Demography: chicken or egg?

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Claude Diebolt & Cédric Doliger *

Abstract: *»Demographie: Huhn oder Ei?«*. This article analyses the demographic matrix of France since the end of World War 2. We first show the fundamental character of the demographic variable for explaining economic growth. The importance of the youngest cohort, and hence fertility, is shown for the economic dynamic. This is followed by verification that the underlying mechanism of this link is founded on Easterlin's hypothesis, that is to say the labour market situation.

1. Introduction: Theories and Hypotheses

The question of the sources of growth has been the subject of renewed interest since the early 1980s. The so-called endogenous growth theories (Romer, Lucas etc.) have been used to extend and go beyond the traditional growth model, that is to say mainly that of Solow (1956/1957). Indeed, in Solow's model, in the absence of exogenous factors, nothing can account for growth in an 'endogenous' manner, from within the system. Now, an empirical explanation of growth phenomena is based on the introduction of a number of explanatory factors such as the existence of growing yields, the level of human capital (training, etc.), learning by doing, endogeneity of technical progress increasing with research, human capital and public expenditure.

In fact, the main factors of endogenous growth, that may or may not generate externalities, are the accumulation of knowledge (Romer), public infrastructure (Barro), human capital (Lucas) and expenditure on research. Population is often absent from theoretical observations or appears implicitly under the head-

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ing 'human capital'[1]. As an extension to this, we aim at showing the fundamental character of the demographic variable for economic growth.

In the sixteenth century, Jean Bodin marked the interest shown in the notion of population and more generally in subjects related to demography, as he affirmed that 'There is no wealth but in people'. The relations between demographic growth, technological changes and the standard of living have therefore been the subject of numerous analyses. The most famous—that of Malthus—holds that the population will regulate itself and above all stagnate. Although this is pertinent for a large part of our history, the changes observed since 1750 call the idea into question.

Many currents have emerged in the analysis of population and there are two opposing views of the subject.

- *The Malthusian line of thinking* (Malthus). Malthus considered that populations grow geometrically while resources grow arithmetically. So either the population voluntarily agrees to limit its growth (with 'moral restraint' or abstaining from marriage) or it will be destroyed by war, famine and plague.
- *Creative pressure* (Boserup). According to Boserup, demographic pressure causes the reorganisation of agricultural production. The size of the population and hence the level of resources needed leads to changes in farming methods. Boserup thus answers the Malthusian trap (insufficient food production) with the low population density trap (poor technical progress).

Starting from this point, this article addresses the causality relations between demographic growth and economic growth and the underlying mechanisms of this dynamics in France since 1950. For this, the results are presented after a justification and reminder of the econometric method used.

2. Data

Three types of variable—economic, demographic and socioeconomic—have been chosen here for use in demonstration of the importance of the demographic matrix on the one hand and of the underlying socioeconomic mechanism suggested by Easterlin (1968) on the other. These different categories of variables are analysed in the case of France for the period 1950-1995 for several reasons. The first is that this period avoids problems of breaks in series (resulting from wars in particular) and therefore gives results that are stronger under analysis, especially as regards stationarisation tests. The second is that it

[1] The excellent synthesis by Aghion and Howitt (1998) is recommended to interested readers.

allows determination of the contemporary mechanism underlying the economic and demographic sphere.

As regards economic variables, we propose use of the GDP as an appropriate indicator of economic growth. Both the total population and the three age groups of the life cycle theory (0-14 years, 15-59 years and 60 and over) were used as demographic variables to show first the dynamics between economic growth and demography and secondly the population group/s responsible for this dynamics. Finally, with regard to the socioeconomic mechanism proposed by Easterlin as underlying this dynamics, we use the average wage and unemployment as indicators of the situation perceived by persons on the labour market. All the data are drawn from the yearbooks of the *Institut National de la Statistique et des Etudes Economiques* (INSEE).

