and *Spree, R.:* Was kommt nach den "langen Wellen" (supra, n. 6) p. 308f.
25. A lowpass filter which achieves a clear separation between the low frequency bands would be the appropriate method to analyze trend-periods. As to the construction of such filters

3. An adequate statistical apparatus, which is a necessary prerequisite of such an empirical proof, was not available. As far as the methods which have hitherto been used are concerned, they have all failed in achieving a clear separation between the trend and the "long waves" and, therefore, no definite clues to the existence of "long waves" could be derived by means of spectral analysis.
4. In most cases, the material available does not meet the requirement of being uniform. The few long-term series available are highly disaggregated product and price series, which have only limited value as indicators of the relevant processes. Moreover, they necessarily span several phases of the structural change of the whole society, and thus simulate a structural uniformity, which in itself constitutes a historical problem.[26]

The pessimistic tenor of these remarks is still enforced by the fact that all models of "long waves" cannot be sufficiently verified with the aid of statistical methods.[27] There are, however, several reasons why it is worth while making a new attempt to prove the existence of "long waves".

1. As long as a more or less great heuristic value is attributed[28] to long-term cycles of the "Kondratieff-type" both in history and in the analysis of the current economic development, an empirical test is absolutely necessary.
2. The filter-method above mentioned renders it possible to test the existence of "long waves" empirically, in a completely new way. The problem of eliminating the trend can be solved by means of this method.
3. The fact that we use highly disaggregated series guarantees that approximately identical phenomena are measured.
4. It is commonly agreed that long-term analyses are necessary and practicable. Although in most cases no continuous long-term series are used to this purpose, the intention is yet nearly the same; the derivation of informations about tendencies with special regard to structural peculiarities.[29]

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see *Stier, W.:* Verfahren zur Analyse saisonaler Schwankungen in ökonomischen Zeitreihen. Berlin/Heidelberg/New York 1980, p. 127 f.

26. This opinion is held by *Knut Borchardt:* Wirtschaftliches Wachstum und Wechsellagen 1800–1914. In: Handbuch der deutschen Wirtschafts- und Sozialgeschichte, Bd. 2, hrsg. v. H. Aubin und W. Zorn, Stuttgart 1976, p. 200.
27. *Spree, R.:* Was kommt nach den "langen Wellen" (supra, n. 2) p. 305.
28. This function seems to be increasingly attributed to long-term cycles, not only in treatises dealing with economic-historical topics, but also in the current economic-political discussion. Only a few examples can be mentioned here: *Fischer, W.:* Die Weltwirtschaft im 20. Jahrhundert, Göttingen 1979, p. 43; *Fels, G.:* Erklärungshypothesen zur internationalen Rezession, In: Die Rezession 1974/75—ein Wendepunkt der längerfristigen Wirtschaftsentwicklung? Symposium zum 50jährigen Bestand des Österreichischen Institus für Wirtschaftsforschung, hrsg. v. H. Seidel, F. Butschek, Stuttgart 1977, pp. 19–31; cf. the discussion on the approach of the Kieler working-group which is based on the "distribution-theory", *Glismann, H, H.; Rodemer, H.; Wolter, F.:* Lange Wellen wirtschaftlichen Wachstums (Replik und Weiterführung). In: *Petzina/Roon:* Konjunktur, Krise... (supra, n. 1), p. 66 ff., as to the criticism of this concept, see the literature given there. Concerning the pre-industrial period see *Haan, H.:* Prosperität und Dreißigjähriger Krieg. In: Strukturprobleme der Frühen Neuzeit. = Geschichte und Gesellschaft, 7. Jhg. Heft 1, Göttingen 1981, pp. 91–118.
29. From the great number of books and articles dealing with this problem the following ones shall be mentioned: *Bairoch, P.:* Niveau de développement économique de 1810 à 1910. In:

The methods and results described in this paper can be regarded as the first attempts to prove oscillations of the "Kondratieff-type" within some selected long-term series. The intention of this paper exceeds all other research work which has hitherto been concerned with this problem in so far, as it intends to determine the shape and position of these long-term cycles. They will only be accepted as patterns of interpretation of economic and social developments if there is a possibility of characterizing them by their upswings and downswings, and their specific length within their historical dimension of time.

The analysis is confined to 9 time-series, which cover the space of time from 1531 to 1979.[30] 6 out of the 9 series are price series, which have only limited value as being representative of economic processes. This paper does not aim to test theoretical models of economic development but, on the contrary, tries to find clear clues as to the empirical evidence of "long waves" within economic time-series. As the empirical material on which the analysis is based also covers the pre-industrial period, it can be expected that the results achieved will give us some hints towards the model of "säkulare Wechsellagen",[31] which has been developed by agrarian history. Although the contents of the model of "Wechsellagen", developed in reference to the pre-industrial period, fundamentally differs from the concept of "long waves", a descriptive comparison between the pre-industrial and the industrial period seems to be very promising, above all, as grain prices to which such a comparison should be confined represent an economic factor of the first rank for the pre-industrial period.[32]

Pragmatic aspects were decisive for the choice of the time-series.[33] In particular, we have analyzed the following series:[34] Wheat and rye prices from 1531–1959 as indicators of the development of grain prices in the "Deutsches Reich", wheat prices from Exeter/GB (1531–1938), and a price index of English vegetable agrarian products (1661–1938) as indicators of the movement of prices of agrarian products in Great Britain; one indicator for both, the English coal and cotton-yarn production

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Annales E.S.C. 15 (1965); *Bairoch, P.:* Europe's Gross National Product: 1800–1975. In: The Journal of European Economic History 5 (1976), pp. 273–340; *Maddison, A.:* Long Run Dynamics of Productivity Growth. In: Banca Nazionale de Lavoro Quarterly Review 32 (1979).

30. As to the description of the empirical material see the comments in the appendix.
31. This kind of model which was mainly developed by W. Abel has recently been discussed in connection with the dynamics of the feudal production, see e.g. *Kriedte, P.:* Spätfeudalismus und Handelskapital. Göttingen 1980; *Kriedte, P.:* Spätmittelalterliche Agrarkrise oder Krise des Feudalismus. In: Strukturprobleme der Frühen Neuzeit. = Geschichte und Gesellschaft 7. Jhg. Heft 1, 1981, pp. 42–68. Without further discussing the problems attached to this model, it must be pointed out that in this model a central importance is attributed to long-term fluctuations of grain prices both as conditioning, and as conditioned elements.
32. It has been pointed out already that such a comparison would be very important for a great deal of research work into business-cycles, see e.g. *Ebeling, D.; Irsigler, F.:* Zur Entwicklung von Agrar- und Lebensmittelpreisen in der vorindustriellen und der industriellen Zeit. Beobachtungen am rheinischen Beispiel. In: Archiv f. Sozialgeschichte 19 (1979), pp. 299–329, who followed a suggestion of Knut Borchardt.
33. Such a kind of procedure can easily be reproached with "Measurement without Theory". The statements given above ought to have shown why I thought it unnecessary to take recourse to a theory.
34. The exact description of the material will be found in the appendix.

from 1700–1950, and one index respectively, of real wages as indicator of the long-term movement of real wages in England and Germany from 1809–1970, and finally the real gross domestic investments of the United Kingdom from 1830 to 1979.

II. Methodical problems and statistical procedures

Inspite of long-lasting and intensive discussions, there is no common consent over what is to be regarded as "long wave". Terms like trend-fluctuations, trend-cycles, "säkulare Wechsellagen", "Wechselspannen", "Kondratieff-cycles", etc., partly designate different and partly identical phenomena.[35] The cyclical character of the phenomenon, which is the basic requirement of the whole concept, suggests the following definition as a working hypothesis:

"Long waves" are cycles within trend-free series with an average duration ranging from about 30 to 60 years; the specific length of the cycle may very well vary within certain limits.[36]

The following comments shall explain the difficulties that arise if one tries to prove the existence of long-term cycles:

If one regards a concrete time-series as the result of a great number of oscillations of different frequencies and different strength of amplitude, spectral analysis gives informations both about the oscillations existing in a concrete time-series[37] and about the relative importance of different oscillations for the total fluctuation which determines them. Oscillations spanning long periods of time generate spectral mass at the zero point, or within a small space around it within the spectral density function. The more distinct these oscillations prove to be within the concrete time-series, the higher is the spectral value within the density function. The fact that the spectral value is as high as that, restricts the importance of spectral analysis as a method of splitting up frequencies to such an extent that actually existing oscillations of higher frequency cannot be proved. Consequently, the spectral density function exhibits a monotonous downward course from the left upper side to the right lower side of the graph.[38] This course is typical of economic time-series.

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35. Rosenberg has already pointed to this semantic confusion. *Rosenberg, H.:* Große Depression (supra, n. 2), p. 8.
36. The essential point is that this definition does not anticipate any decision about the use of certain procedures. The procedures were designed in such a way that cycles which are shorter than 20 years cannot be represented in the dimension of time.
37. Several treatises clearly show the conditions under which spectral analysis constitutes a useful analytical instrument in economic historical research. See e. g. *Granger, C. W. J.; Hatanaka, M.:* Spectral Analysis of Economic Time Series, Princeton 1964; *König, H.; Wolters, J.:* Einführung in die Spektralanalyse ökonomischer Zeitreihen. Meisenheim am Glan 1975; *Koopmans, L. H.:* Spectral Analysis of Economic Time Series. New York 1974; *Fishman, G. S.:* Spectral Methods in Econometrics. Cambridge Mass. 1969, and the literature mentioned in *Metz, R.:* Agrarpreiszyklen und Wirtschaftskonjunktur. Spektralanalytische Untersuchungen zu Kölner Agrarpreisreihen des 19. Jahrhunderts. In: *Schröder/Spree* (Hrsg.): Historische Konjunkturforschung (supra, n. 1), p. 255 ff.
38. Granger already described this shape as typical spectral shape of economic variables, see *Granger, C. W. J.:* The Typical Spectral Shape of an Economic Variable. In: Econometrica 34 (1966), pp. 150–161.

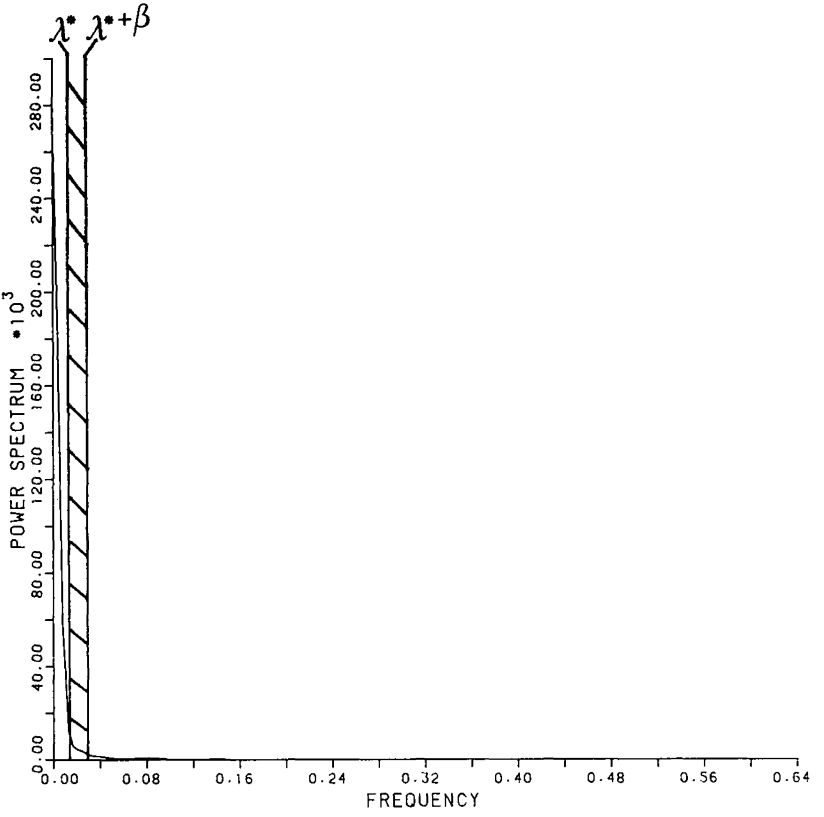

Fig. 1: Spectrum of wheat prices before trend removal

Figure 1 shows a spectral density function for the series of wheat prices (1531–1959). The space within which presumably existing "long waves" ought to exhibit peaks within this spectrum is limited by λ^* and $\lambda^{*+\beta}$. An informative spectral analysis presupposes the elimination of the trend from the series beforehand. The effect of such a trend elimination on the different frequency bands of a time-series can be illustrated with the aid of the transfer function, provided that the elimination procedure is linear and time-invariant: Figure 1 shows that the transfer function[39] is only

39. The opportunity of analyzing the effect of different methods constitutes a great progress in the field of the analysis of time-series; cf. the report on S. Heiler's lecture given in presence of the committee of "Deutsche Statistische Gesellschaft für Neuere Statistische Methoden" on: Zeitreihenanalyse heute—Ein Überblick—. In: Allg. Stat. Archiv 65 (1981) 1. Heft, p. 99ff. Newbold's article shows that a great deal of current research in this field is of little relevance for economic historical research. *Newbold, P.:* Some Recent Developments in Time Series Analysis. In: International Statistical Review 49 (1981), pp. 53–66.

allowed to have the zero value at the zero point, or within a small space around it, and ought to have reached the value 1 not later than at the point λ^* to make sure that "long waves" are not unintentionally eliminated by the trend elimination.[40] Filters which approximate such a course are called highpass filters because they only transmit high frequency oscillations into the filter-output series. Figure 2 shows the transfer function of a highpass filter, which has hitherto met these requirements better than all the other ones. The positions of λ^* and $\lambda^{*+\beta}$ show, however, that this filter is of no use for our statement of the problem because the frequency components in which we are interested, are out-filtered with the trend.[41].

