Output per worker and its evolution in Belgian industry, 1846-1910

Gadisseur, Jean

Veröffentlichungsversion / Published Version
Konferenzbeitrag / conference paper

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.