3. Methodology

3.1. The merits of analysis of causality relations

The results of empirical studies may show certain contradictions in particular because of the differences in the models chosen and the estimation methods. Furthermore, a large proportion of the studies are limited to visual inspection and/or transverse analysis. The conclusions of these studies are therefore based mainly on correlation and correlations between variables do not necessarily mean a causality relation. The demonstration of causal relations between the economic variables allows better understanding of economic phenomena and provides further information about which events occurred first and hence enables the setting up of an optimised economic policy. Finally, socioeconomic or demographic variables rarely have an instantaneous effect. For example, a lag is often observed in demography because couples cannot immediately adjust their level of fertility as soon as their financial situation changes, especially because of the time needed to take the decision that they are financially ready to a have a child, to conceive the child and the duration of pregnancy. Furthermore, it is not unusual for a variable to be affected by its own past behaviour. Thus, analysis of the relation between the economic sphere and the demographic sphere and the socioeconomic mechanism linking the two spheres should be seen not only in a dynamic manner but also as an auto-regressive process. This is why this type of relation should be examined in terms of causality between variables with indication on the one hand of the direction of this causality and on the other of the resulting dynamics, using impulse response functions and the decomposition of forecasting error variance.

3.2. Methodology

3.2.1. Unit root tests and order of integration

It is essential to analyse the stationarity properties of the series chosen before performing causality analysis. We therefore propose the use of standard unit root tests (Dickey Fuller, 1981, Phillips Perron, 1988) and efficient unit root tests (Elliott Rothenberg and Stock, 1996, Ng Perron, 2001) to determine the order of integration of variables, to stationarise series and finally to find out whether there is a risk of cointegration and whether the analyses should be based on a VAR[2] or a VEC[3] model.

3.2.2. Analysis of cointegration and causality as put forward by Granger

The method for analysis cointegration presented by par Engle and Granger (1987) is used to identify the true relation between two variables by seeking the possible existence of an integration vector and eliminating its effect.

Two series X_t and Y_t are said to be cointegrated, that is to say $(X_t,Y_t) \rightarrow CI(d,b)$ if:

- they are awarded the same order of integration, d,
- a linear combination of these series makes it possible to obtain a series with a lower order of integration, that is to say: $X_t \rightarrow I(d)$ and $Y_t \rightarrow I(d)$, in such a way that $(aX_t + bY_t) \rightarrow I(d\text{-}b)$ where $d \geq b \geq 0$.

The test chosen for analysis of the possible cointegration relations between the variables is Johansen's test (1988). If this stage reveals such relations, the study is performed with a VEC model and if not it s continued with a VAR model.

Granger's causality test was chosen among all the possible methods in the light of the favourable results presented by Guilkey and Salemi (1982) and Geweke, Meese and Dent (1983), especially for small samples (fewer than 200 observations). Thus, according to Granger (1969), variable y_{1t} causes variable y_{2t} if the forecasting of the latter is improved by incorporating information about y_{1t} and its past in the analysis. The test can then be conducted with a classic Fisher test of nullity of the coefficients on the estimated model (VAR or VEC), equation by equation, and a causal relation is accepted in the statistical processing if the probability calculated is lower than the risk of the first kind 10%).

[2] Vector Auto Regressive.
[3] Vector Error Correction.

3.2.3. Determination of the sign of causality

If there is a causality relation, it is possible to determine the general sign of this causality. The regression equation on which the causality test is based is therefore as follows:

$$y_{2,t} = c + \sum_{k=1}^{p} a_2^i y_{1,t-k} + \sum_{k=1}^{p} b_2^i y_{2,t-k} + \varepsilon_{2,t}$$

If this causality relation exists between y_{1t} and y_{2t}, its sign is determined by:

$$\eta = \sum_{k=1}^{p} a_2^i = a_2^1 + a_2^2 + a_2^3 + \ldots + a_2^p$$

3.2.4. Impulse response functions and variance decomposition

However, causality in the VAR or VEC models does not provide information about the dynamic properties of the system and does not allow judgement of the relative strength of causality or quantitative measurement of the dynamic interactions between the different variables.

The decomposition and the impulse response functions therefore provide some of this information:

- *Analysis of impulse response functions* makes it possible to measure the impact of a shock on the variables and to trace the effect of the shock of an innovation on the current and future values of the variables.
- *Variance decomposition of forecasting error* for each variable with relation to a shock breaks down the variance of a variable into shock components of the variables of the system and thus provides information about the relative importance of each innovation of the variables of the model.