This fact, which is true of all highpass filters which have hitherto been used means that a spectral analysis based on series that are filtered in such a way cannot give any clues to the existence of "long waves" because they ought to have been al-

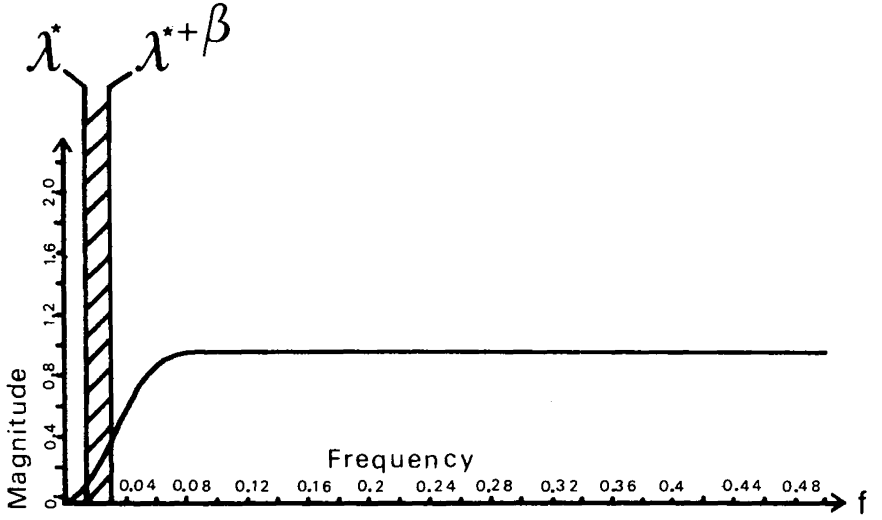

Fig. 2: Transfer function of a highpass filter

40. The transfer function indicates the value with which the input frequency is multiplied before being transferred into the output series. The value, zero, indicates that the frequency is totally eliminated, the value, one, that the frequency is transferred unchanged; all other values indicate that an intensification or decrease, repeated ever so often, is taking place. The difficulties attached to the search of filters with an "optimal transfer function" are described by *Wäsch, P.:* Zur Berechnung von Filtern im Frequenzbereich, In: Vierteljahreshefte zur Wirtschaftsforschung, Heft 4, 1971, pp. 320-329, see *Stier, W.:* Über eine Klasse von einfachen FIR-Tiefpass-Selektionsfiltern. In: Allg. Statist. Archiv (1978), p. 161 ff.
41. The graph has been taken from *Schulte, H.:* Statistisch-methodische Untersuchungen (supra, n. 10), p. 138. Apart from the fact that this kind of filter does not possess ideal transfer-characteristics, it is almost impervious in the domain of the "long waves"; this feature is clearly shown by the course of the function within the hatched plane.

ready out-filtered with the trend.[42] Filters that prove to have intensifying effects on the frequency domain cannot be used, either; because if one makes use of these filters, cycles can be ascertained by means of spectral analysis, even if they do not exist within the original series.[43] There are also serious methodical objections to the attempt to determine the course of the trend with the aid of polynomials. Apart from the fact that it is very difficult to determine the polynomial degree scientifically, it is impossible to determine the transfer function of polynomials and, therefore, the effects of the trend elimination cannot be numerically determined.[44] To regard the analysis of time-series as a "Filter-Design-Problem",[45] is a methodically completely new approach. This concept consists of two main steps: Firstly, a transfer function adequate to the scientific concept is given, and then an optimal filter is constructed accordingly.[46] This procedure constitutes from the methodical view a complete break with the classic component model and that means that considerations formulated with the aid of the estimate theory are no longer decisive for the evalution of the trend elimination.[47]

The necessity of determining an optimal transfer function beforehand presupposes a clearer definition of scientific terms within the frequency domain. Therefore, the researcher has to determine clearly, in advance, what is to be defined as trend. The course of the transfer function realized changes along with the factors that have been determined beforehand. This comparatively strong link between economic-historical concepts and formal-statistical criteria can only be of advantage if scientific interpretations and analyses orientate themselves by the numerical results of statistical methods, as is clearly examplified by research into business-cycles and economic growth. In accordance with these considerations, in the following pages, we define trend as those oscillation components of a time-series which generate spectral mass within the frequency bands between zero and λ^*.[48]

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42. This problem has not yet been adequately solved in all the analyses of "long swings". See e.g. the spectral analytical investigations of the "Kuznets-cycles" by *Adelmann, I.:* Long Cycles-Fact or Artifact? In: American Economic Review 60 (1965) p. 444ff.; *Harkness, J. P.:* A Spectral Analytic Test of the Long-Swing Hypothesis in Canada. In: The Review of Economics and Statistics 50 (1968), p. 429ff.; *Howrey, Ph. E.:* A Spectrum Analysis of the Long-Swing Hypothesis. In: International Economic Review 9 (1968) pp. 228; *Klotz, B. P.: Neal, L.:* Spectral and Cross-Spectral Analysis of the Long-Swing Hypothesis. In: Review of Economic Statistics 15 (1973).
43. This fact is examplified by *König/Wolters:* Eine Spektralanalyse (supra, n. 22) with the aid of the analyses made by Hoffmann and Kuznets.
44. See Schulte's remarks; *Schulte, H.:* Statistisch-methodische Untersuchungen (supra, n. 10), p. 112ff.
45. The theory of linear, discrete, time-invariant systems which are of great importance particularly in natural sciences, constitutes the theoretical foundation for it. As fundamental literature dealing with this topic see *Cadzow, James, A.:* Discrete Time Systems. An Introduction with Interdisciplinary Applications. Englewood Cliffs 1973; *Rabiner, L. R.; Gold, B.:* Theory and Application of Digital Signal Processing. Englewood Cliffs 1975.
46. An attempt to outline the theoretical problems attached to such a kind of procedure is described in *Metz, R.:* Theoretische Aspekte (supra, n. 20).
47. See Stier's remarks: Verfahren zur Analyse (supra, n. 25), p. 112ff.
48. As to the operation and justification of such a definition; see *Schulte's* comments: Statistisch-methodische Untersuchungen (supra, n. 10), p. 140ff.

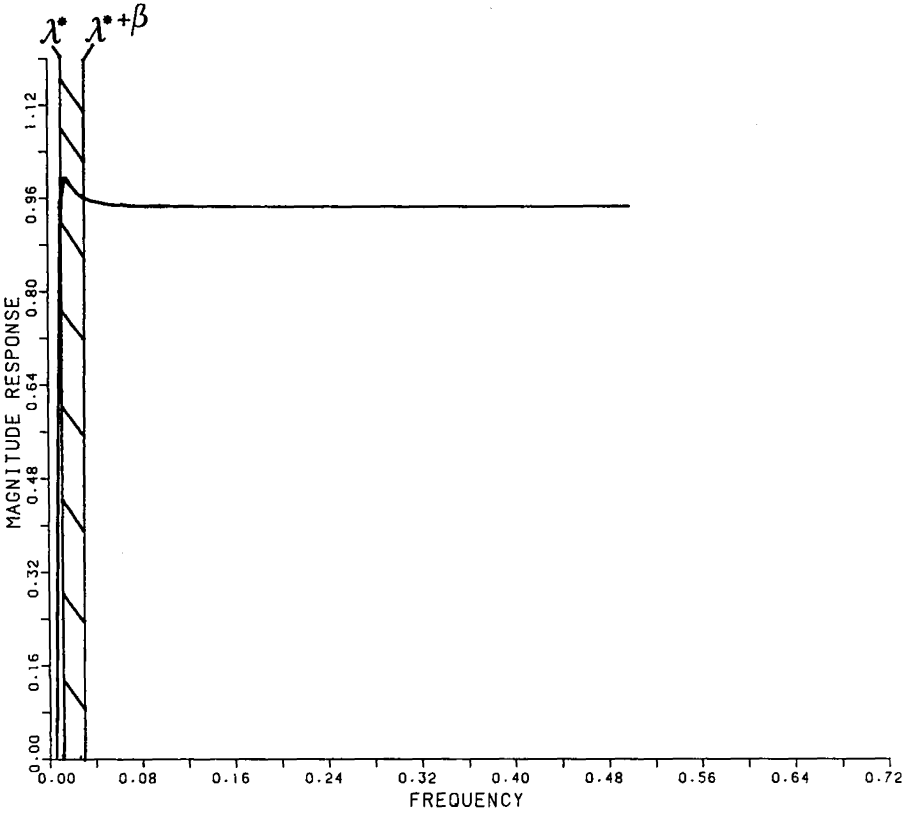

Fig. 3: Transfer function of a notch-filter

In empirical research only time-series of a definite length are available. Therefore it is useful to confine the analysis to those oscillations the periodical duration of which is not longer than the number of values of the time-series. The λ* mentioned above is consequently the inverse-value of the length of the time-series.[49] By means of a special combination of parameters, a so-called notch-filter is designed which exactly achieves this separation.[50] Figure 3 shows the transfer function of such a kind

49. On principle, the maximal length of a provable periodical oscillation is identical with the length of the time-series. Because of practical reasons it is useful, however, to analyze only those oscillations the maximal length of which is equivalent to half of the length of the time-series. See *Schulte, H.:* Statistisch-methodische Untersuchungen (supra, n. 10), p. 157ff.
50. As to the determination of these parameters by means of which the zero points of the notches, the opening of the notches and the normating frequency are determined, see *Schulte, H.:* Statistisch-methodische Untersuchungen (supra, n. 10) and *Stier, W.:* Verfahren zur Analyse (supra, n. 25), in particular, the band-width calculated by means of the

of filter.[51] In this connection the essential point is that a trend formulated, in advance, is transformed with the aid of the filter theory, and that this trend is not influenced by the statistical procedure, but is, on the contrary, defined by the scientist, beforehand, or rather results from the specific formulation of the question. This kind of filter-construction, as well as the transformation of scientific concepts into statistically operable procedures, leave a subjective margin of decision because what is to be defined as trend can only be determined within certain limits.[52] Spectral analysis can, however, supply us with useful criteria of decision for this delimitation. As the

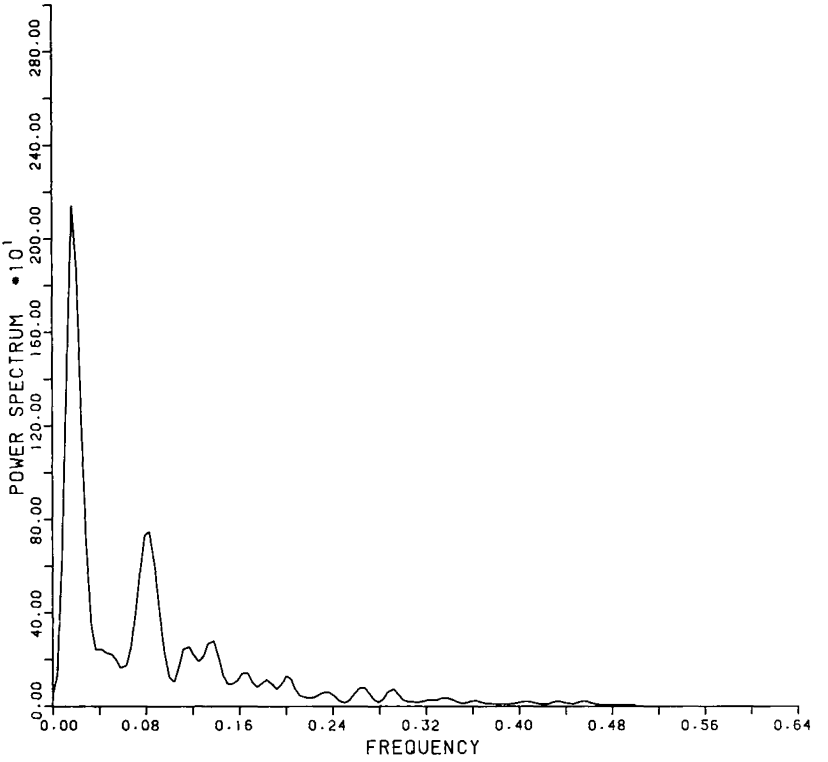

Fig. 4: Spectrum of wheat prices after trend removal

opening of the notches—in time units—, p. 74ff., concerning the effect of the variations of the zero points and notches on the spectrum of the series, see *Metz/Spree:* Kuznets-Zyklen (supra, n. 11), pp. 346-354.

51. The course of the function within the hatched field shows that possibly existing "long waves" are transferred unchanged into the initial series.
52. *Stier, W.:* Verfahren zur Analyse (supra, n. 25), p. 79ff., discusses these problems with regard to methods of seasonal adjustment.

trend manifests itself as spectral mass within the space around the zero-frequency, spectral analysis will be used in the following as a method of testing the effects of the notch-filter on the low-frequency oscillations of the different series.[53]

Figure 4 shows the spectrum of the series underlying Figure 1 after the trend has been determined by means of the notch-filter.[54] The function has now nearly reached the value zero at the frequency band zero and exhibits a clear peak above the frequency band 1/60; a "long wave" with an approximate length of 60 years is implied therein. Figure 5 shows the course of both the trend-free series and the original series.

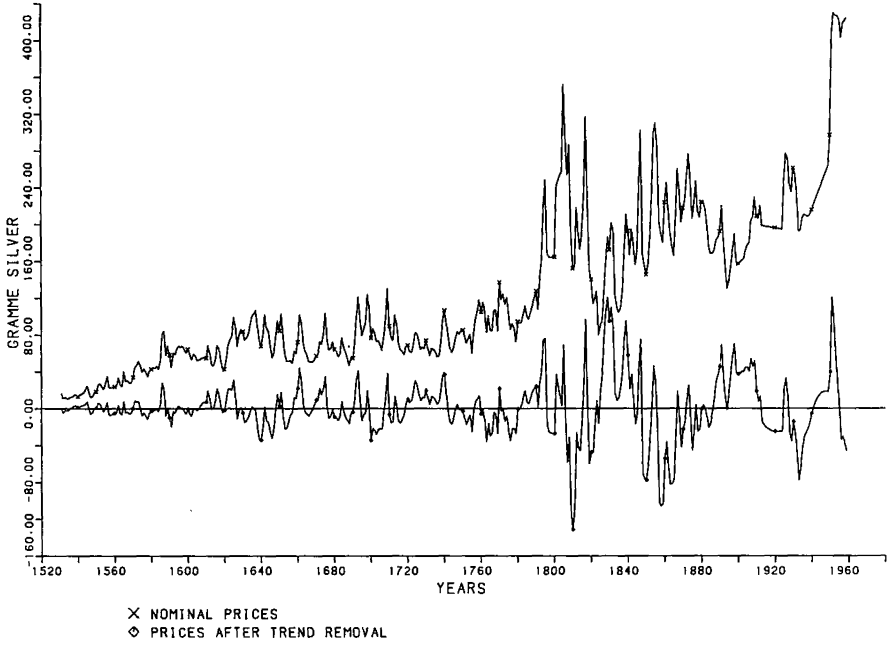

Fig. 5: Wheat prices in Germany 1531–1959

53. Spectral analysis is very often used to analyze the effect of filters in the frequency domain, particularly with regard to methods of seasonal adjustment see *Stier, W.:* Verfahren zur Analyse (supra, n. 25), p. 106ff; additional literature is given in: *König/Wolters:* Einführung (supra, n. 37), p. 106ff. Analyses comparable with Stier's (cf. supra) for the high-frequency domain are not known to me concerning the low-frequency domain.
54. The respective filter parameters: Two zero points at the frequencies 0 and 0.00233; Delta of the first notch 0.05, Delta of the second notch 0.025, normating frequency 0.015922; concerning the determination of the Deltas see *Schulte, H.:* Statistisch-methodische Untersuchungen (supra, n. 10) p. 157ff.