4. Results

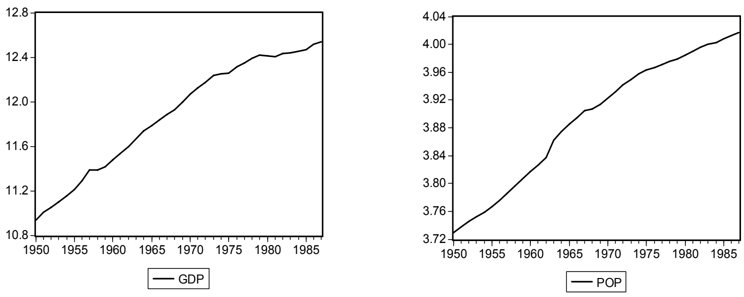
4.1. The relation between economic growth and demographic growth

We first focus on the relation between growth and population, and for this consider total GDP (GDP) and total population (POP) in millions in France since 1950. After performing a logarithmic transformation of sets of figures[4],

[4] All the analyses here were performed here were performed on the logarithms of the sets of figures.

we examined their stationarity using unit root tests (standard and efficient) and found that sets of figures are DS processes that are stationarised with a differences filter.

Figure 1: Time series



As both processes are integrated at the order of 1, Johansen's statistical analysis (1988) is used to check whether they are cointegrated to determine whether analysis of causality relations is to be based on a VAR or a VEC model.

Table 1: Johansen's cointegration test

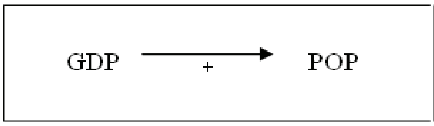
Hypothesized	Eigenvalue	Statistic	5 Percent	1 Percent
None	0.176581	8.548760	14.07	18.63
At most 1	0.038796	1.741016	3.76	6.65
Test indicates no cointegration at both 5% and 1% levels				

This shows that the null hypothesis can be accepted at the 1% and 5% thresholds and so there is no cointegration of the two sets of figures. Granger's analysis of causality can then be performed from estimation of an optimum VAR model[5].

Application of the causality test to the optimum VAR model (VAR(1)) revealed the following causality channel:

5 That minimises the entropy criteria, that is to say the criteria AIC and SBC.

Figure 2: Causality



It can be seen that the GDP growth rate has a direct, positive influence on population growth rate, but that population growth rate does not influence—or at least not directly—the GDP growth rate. It thus emerges that in the contemporary period analysed in this article, the exceptional economic growth of the post-war period led to exceptional population growth. This can be explained in particular by the fact that persons of child-bearing age who entered the post-war labour market had experienced the period of the Great Depression and the war and thus had fairly modest material aspirations. However, their experience on the labour market was satisfactory. Not only did demand for labour increase during the economic prosperity that followed the war, but supply was reduced by the small size of the cohort. People attained or exceeded their natural expectations, that is to say the material expectations that they had developed at adolescence, and felt freer to marry and have children. However, the causality channel gives only an indication of the causality between variables and does not provide information about the relative strength of the causality chain or quantitative measurement of the dynamic interactions between the different variables.

Variance decomposition provides a first idea:

Table 2: Variance decomposition

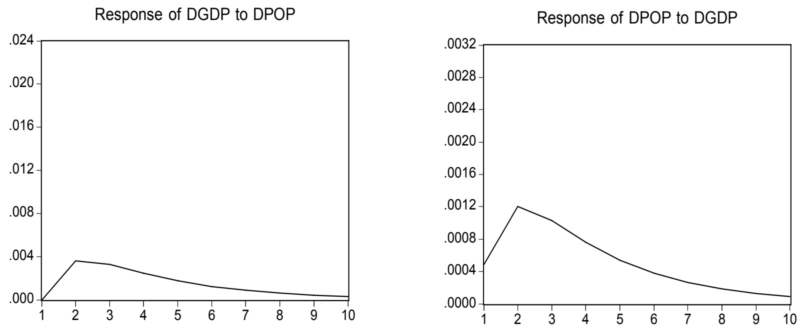
Variance Decomposition of DGDP:		
Period	DGDP	DPOP
2	93.49160	6.508403
15	89.29805	10.70195

In this case, it is seen that a limited but nonetheless significant proportion of the variance of the GDP growth rate (6.5%) is accounted for in the short term (2 years) by a shock affecting the population growth rate, whereas in the long term (15 years) a shock affecting the population growth rate accounts for 10% of innovations in the GDP growth rate. With regard to variance of the demographic growth rate, 8% of variance in the short term is accounted for by a shock affecting the GDP growth rate in contrast with 18% in the long term.