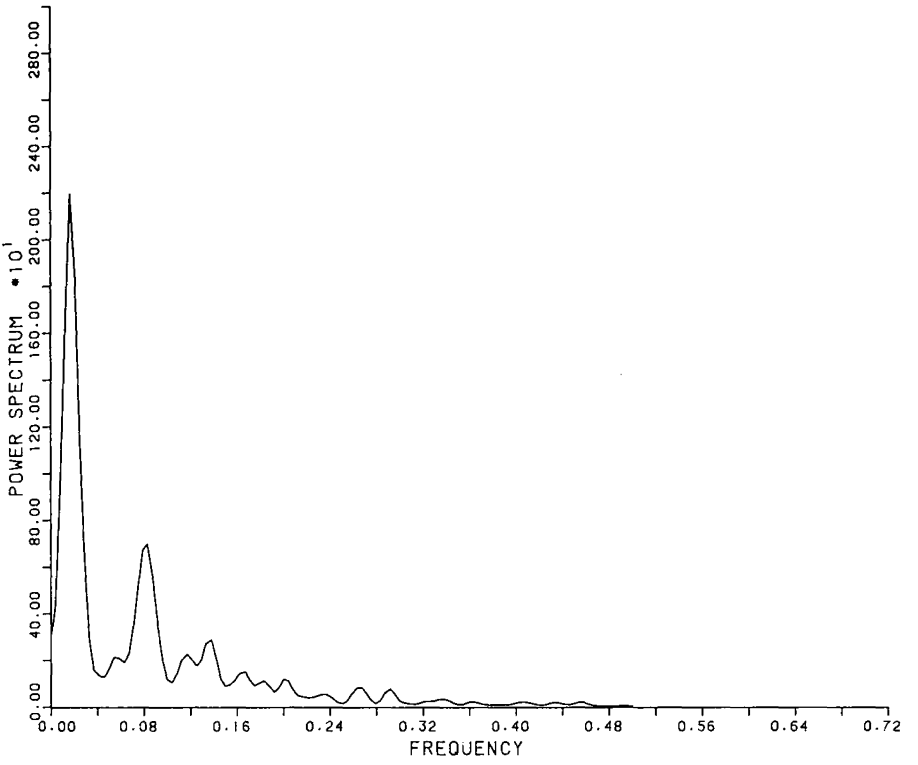

Fig. 6: Spectrum after modified trend removal (Delta = 0.025/0.0125)

The above mentioned margin of decision which is involved in the definition of the trend concerns the determination of the stop-band through the choice of the parameters Δ.

Figure 6 shows the spectrum of grain prices after the passband of the filter has been enlarged by means of a reduction of Δ_1 and Δ_2. As has been expected, the spectral mass of the zero-frequency band is larger than before and, therefore, the question arises which kind of spectral density function indicates the optimal adequation between the filter and the scientific concept. This problem cannot, however, be solved with the aid of the filter theory because no adequate statistical test criteria are available.[55]

The following points should, however, be kept in mind: The notch-filter designed by Schulte/Stier achieves an exact separation between the trend and the long-term cycles, which has been thought impossible up to now.

55. After the use of both filters time-series are stationary; this is necessary for spectral analysis. In the subsequent remarks these problems will be taken up again.

The filtered series are completely stationary time-series. They can be exactly proved with the aid of the filter theory and, therefore, guarantee that the cyclical components analyzed in these series are not artifacts, which might be conditioned by the different filters. The series filtered are fundamental for the spectral analytical proof of cycles of different length within the frequency domain.

Whereas most of the recently published, methodically orientated treatises on this problem have confined themselves to such a spectral analytical proof, in the following, further steps of analysis will be made to determine the position and shape of these long-term cycles within their course of time.[56] Because of the fact that within the spectrum of the trend-free series a considerable number of high-frequency oscillations can still be discerned, it is necessary to try to eliminate these short-term cycles in order to isolate the long-term cycle. To this purpose, as a rule, one makes use of a lowpass filter which only transmits low-frequency oscillations into the initial filter series and, consequently, any existing trend. If one, however, filters a series from which

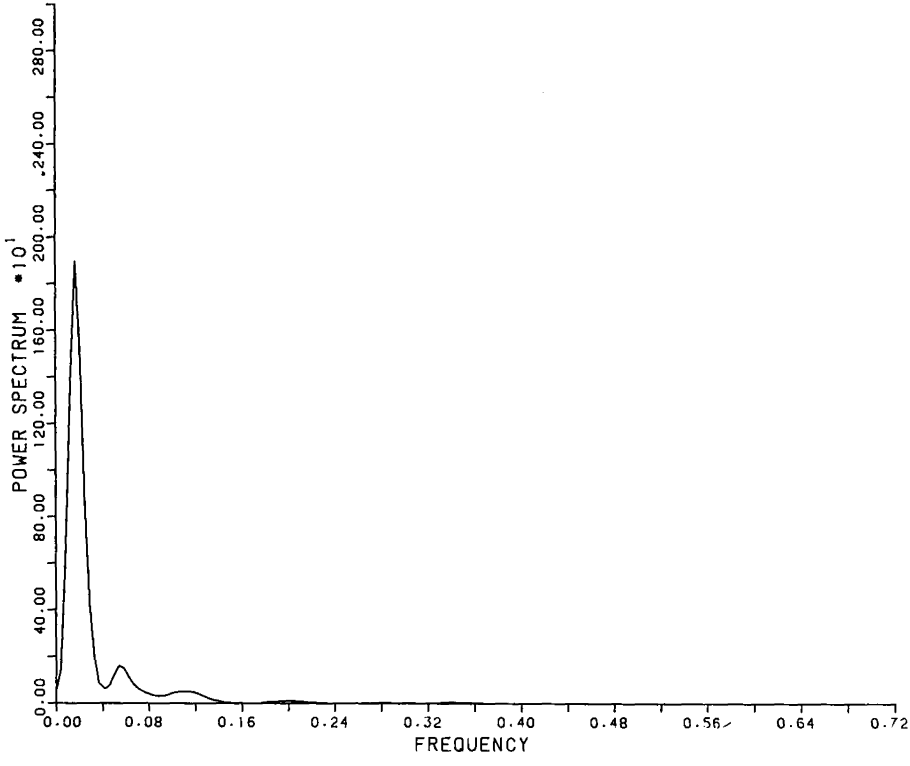

Fig. 7: Spectrum after trend- and high frequency removal

56. Cf. also the methodical remarks in *Metz/Spree:* Kuznets-Zyklen (supra, n. 11), p. 346ff.

the trend has already been eliminated, the desired effect of a bandpass filter is achieved. The series filtered does not contain any other components of oscillation than those that vary between the "Normierungsfrequenz" of the notch-filter and the cut-off frequency of the lowpass filter,[57] and at best contain exactly the "long wave" with a possible length between 20 and 60 years within the dimension of time.

In Figure 7 spectral analysis shows the effect of such a lowpass filter method on the grain price series after trend- and high frequency removal.

III. Main characteristics of "long waves"

In Table 1 (see appendix), the results achieved from the different series by means of spectral analysis after the trend elimination with the notch-filter have been compiled. In each of the series long-term cycles can be ascertained. In all the series of agrarian prices that precisely fix the index of the value aspect of agrarian cycles, at least till 1850,[58] cycles of the "Kondratieff-type" with an average length of about 60 years become visible. An alternative estimate made for the pre-industrial period from 1531–1796 did not bring about any other results concerning the length of the different cycles. In this context it is remarkable, however, that in the pre-industrial period the short-term harvest-cycle seems to be of the same importance for the total variability of the series as the "long-wave"; if the estimate however concerns the whole period of time, the cyclical variation of the series turns out to be clearly dominated by the "long waves". This fact clarifies from a comparison between the two different spectral density functions. They clearly illustrate a decrease in the vulnerability of the agrarian production to crises. By means of a rise in productivity, the extreme price-fluctuations of the classic harvest-cycles could be removed to a high degree.[59]

Concerning the English coal and cotton-yarn production and the investment series, shorter cycles seem to prevail. The proved length of the different cycles fluctuate between 40, 32, and 19 years. The validity of these results is limited, however,

57. A Kaiser-filter was used for the high-frequency elimination of the filtered series with N = 23, cut-off-frequency 0.05. It is not necessary to take account of the phase as this filter-type is symmetrically implemented; as to the calculation of such filters see *Stier, W.*: Konstruktion und Einsatz (supra, n. 9), p. 14ff; *Rabiner/Gold:* Theory and Application (supra, n. 45), p. 93ff.

58. Analyses have shown that value and quantity indicators of the agrarian cycle differ, both regarding their cyclical structure, and their dependency on other indicators of cyclical development; see *Metz, R.*: Agrarpreiszyklen und Wirtschaftskonjunktur (supra, n. 37), p. 273ff., as to the problem of agrarian cycles within the process of industrialization, see *Spree, R.*: Wachstumstrends (supra, n. 7), p. 125ff.

59. This development was very much influenced, of course, by the expansion of traffic, and the resulting growing market-integration, and also by the increase in the supply with substitutional goods, see *Teuteberg, H.-J.*: Die deutsche Landwirtschaft beim Eintritt in die Hochindustrialisierung (= Kölner Vorträge und Abhandlungen zur Sozial- und Wirtschaftsgeschichte) Köln 1977; *Abel, W.*: Geschichte der deutschen Landwirtschaft—vom frühen Mittelalter bis zum 19. Jahrhundert. = Deutsche Agrargeschichte, Bd. 2, hrsg. v. G. Franz, 3. Aufl. Stuttgart 1978; *Boserup, M.*: Agrarstruktur und take-off. In: *Rudolf, Braun* u.a. (Hrsg.): Industrielle Revolution. Wirtschaftliche Aspekte. Köln/Berlin 1972, pp. 309–330.

by the fact that in some of the series trend can be proved with the aid of spectral analysis even after the trend elimination has been carried out.[60] This peculiarity, as a rule, occurs if the original series exhibits a clear exponential growth. The trend-free values of such time-series are marked by extreme fluctuations at the end of the series. These series are no longer stationary covariant, and because of this reason, the requirements attached to the use of spectral analysis are only partly met.[61] Additionally, series of that kind had to be made trend-free with a modified notch-filter in order to check undesirable effects of distortion.[62] The cycles evidenced remain unchanged even after the modified trend elimination has been carried out. This fact can be taken as a clear hint on the existence of cycles of this very length. It must be confessed, however, that the lengths of the different cycles, which have been evidenced, are of historical value, only for the period since 1840/50, as the majority of the total variance of the series refers to this period. This fact is, for example, clearly to be seen in Figures 17, 18, and 21 (see appendix).

Concerning the series of agrarian prices, a significant change in the length of the cycles, which might be caused by the beginning of the industrialization, can hardly be discerned.[63] The lengths of the cycles of the production series, however, seem to have reduced since the middle of the 19th century. Besides, the numerical course of the trend-free production series exhibits strong dynamics in the cyclical behaviour during this period. Although the material compiled by Hoffmann cannot be used for any far-reaching interpretation because of its heterogeneous character, clear differences become visible if one compares the period before the middle of the 19th century with the one afterwards, and the curves of production series with the cyclical course of the series of agrarian prices. The rapid growth which is of fundamental importance for the process of industrialization[64] is primarily expressed in the cyclical course of the production indicators, without at the same time determining the fluctuations of prices in the one, or the other way.

Long-term cycles can thus be sufficiently described in their historical course by means of their formal characteristics. These are the following: The position and

60. Similar results were achieved when the attempt was made to isolate "Kuznets-cycles" see, *Metz/Spree:* Kuznets-Zyklen (supra, n. 11), p. 353ff.
61. Stationary processes are the necessary prerequisite of spectral analysis. In practice, a constant mean value (E(u) = 0 is generally assumed) and a time-invariant covariance are required. The second requirement does not seem to be met in these series and consequently trend can be ascertained within the spectrum see e.g. *Granger/Hatanaka:* Spectral Analysis (supra, n. 37), p. 190ff; *König/Wolters:* Einführung (supra, n. 37), p. 150ff. As far as I know, reliable estimate procedures for series with a non-stationary covariance are not available, cf., however, *Priestly's* treatises, e.g. *Priestley, M. B.:* Evolutionary Spectra and Non Stationary Processes. In: Journal of the Royal Statistical Society, Ser. B 27 (1965), pp. 204–237.
62. With the aid of such a filter, additional low-frequency oscillations are outfiltered through a third zero point; in this way we succeed in confining the leakage problem.
63. That means that the differences between the respective lengths of the cycles are as great with regard to the 19th and 20th centuries as they are with regard to the preceding period. See Tables 13a and b.
64. This course which is typical only of production series, is surely one of the reasons, why it is so difficult to achieve clear hints as to concrete cycle lengths by means of spectral analysis.

Table 1

Output of the Prussian coal-mining industry		English coal production	
peaks	troughs	peaks	troughs
1839	1846	1828	
1867	1876	(1863)	(1854)
1885	1890		1876
1902		1901	1917
yarn production of the cotton spinning industry		English cotton-yarn production	
peaks	troughs	peaks	troughs
1839	1847	1826	(1847)
1855	1864	(1853)	1861
1871	1880	1872	1895
1892			

the length of the upswings and downswings, the turning points, and the position and length of the amplitude.[65] The question whether the cycle of the production series, which was at first designated as "long wave", is according to its formal characteristics rather to be numbered among the "Kuznets-type" after the year 1850 can only be discussed in this paper by means of one example.[66]

The following table lists the troughs and the peaks of the English coal- and cotton-yarn production in the 19th and in the beginning of the 20th century[67] and, moreover, contrasts them with the turning points of the Kuznets-cycles ascertained for the

65. In Table 3 (appendix) the troughs and peaks and in Table 4 (appendix) the resulting upswings and downswings were compiled. Figures 13a and 13b are graphical transformations of Table 4 and show the temporal course of these cycles. The short intermediate cycles which can be ascertained in Figs. 10, 14, 15–21 (appendix) were not taken into consideration because they are only the results of an insufficient lowpass filtering.
66. Regarding the results achieved, a further analysis of this question appears to be of advantage, above all, because the empirical and theoretical fundament of the "Kuznets-cycles" appears in a more positive light, see e.g. *Aldcroft, D. H.; Fearon, P.:* British Economic Fluctuations 1790–1939. London 1972; *Easterlin, R. A.:* Population, Labor Force and Long Swings in Economic Growth. New York 1978; see e.g, *Metz/Spree:* Kuznets-Zyklen (supra, n. 11). This, however, requires an analysis of standardized material by means of identical methods.
67. As to the English series, the years which are put in brackets are intermediate cycles which were not taken into consideration when dating the "long waves", but which mark, however, a relative trough, or peak, in the numerical course of the series.

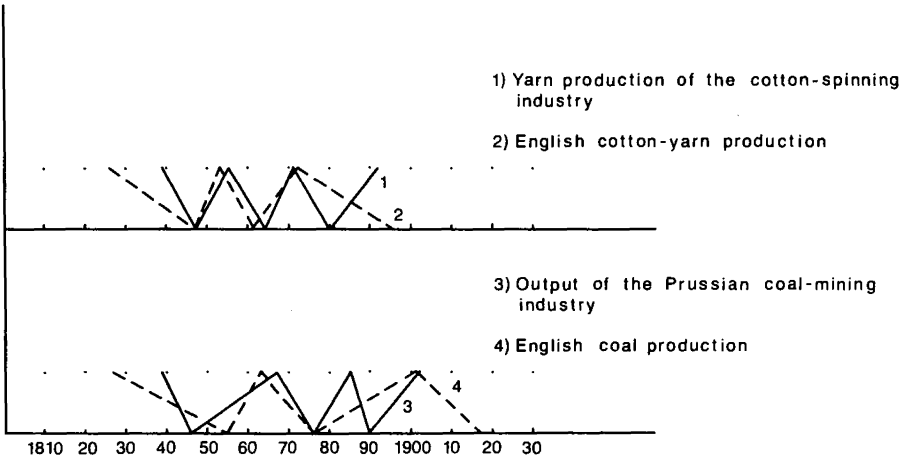

Fig. 8: Schematic course of the long term cycles of table 1

German series.[68] In Figure 8 the resulting upswings and downswings are graphically represented.[69]

Inspite of the fact that the trend has been eliminated from series of different length, with the aid of different notch-filters, we nevertheless get some useful hints for the solution of the question mentioned above. Notwithstanding the fact that the series are based on very heterogeneous material, they exhibit homogeneous turning-points; concerning the coal production: 1863/67, 1876, 1901/02; concerning the yarn production: 1847, 1853/55, 1861/64, 1871/72.