Thus on the one hand demographic growth has a dynamic interaction with economic growth in the long and short term (greater in the long term) and on the other a shock affecting the GDP growth rate has more impact on the population growth rate than the latter has on that of the GDP.

Impulse response functions also provide information about the relative dynamic forces that can exist between economic growth and demography:

Figure 3: Impulse response functions



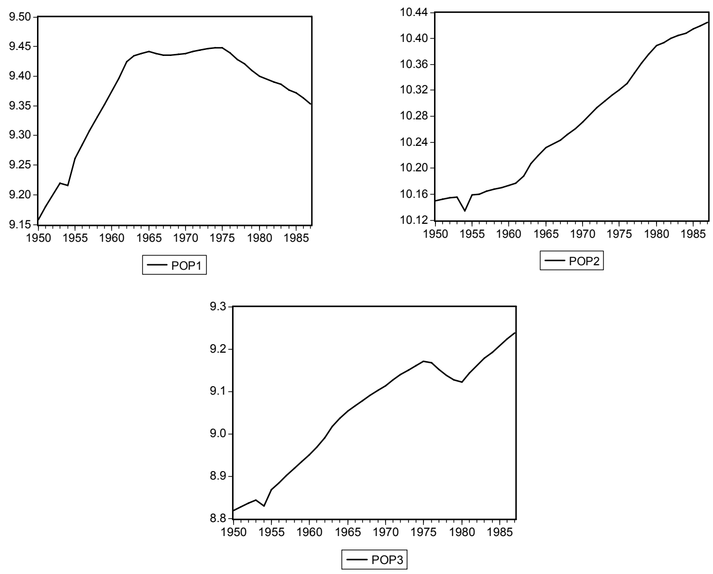
It can then be seen that a shock affecting the GDP growth rate and/or the population growth rate had a positive, increasing influence until the second period and then this influence decreased in the subsequent periods but nevertheless remained positive during all 10 periods. It is also seen that an initial shock affecting GDP only has a truly significant effect on population after 2 periods. Indeed, as mentioned above, it takes several years for people to take a change in the economic situation into account and take the decision to have children. Furthermore, as conception to childbirth lasts for nearly a year, a time-lag of at least a year is always observed in this type of analysis to obtain significant change. This shows the interest of performing this type of study in terms of causality with VAR (or VEC) modelling to take these features into account.

This preliminary analysis shows that there is indeed a relation between economic and demographic dynamics. However, this result must be completed by following two different, complementary pathways. Firstly, the link must be strengthened by including several population age groups to show that the youngest group has particular importance in economic and demographic dynamics in the contemporary period (1950-1995) and hence that fertility is the demographic phenomenon behind the dynamics. Furthermore, it is important to determine whether the mechanism allowing such a link between the economic and demographic spheres is that put forward by Easterlin (1968), that is to say the situation perceived by persons on the labour market.

4.2. The demographic phenomenon behind the relationship

The same variables as above are examined in the second analysis, with the addition of the three usual age groups (0-14 years (POP1), 15-59 years (POP2) and 60 and over (POP3)).

Figure 4: Time series



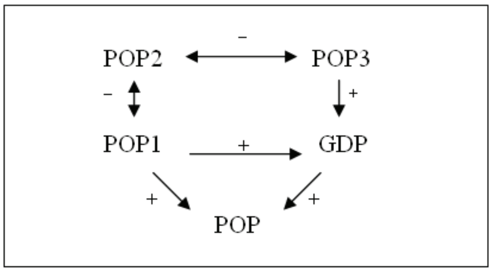
The methodology laid out above is used to examine the stationarity of these sets of figures using standard and efficient unit root tests. As the different processes are integrated processes of order 1 that are made stationary by differentiation, it should be checked where they are cointegrated.