The degree of conformity is very astonishing. More detailed analyses into the problem should be made, above all, as the historical value and the empirical plausibility of the "Kondratieff-hypothesis" largely depend on the solution of this problem, at least as far as the period of high-industrialization is concerned.[70]

In all the series that have been analyzed, a high degree of variation can be discerned within the specific lengths of the different cycles.[71] Concerning grain prices, the shortest cycle measures at about 40, and the longest one at about 70 years. The lengths of the upswings and downswings vary to the same extent. Both the English and the German grain prices pass through a complete cycle from the beginning of the 18th century until 1775. The English upswing phase is, however, twice as long as the German one, concerning the downswing phase, just the opposite is true.

68. Without considering the shorter intermediate cycles, the corresponding years can be easily derived from the graphs printed in *Metz/Spree:* Kuznets-Zyklen (supra, n. 11).
69. Cf. the course of the series in Fig. 17 and 18 in the appendix.
70. A similar view is supported by *Metz/Spree:* Kuznets-Zyklen (supra, n. 11), p. 365.
71. The following comments refer to the results which emerge from Figures 13a and 13b.

It is very astonishing that the different upswings and downswings of the series of agrarian prices nearly synchronize, except for the series of the English wheat prices, which take a different course during the period from 1580 to 1650. This exception is not very important, however, considering the high degree of synchronity of the series. Both the English and the German development of agrarian prices seems to be marked by much shorter upswings and downswings from the end of the 18th until the middle of the 19th century, compared with the period before and afterwards.

Whereas the lengths of the cycles referring to the pre-industrial and industrial period prove to be fairly stable, important changes in the dimensions of the amplitudes of the different cycles become visible at the beginning of the 19th century.

Until about 1780, there is a possibility of linking the upper and the lower turning-points of the "long waves" of grain prices (see Figure 14) by a horizontal straight line. If these "long waves" of grain prices are interpreted within a cycle-model which aims at describing the dynamics of the "feudal production",[72] the turning-points mark the temporal change of the secular development.[73] The strength of the amplitude, which proves to remain unchanged during a space of time of 250 years, characterizes the narrow corridor in the limits of which the agricultural productivity fluctuated.[74] In consequence, the turning-points clearly reflect the so-called "plafond pluriséculaire"[75] of the pre-industrial production, which has been a very important topic in French agrarian historical research.

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72. *G. Bois:* Crise du féodalisme. Économie rurale et démographie en Normandie orientale du début du 14e siècle au milieu du 16e siècle, Paris 1976, has developed this model, which constitutes an attempt to combine the main ideas of the theory of agrarian crisis with the theory of feudal production. See e.g. *Kriedte, P.:* Spätmittelalterliche Agrarkrise oder Krise des Feudalismus. In: Geschichte und Gesellschaft 6 (1980).
73. It should not be left out of account, however, that the way in which secular trends of grain price series of the pre-industrial period are dated, as a rule, is incompatible with the "long waves" which are analyzed in this paper. As to such a dating see *Imbert, G.:* Des mouvements de Longue Durée Kondratieff. Aix en Provence 1959, p. 18; a dating which obviously goes back to this treatise: Le mouvement Kondratieff. In: Bulletin hebdomadaire 35 (1978). See also K. Borchardt's "Überblick über die säkulären Bewegungen der Wirtschaft". In: *Borchardt, K.:* Grundriß der deutschen Wirtschaftsgeschichte, Göttingen 1978, p. 11.
74. This margin of productivity becomes evident in the ratio between seed and harvest. The fundamental treatises dealing with this topic are: *Slicher van Bath, B. H.:* Yield ratios, 810–1820, In: A. A. G. Bijdragen 10 (1963); Jansen has recently published a very informative analysis of these problems: *Jansen, J. C. G. M.:* Landbouw en Economische Golfbeweging in Zuid-Limburg 1250–1800. Van Gorcum/Assen 1979. See, as well, the omnibous volume which is representative of French research in the agrarian cycles, *Goy, J.; Le Roy Ladurie, E.:* Les fluctuations du produit de la dîme. Conjoncture décimal et domaniale de la fin du Moyen Age au XVIIIe siècle. (Cahiers des études rurales) Paris–The Hague 1972.
75. This thesis of a "plafond pluriséculaire", which has been developed by le Roy Ladurie, is very much at the centre of interest of French research, see *Neveux, H.:* Die langfristigen Bewegungen der französischen Getreideproduktion vom 14. bis zum 18. Jahrhundert. In: Scripta Mercaturae 13 (1979), pp. 75–88. For an excellent short characteristic of French research dealing with these problems see *Irsigler, F.:* Möglichkeiten und Grenzen quantifizierender Forschung in der Wirtschafts- und Sozialgeschichte des Spätmittelalters und der frühen Neuzeit. In: Rhein. Vjjbl. 43 (1979), pp. 236–259.

It has not yet been tested, however, whether the phenomena described are conditioned on monetary factors. If this proved to be true, they would only be expressions of a long-term fluctuating currency stability[76], but could not contribute to the explanation of real economic phenomena. In order to get some hints for the solution of this question, the Cologne wheat prices[77], which were passed to us in money of account, that means as nominal prices,[78] had to be deflationed.[79] By means of this procedure, only those price-variations that arise from a change in the silver equivalent of the money of account are eliminated from the series. Other monetary influences, which might have resulted from an absolute increase in the total amount of money, or from an increasing circulation rate of the total amount of money, could not be taken into consideration.

Figure 9 representing the "long waves" of the trend-free and deflationed prices shows that the process of deflationing prices neither influences the shape, nor the position of the long-term cycles. The trend of these deflationed prices appears to take an approximately stationary course since the beginning of the 17th century, whereas concerning the 16th century, an increasing trend can be ascertained within the series, now as before. Because of this fact, there is no doubt that the price-revolution which occurred in this century was not due to a debasement of the circulating silver mon-

76. Long-term cycles were very early explained by changes of monetary variables see e. g. *Kondratieff:* Die langen Wellen (supra, n. 15), p. 595 ff., this question is still under discussion, cf. e. g. *Rostow, W. W.:* Why the Pour get Richer and the Richer Slow Down, Austin 1980, esp., Money and Prices, p. 189 ff., concerning the pre-industrial period see *Braudel, F. P.; Spooner, F.:* Prices in Europe from 1450 to 1750. In: The Economy of Expanding Europe in the 16th and 17th Centuries. = The Cambridge Economic History of Europe, vol. IV, publ. by E. E. Rich and C. H. Wilson, Cambridge 1967, and also Abel's remarks, *Abel, W.:* Agrarkrisen und Agrarkonjunktur. Hamburg/Berlin 1978, p. 13 ff.; p. 188 f.

77. See the detailed criticism of the historical sources in *Ebeling/Irsigler:* Getreideumsatz, Getreide- und Brotpreise in Köln, 1368–1797, 1. Teil, Mitt. aus dem Stadtarchiv von Köln, Köln/Wien 1976, p. 11 ff. As the prices are handed down in money of account, they are very much influenced by inflationary movements. The actual value of the money of account can be determined with the aid of the silver contents of the coins which were actually minted. In order to exclude the changes in prices which were due to the demonetization of the money of account, all prices were multiplied with the silver weight of the albus of account.

78. All pre-industrial grain price series are nominal price series, see *Sprenger, B.:* Preisindizes unter besonderer Berücksichtigung verschiedener Münzsorten als Bezugsgrößen für das 16. und 17. Jahrhundert — dargestellt anhand von Getreidepreisen in Frankfurt/Main. In: Scripta Mercaturae 1 (1977), pp. 57–72; concerning the situation in Cologne see *Ebeling/Irsigler:* Getreideumsatz (supra, n. 77) p. 32 ff.

79. In order to deflate these prices we have made use of the tables published in *Ebeling/Irsigler:* Getreideumsatz (supra, n. 77) p. 38 ff. Within a project which is concerned with the "Geld- und Währungsgeschichte Mitteleuropas von 1300–1800", and is promoted by the "Stiftung Volkswagenwerk", a group of scientists under the leadership of Prof. F. Irsigler at the University of Trier is attempting to compile such long-term tables for other towns, too. See *Irsigler, F.:* Das Projekt: Geld- und Währungsgeschichte Mitteleuropas im Spätmittelalter und der Frühen Neuzeit. In: Quantitative Methoden in der Wirtschafts- und Sozialgeschichte der Vorneuzeit, hrsg. v. F. Irsigler. Stuttgart 1978 (= Historisch Sozialwissenschaftl. Forschungen Bd. 4).

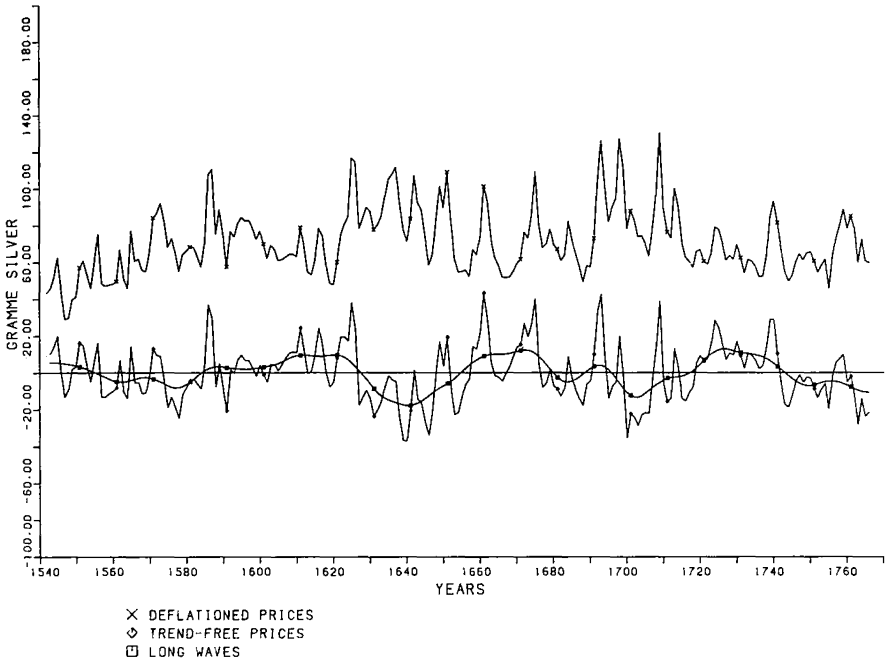

Fig. 9: Long waves of deflationed wheat prices

ey.[80] The presumption that long-term cycles are only expressions of the fluctuating currency stability[81] cannot be supported by these few results, on the contrary: the system of small change, which proves to have been extremely unstable in the pre-in-

80. The term "price-revolution" is used in literature to describe the process of rise in prices. There is not yet a common agreement on the causes of this phenomenon. See *Abel, W.:* Agrarkrisen (supra, n. 76), p. 122 ff., see as well *Irsigler, F.:* Getreidepreise, Getreidehandel und städtische Versorgunspolitik in Köln vornehmlich im 15. und 16. Jahrhundert. In: Die Stadt in der Europäischen Geschichte. Festschrift Edith Ennen, hrsg. v. W. Besch, K. Fehn u. a. Bonn 1972, who excellently discusses the fundamental problems and functions of grain prices in pre-modern times with the aid of the Cologne example.

81. The term "currency stability" designates the contents of precious metal of the coins which were minted over a long period of time. The other monetary factors of a possible destabilization of the economic system were not taken into consideration; as to these factors see *Schüttenhelm, J.:* Der Geldumlauf im südwestdeutschen Raum vom Rüdlinger Münzvertrag 1423 bis zur ersten Kipperzeit 1618. Eine statistische Münzfundanalyse unter Anwendung der elektronischen Datenverarbeitung, 2 Bde. (under preparation) and Spooner's treatise which is of general importance, *Spooner, F. C.:* The International Economy and Monetary Movements in France, 1493–1725, Cambridge Mass. 1972.

dustrial period, seems to have effected only the trend, but not the long-term cyclical variations of the price series.

If, however, the long-term movement of the English and German real wage index is included in the comparison,[82] a striking uniformity of both series, the courses of which are quite the reverse of the long-term movement of grain prices, can be discerned till the 70s/80s of the 19th century. This result emphasizes the importance of the development of agrarian, especially of grain prices for the change of the level of real wages until the beginning of the industrial "take-off". In the following period more complex factors seem to have operated, therefore, a model which is based on such a small number of factors does not suffice any longer to explain the economic development. In this context, it is very remarkable that the German development is marked by much shorter cycles since the 70s/80s of the 19th century, whereas the English index passes through one more complete "long wave" since 1890.[83] These results can only be interpreted, however, with serious provisos because the deteriorations caused by the two World Wars can hardly be measured.

IV. Comments on the problem of interpreting "long waves" within their historical dimension of time

In the following paragraph the importance of the "long waves" deduced with the aid of a small number of indicators and their classification in the present state of historical growth and business-cycle research shall be described in rough outlines. The authors who have been concerned with the problem of dating trend-periods and "long waves" of the pre-industrial period have, as a rule, based their analyses on series of grain prices. These series have been analyzed with the aid of rather different methods.[84] Irrespective of this fact, a comparison between the results achieved seems to be

82. This analysis of the real wage indices does not intend to contribute to the discussion about the development of real wages and of the living standard. The only aim is, to test whether long-term cyclical oscillations of the Kondratieff-type emerge from these series, or not. The economic and social relevance of such a pattern of oscillations for the question of the living standard is quite a different problem. Apart from the literature mentioned in n. 122 see *Desai, V.:* Real Wages in Germany 1871–1913, Oxford 1968; *Bry, G.:* Wages in Germany 1871–1945. Princeton 1960; *Weigand, E.:* Zur historischen Entwicklung der Löhne und Lebenshaltungskosten in Deutschland. In: Historische Sozialforschung 19 (1981), July; for England e. g. *Hobsbawm, E. J.:* The Standard of Living during the Industrial Revolution. A Discussion. In: Economic History Review 16 (1963); *Flinn, M. W.:* Trends in Real Wages 1750–1850. In: The Economic History Review 27 (1974), pp. 395–413; *Tunzelmann, G. N. von:* Trends in Real Wages, 1750–1850, Revisited. In: The Economic History Review 32 (1979), pp. 33–49.

83. See the comments made by *Gömmel* which concern this period: Realeinkommen in Deutschland. Ein internationaler Vergleich. Nürnberg 1979 (= Vorträge zur Wirtschaftsgeschichte, hrsg, v. H. Kellenbenz; J. Schneider, Heft 4).

84. Apart from *Abel's and Neveux's* treatises, which have already been mentioned, see *Rostow, W. W.:* The World Economy (supra, n. 24), pp. 81–90; *van der Wee, H.:* Prices and Wages as Development Variables (supra, n. 19); *Freiburg, H.:* Agrarkonjunktur und Agrarstruktur in vorindustrieller Zeit. In: Vierteljahrschrift für Sozial- und Wirtschaftsgeschichte 64 (1977), pp. 289–327.

of advantage because of the uniformity of the material that has been used. For instance, the "long waves" of grain prices were determined by Ebeling/Irsigler by means of the Cologne grain prices.[85] The dating of these series was based on material that had been smoothed by means of a binomial filter. The trend periods were consequently at the centre of interest. This procedure differs from the method I have introduced in this paper, both from the methodical point of view and in the way it conceptualizes the object which is analyzed. Nevertheless, fairly astonishing results were achieved: showing identical turning-points, the upswings from 1620–42, 1668–98 and 1736–70, to which Ebeling/Irsigler refer, are all characterized in our representation by cyclical downswings. As this kind of dating of the upswings largely corresponds to the results achieved by other scientists,[86] a more precise analysis of the state of affairs proves to be necessary.

To this end, the trend eliminated with the aid of the notch-filter was calculated and represented in a graph: The trend determined with the aid of the filter theory reveals a mounting course with wavy tendency (see Fig. 10). The upswings and downswings

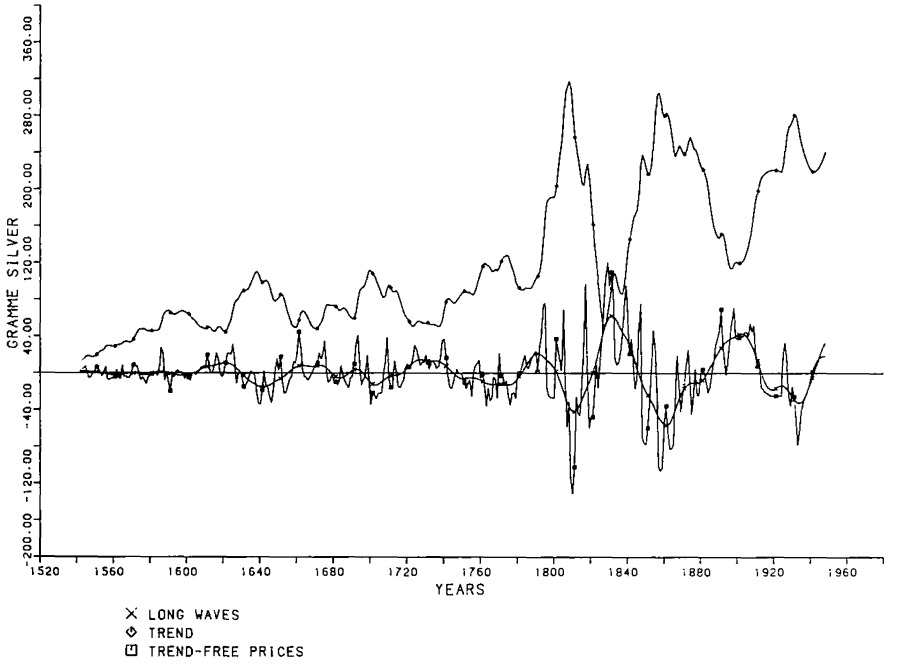

Fig. 10: Trend and long waves of wheat prices

85. *Ebeling/Irsigler:* Getreidepreise (supra, n. 77), p. 47.
86. As to such datings, the corresponding periods are in most cases interpreted as phases of enforced economic growth. See e.g. *Braudel/Spooner:* Prices in Europe (supra, n. 76), p. 436, whose comments mainly refer to Baehrel's treatises.

of the trend take a course that is quite the reverse of the "long waves" of the trend-free series.

The supposition that this result is due to the method that has been used requires a careful analysis of this phenomenon. To this end, the attempt has been made of eliminating the trend from the series with the aid of modified filter parameters in a way that any wavy movement ought to be eliminated from the trend.[87] Figures 11 and 12 indicate that this aim cannot be achieved without abandoning the previous definition of trend that underlies this procedure.[88]

Although the frequency domain within which the notch-filter is meant to out-filter frequencies can be reduced in size, as much as you like, non periodical oscillations are simultaneously transferred into the filter-output in increasing numbers. This kind of procedure soon collides with the trend-definition given beforehand.[89] The effect is

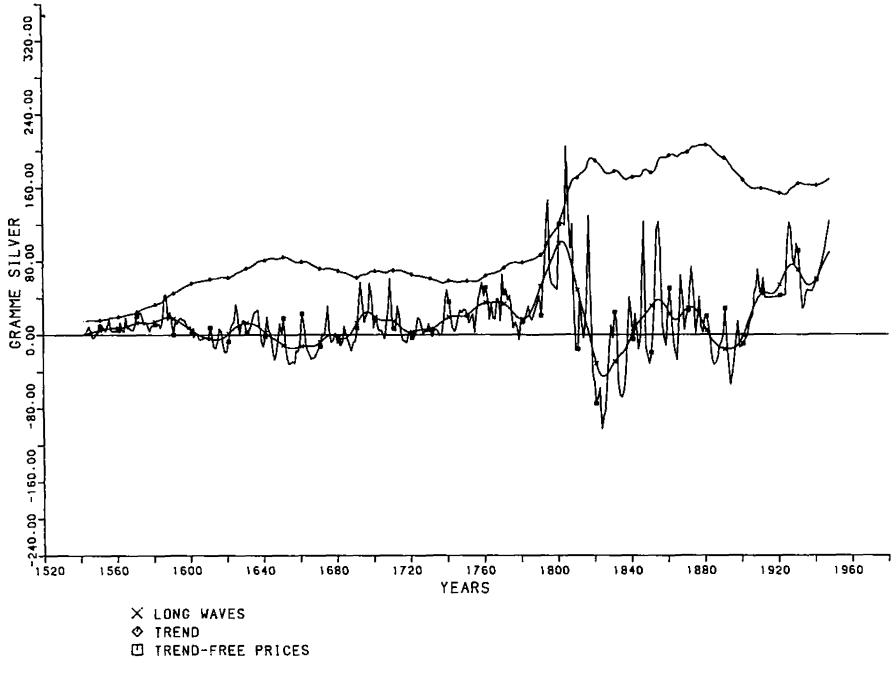

Fig. 11: Trend and long waves of wheat prices ** Delta = 0.01 **

87. The ulterior motif was to transfer more low-frequencies into the filter-output by means of a diminution of the Delta, in order to smooth the trend.
88. In this series, the spectrum clearly exhibits a "trend" in the trend-free series.
89. As to these problem see, *Schulte, H.:* Statistisch-methodische Untersuchungen (supra, n. 10), p. 157ff.

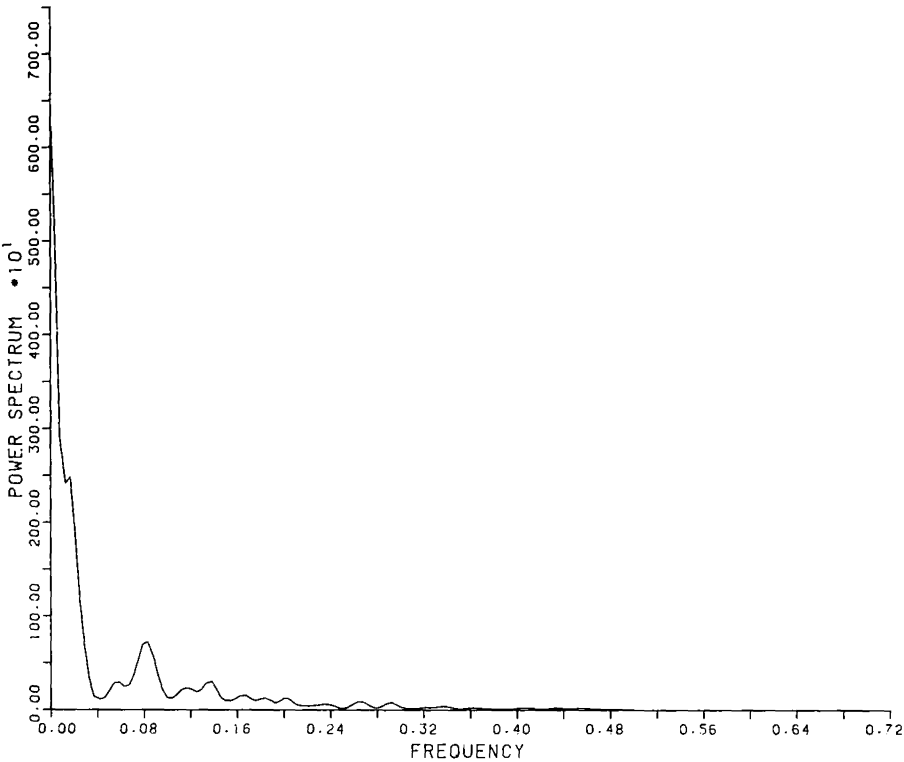

Fig. 12: Spectrum of trend-free wheat prices in Fig. 11

that the spectral density function exhibits an increasing quantity of spectral mass within the zero frequency band. As has been expected, the numerical course of the filtered series changes along with the change of the trend-definition, and from this results a shifting of the turning-points of the "long waves". That is due to the fact that with the reduction of the notch such a great number of low-frequency oscillation components are transferred into the filter-output that the initial series and the filtered series are in extreme cases nearly identical.[90] Consequently, both series achieve an identical dating of the "long waves". The questions whether this procedure leads to a collision between the purposes, or whether the results achieved have only been conditioned by peculiarities of the trend elimination, which in turn might depend on the procedure itself, shall be left undecided.

90. With regard to "seasonal adjustment" *Stier, W.:* Verfahren zur Analyse (supra, n. 25), p. 89 describes this effect.

In this context, is must be pointed out that the trend eliminated from the series which show exponential growth does not take a wavy course, which might be the reverse of the trend-free series, on the contrary, the trend proves to take an exponentially increasing course.

If, however, this phenomenon does not result from a methodically exact separation of oscillations in the low-frequency domain, it ought to lead to a revision of handed-down conceptions in economic history. The problems attached to these questions are evident: A methodically exact trend removal, which can be tested by means of the filter-theory, eliminates a kind of trend that has hitherto been identified and interpreted as "long waves". By means of the trend removal, the existence of "long waves" can be proved within the trend-free series, which in turn take a course that is inverse to the wavy course of the trend. The connection between both movements has, however, not yet been explained.

Some theoretical considerations shall be added which are meant to make the preliminary result of the inverse course appear more plausible, at least for the pre-industrial period. In times of economic growth, which manifests itself in the secular movement of prices, an increase in productivity in its first phase can be ascertained. This results in the long term, in an improvement in the supply of grain. Owing to this, the cycles of the price curve, which indicate short-term tendencies of shortage and surplus within this process of improvement in supply, move erratically down; in consequence, the short-term cyclical variation becomes less erratic. This development abruptly changes at the upper turning-point of the trend-period. The short-term cycle is enforced, in that, an increased strain on the level of demand and production is evident, which in turn leads to a rise of the long-term cycle. These considerations appear to be fairly plausible to explain the movement of grain prices in the pre-industrial period. Production series, however, only partly exhibit the same phenomenon: The trend course is quite the reverse of the "long wave"; that is true as long as the course of the values of the different series does not show any exponential growth, that means, before the period of high-industrialization. Because of the fact that such an inverse-development which can be discerned in production series cannot be plausibly interpreted, the presumption suggests itself that these results concerning the dating of the turning-points are conditioned by the method itself. Further analyses ought to show whether this supposition is really founded on facts and what kinds of methodical peculiarities achieve such a result.[91]

By means of one more example, the results achieved concerning the cycle-length shall be critically compared with other analyses which have relied on different methods. Glismann/Rodemer/Wolter[92] made the attempt of achieving an international comparative dating of "long waves" by means of several series for the period from 1800–1979. The methodical procedure can be regarded as representative of a great number of treatises that have been concerned with this problem. The trend is esti-

91. Because of this reason, the data given in Tables 3 and 4 can only be used with the proviso of further analyses. It must, however, be mentioned once again that the determination of the cycle-length and of the lengths of the upswings and downswings does not depend on this problem.

92. *Glismann, H. H.; Rodemer, H.; Wolter, F.:* Lange Wellen wirtschaftlichen Wachstums (supra, n. 28).

mated as exponential trend according to the least squares method.[93] This estimate cannot, however, be numerically determined within the frequency domain.[94] The series of investments in the United Kingdom from 1830 to 1975, for instance, exhibits several cycles, at least till about 1890, whereas its course escapes a clear interpretation for the period from 1914 till 1940.[95] The authors deduce from this and other similar courses of different series that the economic development in the United Kingdom may be fitted very well into the pattern of "Kondratieff-cycles".[96] This result is very surprising in connection with the statement of these authors[97] that there is a possibility of deriving long-term oscillations with a duration of 30 or more years from some of the German index numbers, i.e., long-term cycles which are shorter than "Kondratieff-cycles". This hypothesis can be supported by comparative analyses which I have recently made. The spectral analysis of series from which the trend has been eliminated by means of the notch-filter reveals the existence of a cycle with an average length of nearly 36 years.[98] Leaving aside the problem of how to date the turning-points, the course of the series shows much shorter cycles than is typical of the "Kondratieff-cycles". The course of the series, which has been made trend-free by means of the exponential function,[99] clearly shows that the exponential trend underestimates the cyclical development till 1880; consequently, nearly all values are marked by a positive amplitude till that date. If the trend is, however, calculated by means of the procedure discussed in this paper, the effects which it has on the frequency domain are already known, much shorter cycles are indicated within the course of the trend-free series. If the attempt is made to transform the trend by means of the filter-theory, the great cycle, which Glismann/Rodemer/Wolter deduced as "bürgerlicher Kondratieff" proves to be a sequence of much shorter-term cycles in which trend is still discernable. Without discussing the serious problems attached to such an approach any further, it should be noted that a proof of really existing cycles presupposes an exact determination of non-periodical oscillations within the time-series, with the aid of the filter-theory. That is the only possibility of preventing oscillation components, which must be taken into consideration as part of the trend because they do not prove to have a periodical course, from influencing the dating of cyclical phenomena. Combined with spectral analysis this procedure offers the only opportunity of distinguishing between the different types of cyclical fluctuations which are of historical relevance, in an analytically exact way. In view of the importance attached to empirical results in economic-historical models, the discussion

93. This procedure is justified as follows: "Der gewählte Funktionstyp muß die *"tatsächliche Entwicklung"* (stressed by R. M.) möglichst genau beschreiben". Glismann et. al. p. 77. This, however, presupposes that this development is known beforehand.
94. See the critical comments on an exponential trend course, *Schulte, H.:* Statistisch-methodische Untersuchungen (supra, n. 10), p. 115.
95. This emerges from Figure 4 published by the authors, p. 105.
96. Glismann et.al., p. 80. Inspite of these 'international parallelen Entwicklungen' deviations can be ascertained, of course.
97. Glismann et.al., p. 77 "Aus einigen Kennziffern konnte gefolgert werden, daß möglicherweise eine längerfristige Schwingung mit einer Phase von 30 oder mehr Jahren besteht".
98. See the values in Table 2 and Figure 21 concerning the course of the trend-free series.
99. See Figure A 4, Glismann et.al., p. 105.

about the peculiarities which are conditioned by the procedure ought to be intensified in a way that has hitherto been thought unnecessary.