Table 3: Johansen's cointegration test

Hypothesized	Eigenvalue	Statistic	5 Percent	1 Percent
None	0.586159	31.76186	33.46	38.77
At most 1	0.416338	19.38360	27.07	32.24
At most 2	0.367639	16.49861	20.97	25.52
At most 3	0.321715	13.97478	14.07	18.63
At most 4 *	0.151626	5.919632	3.76	6.65
Test indicates no cointegration at both 5% and 1% levels				

The null hypothesis is accepted at the 1% and 5% thresholds and so there is no cointegration relation between the sets of figures. Causality analysis can therefore be conducted using VAR modelling. This is optimal for lag p = 1, giving the following causality channel:

Figure 5: Causality



Several important features can be observed. First, the growth rate of the youngest cohort (0-14 years old) and that of the oldest (60 and over) have a direct, positive effect on the GDP growth rate; this can be explained by the particularly high consumer expenditure for these two categories. Next, only the growth rate of the youngest population has a direct, positive influence on population growth. This is particularly interesting as three demographic phenomena can account for changes in population growth—deaths, migration and births. Within the framework of this work, each population category can be matched with one of these phenomena, as it can be considered that the 0-14 group indicates fertility, that the growth rate of the 60+ group indicates an evolution of mortality and that the growth rate of the working population shows the movement of migration (as immigration and emigration are characteristic behaviours of this group). The first two points thus show that the essential demographic phenomenon of the contemporary period with regard to the dynamics above is the fertility (POP1) of households (POP2). Finally, the last important point in this causality channel concerns the relations between the three population categories. Indeed, it is observed on the one hand that there is a feedback effect between the growth rate of the youngest age group and that of the working population and between the growth rate of the working population and that of the oldest group. Furthermore, these mutual influence effects are negative, that is to say that the growth rates have inverse relationships. In other words, when the working population group is particularly large, the youngest age group shrinks, meaning that fertility decreases and the same applies to the working population and retired groups (as a result of the relation between the youngest group and the working group). This inverse relationship is explained by Richard Easterlin (1968), who explains that American fertility displays expansion and regression cycles and considers that these variations are probably linked to the conditions of entry to the labour market for young people. A small cohort is better able to gain a foothold on the labour market, a better standard of living and hence greater fertility. This results in a larger cohort 20 years later, more difficult access to jobs and hence decreased fertility.

The analysis is continued to variance decomposition to complete the results for the first two features mentioned above, i.e. the importance of the youngest group, that is to say fertility, for economic and demographic dynamics.