V. Summary and prospects

The results of spectral analysis indicate the existence of long-term cyles in all the series that have been analyzed. Such a proof presupposes an exact transformation of those components of oscillation of a series which cannot be proved any longer as periodical oscillations within the respective length of the series, and which are as a rule subsumed under the term "trend". It is, however, only in agrarian price series that those cycle-lenghts which are regarded as typical of the "Kondratieff-type" can be proved by means of spectral analysis.[100] The other series that have been analyzed appear to exhibit much shorter cycles, at least during the period of evident growth.[101] After the series have been filtered with the aid of several other filters, the courses of the long-term cycles reveal clear differences in respect to their formal characteristics. These extreme differences in the lengths of the different cycles and in the duration of the upswings and downswings are of great importance for a further evaluation and interpretation of this pattern of oscillations. There is, however, much reason to doubt whether such a sequence of cycles can still be interpreted theoretically or whether it must be regarded as the result of specific historical events and detached from a concept of relations between variables.[102] On the other hand, the representation of these long-term cycles within their dimension of time clearly shows the heuristic value of models which starting from a hypothetical cycle-length try to define those complexes of variables that generate cycles of this very length, or at least try to make them plausible.[103] The scientist must, however, be always aware of the danger of constructing approaches of explanation of phenomena which in reality do not exist, or which exist in a completely different form.

As the course of the "long waves" represented here appears to result from a wavy variation of the level of shorter-term cycles, it is worth while questioning to what extent "long waves" are only formal expressions of specific characteristics of successive shorter-term cycles.[104] It depends on the answer to this question whether "long waves" can be of use as autonomous explanatory elements.

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100. An average length of about 50 years is generally assumed, see e.g. *Rostow, W. W.:* The Long Cycle: An Integrated View. In: *Rostow:* Why the Poor get Richer (supra, n. 76), p. 4.
101. Both, the results of the spectral analysis, and the historical course of these cycles confirm this fact.
102. An approval of this view would limit the explanatory value of such a model very much; *Spree, R.:* Was kommt nach den "langen Wellen" (supra, n. 2), p. 311.
103. See *Wagner, A.:* Demographische Ursachen langfristiger Wachstumszyklen? Fragen zur Konzeption ökonomischer Zyklentheorien. In: *Schröder/Spree:* Historische Konjunkturforschung (supra, n. 1), p. 339ff. Although Wagner argues that this hypothetical cycle-length is problematic, he tries to overcome this difficulty by taking recourse to the demographic development, but without determining the uncertain cycle-length empirically, beforehand. Wagner is not the only one who tries to solve this problem in such a way.
104. As to the relevance of such an idea for the Kuznets-cycles, *see Metz/Spree:* Kuznets-Zyklen (supra, n. 11), p. 365.

Irrespective of these problems, the fact that short-term cycles exhibit a specific course requires an explanation of those factors of macro-economic dynamics which cause the turn of the course of the different cycles with an appreciable regularity. Even if the scientist regards "long waves" as a sequence of phases of the structural change of the whole society, he has to explain those factors beforehand.[105] The interpretation of empirical evidences is rendered more difficult by the fact that if one tries to date the turning-points, it cannot be estimated how far the results that have been achieved, especially the inverse course of the upswings and downswings in the trend and in the "long wave," are conditioned by the statistical procedures. This re-

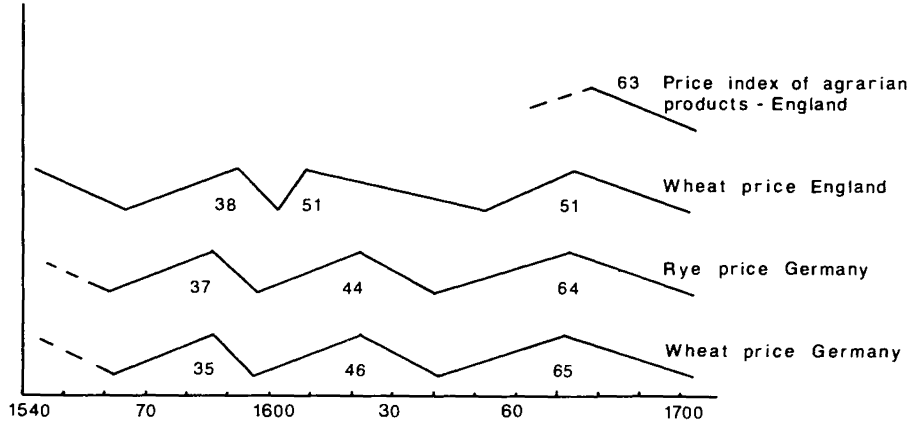

Fig. 13a: Schematic course of the "long waves" in the individual series 1531-1700

sult ought to be carefully analyzed with the aid of the filter-theory, in particular the special characteristics of the phase of the filter within the low-frequency domain.[106] Filters which dispose of a plain zero-phase, and which moreover achieve an exact separation between the trend and the "long wave" are being developed and, therefore, relevant results might be achieved by future research work.[107]

Notwithstanding the fact that these methodical difficulties have not yet been solved, the use of formally exact methods already indicates the necessity of revising

105. See *Spree, R.:* Was kommt nach den "langen Wellen" (supra, n. 2), p. 311.
106. On principle, the phase of these recursive filters can only be analyzed with certain provisos, see *Stier, W.:* Verfahren zur Analyse (supra, n. 25), p. 67 ff. The results which have been achieved, however, imply that the filter causes a phase shift near by the zero point.
107. These filters work according to a principle that differs very much from the one of the recursive filters. See the report on Stier's lecture before the commitee of the "Deutsche Statistische Gesellschaft für Neuere Statistische Methoden" on: Konstruktionsprinzipien digitaler Filter. In: Allg. Stat. Archiv 65 (1981), 1. Heft, p. 101.

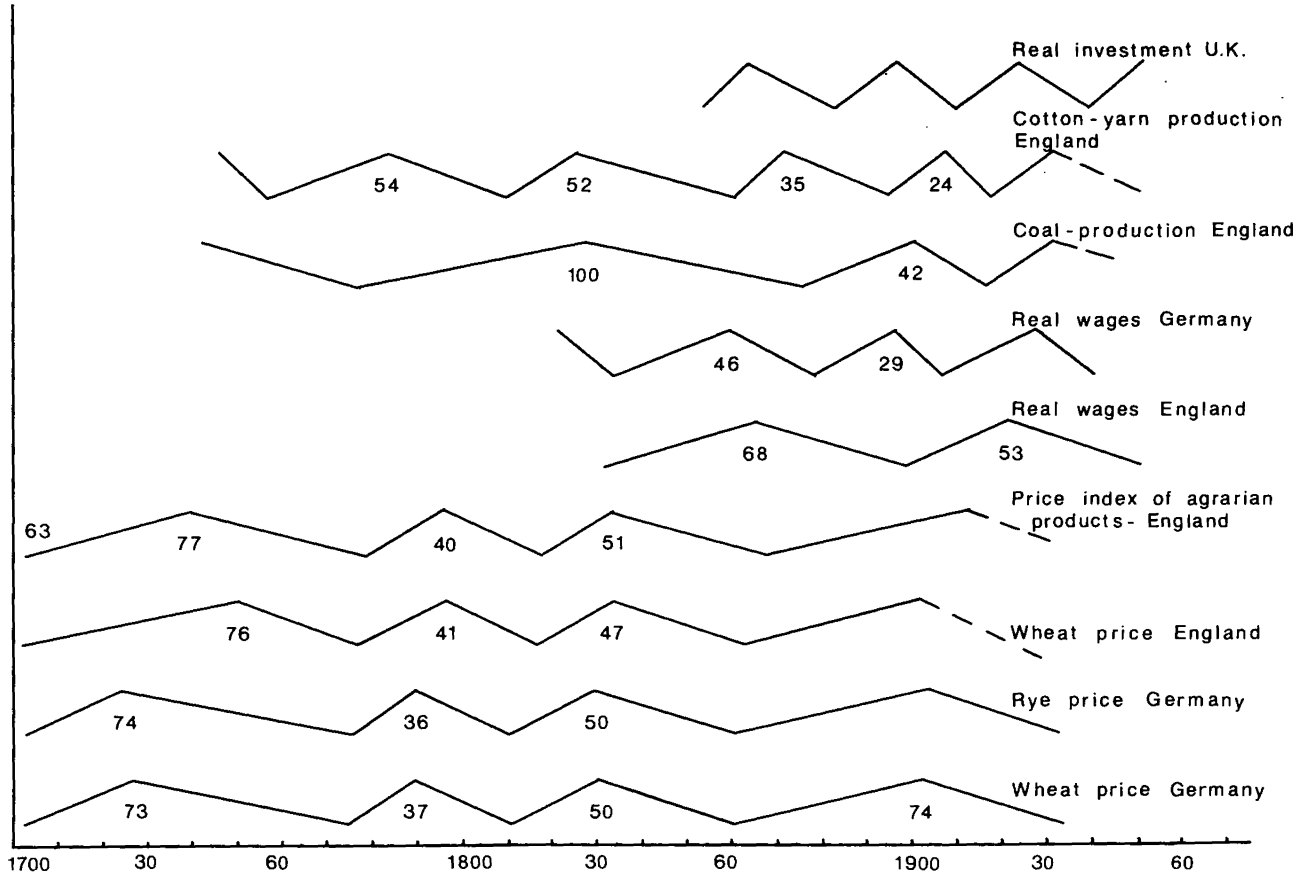

Fig. 13b: Schematic course of the "long waves" in the individual series 1700–1968

traditional conceptions about the shape and the contents of economic terms. Contents that are constituent of economic terms have nearly always been derived from an inadequate use of the results of simple statistical procedures, as for example from the calculation of polynomials of low degree. The analytical tools which are roughly described in this paper achieve an exact transformation of scientific terms into adequate formal-statistical concepts, i.e., into different types of filters. The fact that a clear separation between the trend and the "long wave" can be achieved by means of these filters indicates the necessity of defining scientific terms more precisely and with more attention to the methods than has hitherto been done. An empirical-statistical analysis ought to be preceded by a new attempt to define the main terms of eco-

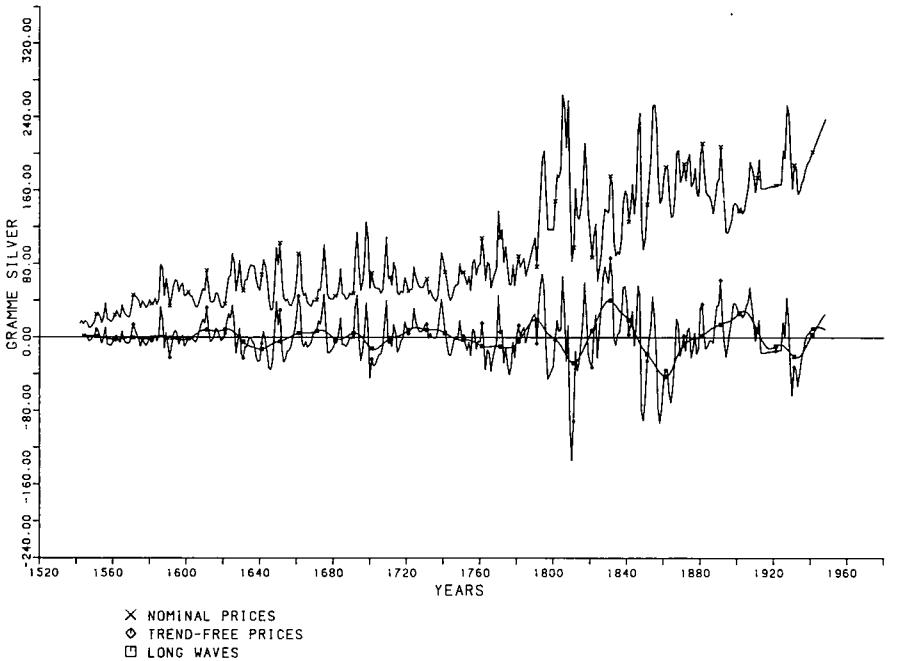

Fig. 14: "Long waves" of the German rye prices 1542–1948

nomic and historical research in a way that shall be appropriate to the new methods of analysis of time-series, if an empirical proof cannot be achieved otherwise. This kind of empirical research also points to the difficulties which arise if ambiguous economic terms are transformed into formal-statistical terms without being scientifically conceptualized beforehand. This, for example, applies to the decision about what is to be defined as trend, in terms of the filter-theory. The empirical results prove that by means of spectral analysis only the limits within which a sound defini-

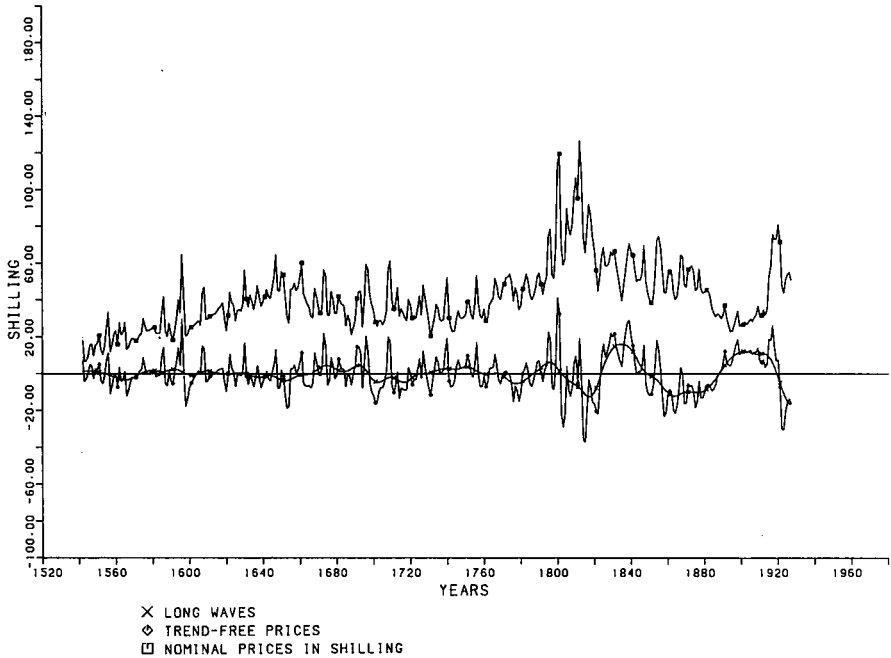

Fig. 15: "Long waves" of the English wheat prices 1542–1927

tion is to be found can be determined. This fact clearly shows that statistical-mathematical procedures cannot claim to offer an opportunity of determining the meaning and dimension of economic terms. On the contrary, the important function of such methods for economic history is to confront economic and historical terms, models or theoretical systems with empirical evidences, in order to deduce clear statements about the explanatory value of such theoretical constructions. Statistics can play an important role in this research-process only if the empirical evidences which contradict these models induce the scientist to revise his theoretical concepts.

Appendix

Description of the empirical data.

The Cologne wheat and rye prices were drawn from the edition published by Ebeling/Irsigler.[108] As regards the quotations of prices, they are unweighted nominal av-

108. See the exact description of the source in *Ebeling/Irsigler:* Getreideumsatz (supra, n. 77).

erage annual prices of the Cologne weekly market from 1531 to 1796. In order to compare them with quotations of prices of later periods, the Cologne prices had to be uniformly converted into Reichsmark per ton; to this end, all quotations of prices had to be multiplied with the silver equivalent of the albus of account[109] of 1777 and the results had to be divided through the fictive silver content of the 'Reichsmark', which was measured at 5.56 gramme.[110] In addition, the weight per malter, which was

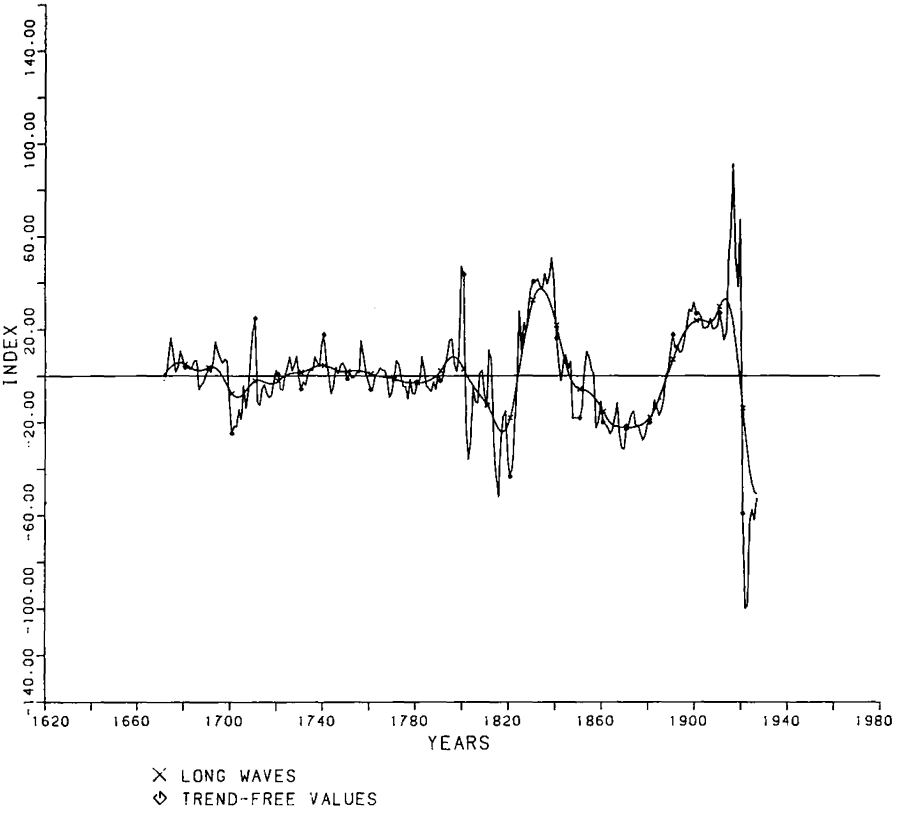

Fig. 16: "Long waves" of the English agrarian price index 1672–1927

109. Because of reasons of compatability all the prices had to be reduced to gramme silver; the use of the last given value of silver of the "Albus of account" guarantees that there is no shift of level within the series. The silver value is 0.157 g; see *Ebeling/Irsigler:* Getreideumsatz (supra, n. 77), p. 42.
110. See *Abel, W.:* Agrarkonjunktur (supra, n. 76), p. 290ff. concerning the problems of reduction of coins and measures esp. p. 293.

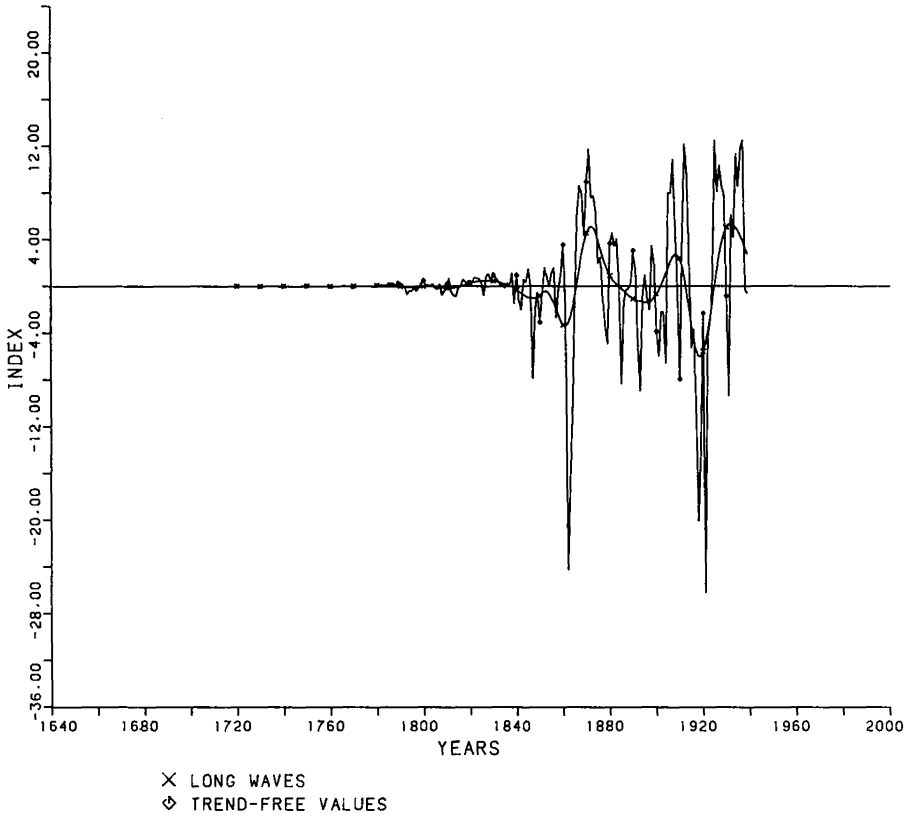

Fig. 17: "Long waves" of the English cotton yarn production 1711-1939

measured at 117 kg for wheat, and at 108 kg for rye,[111] had to be converted into units of 1,000 kg. The analyses referring to the period from 1797 to 1817 were based on the Berlin wheat prices, which have been published in Wilhelm Abel's book. In order to avoid a shift of the price level of these series, they had to be chained statistically.[112] The quotations from 1818 to 1850 and from 1876 to 1913 refer to the Cologne wheat prices, as well; those concerning the period from 1851 to 1875 had to be completed with quotations drawn from the "Vierteljahresheft zur Statistik des Deutschen

111. There are different data in literature concerning dry measure reductions. The data published here are based on the malter weights given by *Ebeling/Irsigler*. *Abel*'s data are slightly different: Agrarkrisen (supra, n. 76), p. 294.

112. As to the statistical problems see *Anderson, O.:* Indexzahlen. In: Handwörterbuch der Wirtschaftswissenschaften, 4. Bd., Stuttgart/New York 1978, pp. 98-108.

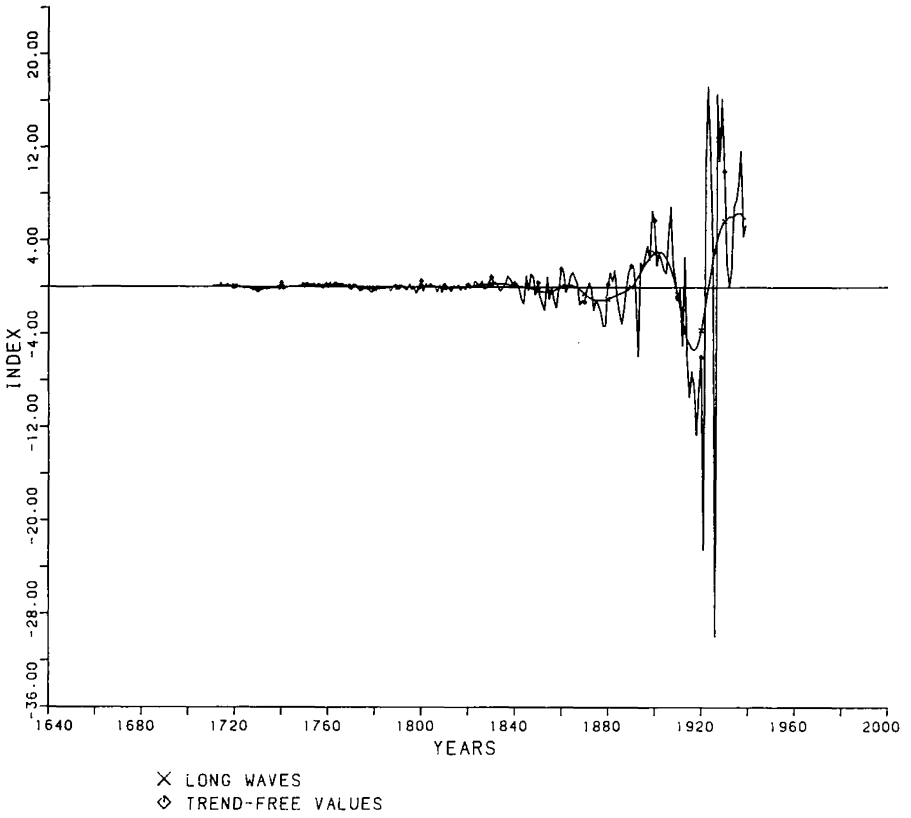

Fig. 18: "Long waves" of the English coal production 1711–1939

Reiches".[113] The quotations of prices concerning the period from 1914 to 1959 were drawn from the series of producers' prices of agricultural products published by Hoffmann.[114] All these quotations of prices are nominal prices,[115] the same is true of the rye prices.

The series of the English wheat prices referring to the period from 1531 to 1770 were taken from the Exeter wheat prices published by Beveridge, and those concern-

113. Concerning the description of the material see *Ebeling/Irsigler:* Zur Entwicklung (supra, n. 32), p. 301 ff.
114. *Hoffmann, W. G.; Grumbach, F.; Hesse, H.:* Das Wachstum der deutschen Wirtschaft seit der Mitte des 19. Jahrhunderts. Berlin 1965.
115. This is not even altered by a multiplication with a constant silver weight.

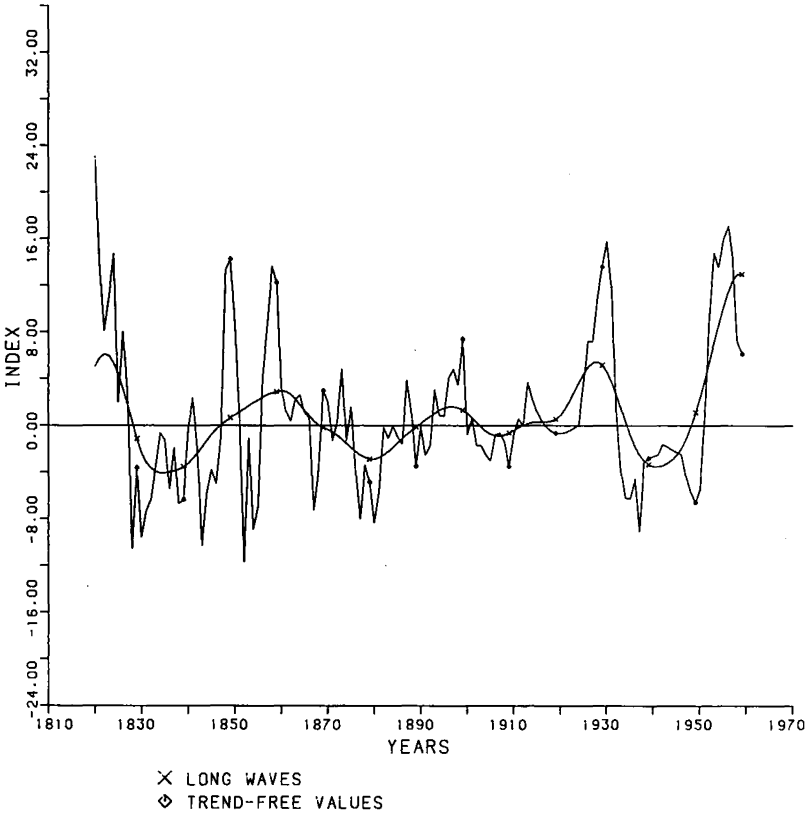

Fig. 19: "Long waves" of the real wage index in Gemany 1820-1959

ing the time from 1771 to 1938 were drawn from the "London Gazette"[116], which published the official prices for England, Wales and Scotland.[117] All the prices had to be converted into shilling per Imperial Quarter (Winchester Quarter = 281,9 liters, Imperial Quarter = 290,8 liters).[118] The series concerning the English vegetable agrarian products contains three different series of indices. These series were in turn selected with regard to the highest degree of uniformity of the data inquiry and of the contents of the shopping-basket, moreover, the material had to be comparable with

116. Price indices were taken from *Mitchell, B. R.; Deane, Ph.:* Abstract of British Historical Statistics. Cambridge 1971, p. 484ff.
117. As to this material, cf. also *Abel, W.:* Agrarkrisen (supra, n. 76), p. 295ff.
118. According to Abel, a. a. O., p. 296f. the Winchester Quarter comprised 281,9 and the Imperial Quarter 290,8 liters.

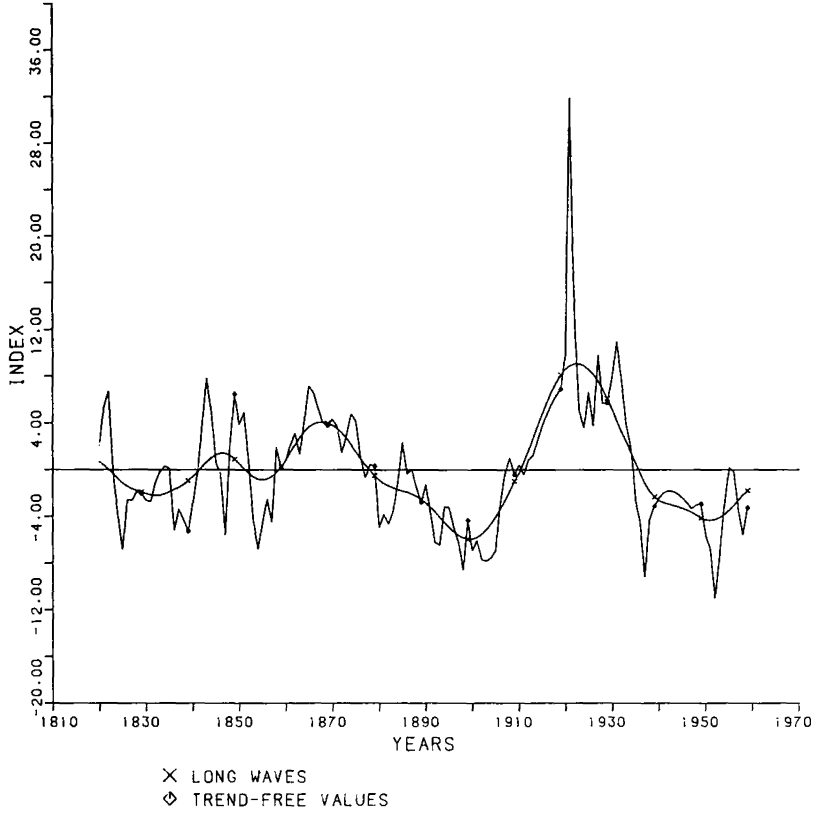

Fig. 20: "Long waves" of the real wage index in England 1820-1959

the German series. In detail, the following indices were chained statistically: Schumpeter's index to "Consumers' goods (a)" from 1661 to 1822; from 1822 to 1913 Rouseaux's index to "Vegetable Products (a)"; from 1914 to 1938 Sauerbeck's index to "Vegetable (a)".[119] In contrast to the index determined by Gayer, Rostow, Schwartz, which can be regarded as the best of all price indices for the period from 1790 to 1850, all the indices mentioned above were calculated without being weighted before.

The quotations concerning the English cotton-yarn production were drawn from Hoffmann's book.[120] Hoffmann compiled this index series with the aid of different

119. Regarding the index series see *Mitchell/Deane:* Abstract (supra, n. 116), p. 468ff., the letters put in brackets refer to the respective footnotes of the series in *Mitchell/Deane.*
120. As to the following remarks see *Hoffmann, W. G.:* British Industry 1700-1950. Oxford 1965, p. 228-230, 254f.

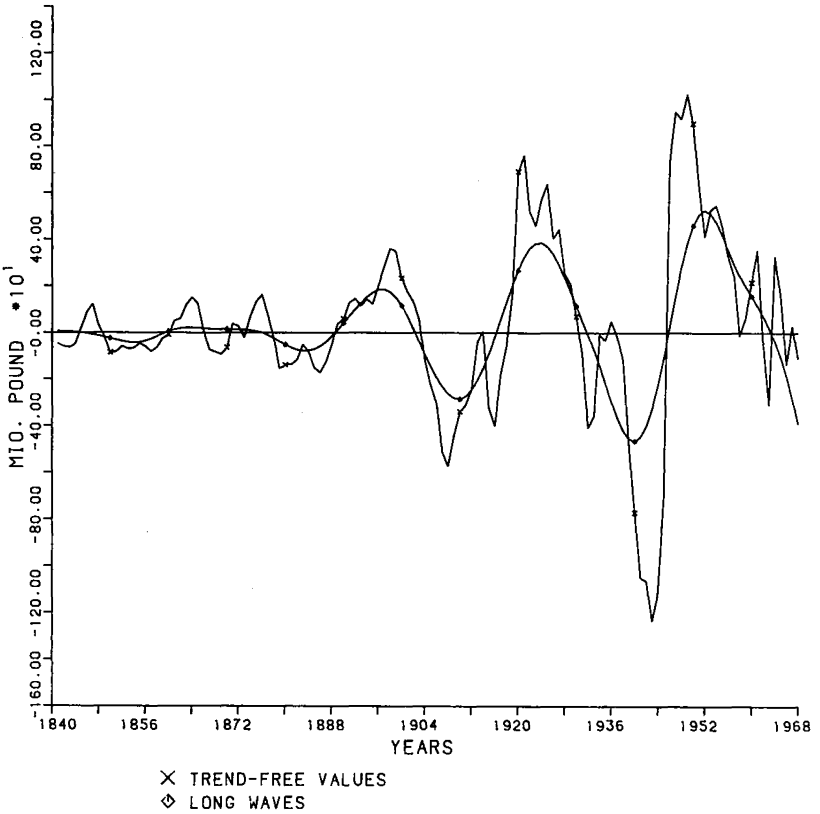

Fig. 21: "Long waves" of the real gross domestic investments in the United Kingdom 1841–1968

series; their representative value consequently varies from series to series. For instance, the cotton stored in England until 1800 was completely left out of consideration. It is due to the fact that the contents of the different series of indices are subject to permanent changes that the results achieved can only be interpreted with great provisos. Moreover, it must be taken into account that the series concerning the period from 1700 to 1800 differs very much in its indicatory function from the series which refers to the subsequent period. The same applies to the series of the English coal production. From 1700 to 1853 the content of this series differ very much from that which refer to the subsequent period.

The compilation of the English series of real wages required some additional steps.

Table 2: Results of the spectral analysis referring to the "long waves" in the individual series

(Cycle-length in years, short-term cycles were not listed)

	TRE1*	TRE1 a.K.**	TRE1 (3 notches)
Wheat prices Germany	60	60	-
Rye prices Germany	60	60	-
Wheat prices Cologne (1531-1796)	60	60	-
Wheat prices England	60	60	-
Agrarian price index England	55	55	-
Coal production England	40	40	40
Cotton yarn production England	30	30	30, 19
Real wage index England	50	50	-
Real wage index Germany	NF, 40	32	32
Real gross domestic investments U. K. 1830-1979	33	33	-

* after trend elimination with a notch-filter

** after trend elimination with a notch-filter and subsequent lowpass filter (Kaiser-filter)

This was due to the fact that the real wage index determined by Phelps Brown[121] does not start before 1860. To this end, the nominal wages paid for both industrial[122] and agricultural labour[123] had to be summed up to one total index according to the percentage of persons employed in the different sectors of production. In order to achieve an appropriate weighting for each year, the estimates made by Deane/Cole about the percentage of persons employed in the lines of production: agriculture, forestry, fishing, manufacture, mining, and industry had to be lineary interpoled.[124] The total wage index resulting from this procedure was thereupon deflationed until

121. *Phelps Brown, E. H.:* Levels and Movements of Industrial Productivity and Real Wages Internationally Compared, 1860-1970. In: The Economic Journal 83 (1973), pp. 58-71.

122. As to the period from 1809-1850, the index series of average wages of different professions publ. by *Mitchell, B. R.:* European Historical Statistics, 1750-1970. London 1975, p. 184 and p. 190 is concerned. As to the period from 1850-59, the series is based on Wood's treatise. *G. H. Wood:* Real Wages and the Standard Comfort since 1850. In: Journal of the Royal Statistical Society (1909).

123. The data concerning wages in agriculture in England and Wales were taken from *Mitchell/Deane:* Abstract (supra, n. 116), p. 348ff.

124. The relative importance of the wages of the different lines of production for the whole wage level can be estimated to some extent by means of the proportion of persons employed in the different branches of production. Although the data published by *Deane/Cole:* British Economic Growth 1688-1959. Cambridge ^{2}1969, p. 142, may be faulty, they were nevertheless used to determine the index of real wages as they appeared to reflect the general tendency rather correctly.

Table 3: Turning-points of the "long waves" in England and Germany

Series	Peaks	Troughs
Wheat prices Germany	1586, 1622, 1672, 1727, 1790, 1831, 1903	1562, 1596, 1641, 1703, 1775, 1811, 1861, 1934
Rye prices Germany	1586, 1622, 1673, 1725, 1790, 1830, 1904	1561, 1597, 1640, 1703, 1776, 1811, 1861, 1933
Wheat prices England	(1543), 1592, 1609, 1674, 1751, 1797, 1834, 1902	1565, 1602, 1652, 1702, 1777, 1817, 1863
Agrarian price index England	1678, 1740, 1796, 1834, 1913	1703, 1779, 1818, 1868
Coal production England	1742, 1828, 1901, (1932)	1777, 1876, 1917
Cotton yarn prod. England	1746, 1784, 1826, 1872, 1908, (1932)	1757, 1810, 1861, 1895, 1918
Real wage index England	1868, 1922	1832, 1899, 1951
Real wage index Germany	1822, 1860, 1897, 1928	1834, 1879, 1907, (1941)
Real groß domestic investments U. K.	1864, 1897, 1924, 1952	1854, 1883, 1910, 1940

Table 4: Upswings and downswings of the "long waves"

	Upswings	Downswings
Wheat prices Germany	1562/86, 1596/22, 41/72, 1703/27, 75/90, 1811/31, 1861/1903	1586/96, 1622/41, 72/1703, 1727/75, 90/1811, 1831/61, 1903/34
Rye prices Germany	1561/86, 97/1622, 40/73, 1703/25, 76/90, 1811/30, 61/1904	1586/97, 1622/40, 73/1703, 25/76, 90/1811, 30/61, 1904/33
Wheat prices England	1565/92, 1602/09, 52/74, 1702/51, 77/97, 1817/34, 1863/1902	1543/65, 1592/1602, 09/52, 74/1702, 51/77, 97/1817, 1834/63, 1902-?
Agrarian price index England	1703/40, 79/96, 1818/34, 68/1913	1678/1703, 40/79, 1796/1818, 1834/68
Coal prod.	1777/1828, 76/1901, 1917/(32)	1742/77, 1828/76, 1901/17
Cotton prod. England	1757/84, 1810/26, 61/72, 95/1908, 18/(32)	1742/77, 84/1810, 26/61, 72/95, 1908/18
Real wage England	1832/68, 1899/1922, 1951/(?)	1868/99, 1922/51
Real wage Germany	1834/60, 79/97, 1907/28	1822/34, 1860/79, 97/1907, (1928/41)
Real gross domestic investments U. K.	1854/64, 1883/97, 1910/24, 1940/52	?/1854, 1864/83, 1897/1910, 1924/40, 1952/?

1850 with the general price index determined by Gayer/Rostow/Schwartz[125] and for the period from 1851 to 1859 with Rousseaux's price index,[126] which to this end had to be chained, before, with the index determined by Gayer/Rostow/Schwartz. The real wage index that resulted from this procedure until 1859 was finally statistically chained with Phelps Brown's index (1860–1970).

In order to calculate the German real wage index, only two series of indices had to be chained. For the period from 1809 to 1859 the index compiled by R. Gömmel,[127] which seemed to be the most appropriate one to be compared with the English index, was involved; for the period from 1860 to 1970 Phelps Brown's index was used once more.

Zusammenfassung: "Lange Wellen" in wirtschaftshistorischen Reihen Englands und Deutschlands von der Mitte des 16. bis zur Mitte des 20. Jh.

Angesichts der gegenwärtigen weltweiten Rezession ist das Interesse am Phänomen der Kondratieff-Zyklen wieder stark belebt worden. Trotz einer intensiven wissenschaftlichen Diskussion und zahlreicher empirischer Analysen besteht bis heute kein Konsens in der Frage der Realität solcher Zyklen. Zwar zeigen sich in vielen ökonomischen Indikatorenreihen Trendschwankungen, doch es ist sowohl in der theoretischen wie der statistischen Forschung ungeklärt, ob sich diese Schwankungen mit einer angebbaren Regelmäßigkeit wiederholen.

Die Nichtlösbarkeit des Problems in der bisherigen Forschung ist einmal auf das Fehlen geeigneter Datenreihen zurückzuführen, zum anderen auf den Umstand, daß kein brauchbares statistisches Verfahren für eine gegenstandsneutrale Untersuchung zur Verfügung stand. Die zunächst mit hohen Erwartungen eingesetzte Spektralanalyse wird neuerdings mit Recht starker methodischer Kritik unterzogen; denn der in allen ökonomischen Zeitreihen vorhandene Trend macht eine informative Spektralanalyse unmöglich, da diese immer ein Ergebnis liefert, dessen Form bereits *Granger* als "typical spectral shape of an economic variable" bezeichnet hat. Ein spektralanalytischer Nachweis langer Wellen erfordert daher immer die vorherige Trendbereinigung der Zeitreihe.

Diese exakte Trendbereinigung gelang bislang nicht. Entweder wurden die langen Wellen mit dem Trend ausgefiltert oder es waren die Auswirkungen der Trendbereinigung im Frequenzbereich nicht überprüfbar, so daß immer offen blieb, ob eventuell ausgewiesene lange Schwingungen erst durch das Verfahren erzeugt wurden (Slutzky-Effekt). Die Nichtüberprüfbarkeit der Hypothese von der Existenz langer Wellen war insgesamt ein sehr unbefriedigender Zustand.

125. *Gayer, A. D.; Rostow, W. W.; Schwartz, A. J.:* The Growth and Fluctuation of the British Economy 1790–1850, 2 vols., Oxford 1953, vol. 1, p. 468–470.
126. The index can be found in *Mitchell/Deane:* Abstract (supra, n. 116), p. 471.
127. *Gömmel, R.:* Realeinkommen in Deutschland. Ein internationaler Vergleich 1810–1914 (supra, n. 83).

Ein völlig neuer Weg zur Lösung dieser Frage besteht darin, Zeitreihenanalyse als Filter-Design-Problem zu begreifen und sich methodisch ganz vom klassischen Komponentenmodell zu lösen. Einer Arbeitsgruppe um Prof. Stier in Bochum ist es gelungen, Filter zu konstruieren, die jene scharfen Trenneigenschaften aufweisen, mit denen das Problem der langen Wellen optimal angegangen werden kann. Der Schlüssel liegt in der Kombination dieser neuen rekursiven Filter mit der Spektralanalyse. Damit lassen sich, über die Intention bisheriger Arbeiten hinausgehend, Form und Lage von Langfristzyklen in der historischen Zeitdimension erstmals darstellen.

Das Verfahren wurde auf verschiedene Zeitreihen (Preisserien, Produktions- und Lohndaten) angewandt. Von den z. T. überraschenden Ergebnissen seien nur einige kurz skizziert: Langfristzyklen sind in allen untersuchten Reihen nachweisbar. Allerdings zeigt sich der typische Kondratieff-Zyklus nur in Preisreihen. Produktionsreihen weisen eindeutig kürzerfristige Zyklen auf, die vielleicht dem Typ der Kuznets-Zyklen zuzuordnen sind, wahrscheinlich aber einen neuen Typus langer Wellen darstellen. Die mit Hilfe der Spektralanalyse diagnostizierten Zyklen-Typen erfahren allerdings bei der Darstellung in der historischen Zeit wesentliche Modifikationen. Von Zyklus zu Zyklus ändert sich nicht nur die jeweilige Zyklenlänge, sondern auch die Dauer der Auf- und Abschwungsphasen. Hinzu kommt, daß die Amplitudenausschläge deutliche Unterschiede zwischen vorindustrieller und industrieller Zeit aufzeigen.

Vergleichsuntersuchungen mit deflationierten Preisreihen haben gezeigt, daß eine schwankende Geldwertstabilität nicht Ursache dieser Zyklen sein kann, sondern nur den Trend beeinflußte.

Die als Trend ausgefilterten nicht-periodischen Schwingungen zeigen keinen gleichmäßig linearen, sondern einen wellenförmigen Verlauf. Ob es sich bei diesem Phänomen um ein methodenbedingtes Ergebnis handelt muß vorerst offen bleiben.

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