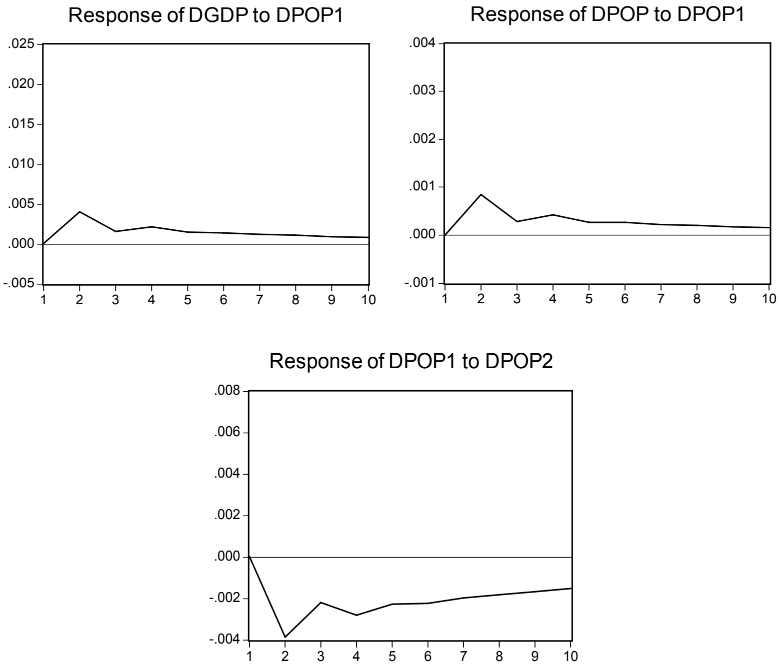
Table 4: Variance décomposition

Variance Decomposition of DGDP:					
Period	DGDP	DPOP	DPOP1	DPOP2	DPOP3
2	95.87157	0.243797	0.295592	1.660882	1.928158
15	80.03589	0.634907	8.767695	5.217497	5.344011
Variance Decomposition of DPOP:					
Period	DGDP	DPOP	DPOP1	DPOP2	DPOP3
2	6.147359	42.37536	18.68492	28.00626	4.786101
15	6.269844	31.91129	27.57980	26.37799	7.861077

In the short term, 0.3% of the variance of the GDP growth rate is accounted for by a shock affecting the growth rate of the 0-14 age group, whereas in the long term a shock affecting this rate accounts for 9% of innovations in the GDP growth rate. In variance of the demographic growth rate, 19% is accounted for by a shock affecting fertility in the short term against 28% in the long term. The fundamental demographic phenomenon for the demographic and economic sphere is thus indeed fertility behaviour.

Mutual influences between variables are determined by the following impulse response functions:

Figure 6: Impulse response functions



We thus confirm the proposals above, i.e. a shock affecting fertility (POP1 growth rate) has a positive, lasting effect on the GDP growth rate. Then the rate of growth of the youngest cohort has a positive, non-negligible influence on the growth rate of the population and so fertility is a determinant factor in the relation between the rate of economic growth and the rate of demographic growth. In fact, the birth rate is the adjustment variable for demography. The economic and demographic spheres are closely linked and any positive or negative impact in the economic sphere will result mainly in a rise or fall in the number of births. The birth makes the adjustment necessitated by economic movements, whence the interest of the analyses of Richard Easterlin, Gary Becker and others on fertility in defining the factors influencing the decision to have children or not and to make more effective and lasting birth rate policies. Finally, we note that an increase in the working population has a neagtive effect on fertility that is lasting but dwindles, confirming the hypotheses of relative size of cohort described by Richard Easterlin (1968) in Population, Labor Force, and Long Swings in Economic Growth: the American Experience: a small cohort is better able to join the working population, has a better standard of living and hence greater fertility. This results 20 years later in a larger cohort that finds it difficult to find work and is thus less fertile.

Easterlin formulated one of the most popular theories of fertility. He holds that fertility is in cycles with large birth cohorts producing small cohorts and vice versa. He says that the proportion of young adults in any given 20-year period is a reflection of the birth rate during the preceding 20 years and thus postulates that the persons born during a period with a low birth rate find an open labour market with good wages and rapid career promotion whereas, in contrast, persons forming part of a large cohort have fewer favourable economic effects.

The theory is constructed around two large complementary parts:

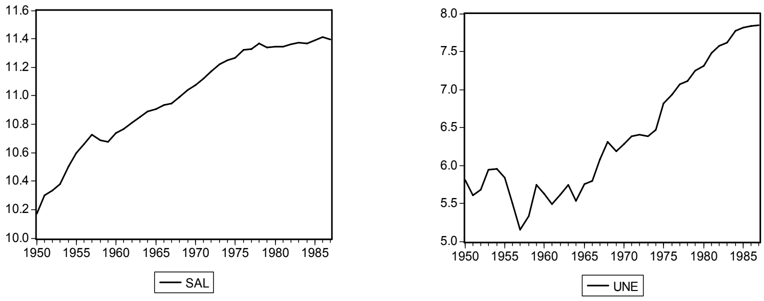
- the effect of the relative number of young adults on the birth rate,
- the effect of wages and unemployment on the birth rate.

On the one hand, when young workers are few their standard of living improves, resulting in an increase in marriages and childbearing. This is then followed 20 years later by an increasingly abundant supply of young workers and there a decrease in marriages and fertility. This first part of Easterlin's theory is corroborated by the results above and the relation can be explained by simple arguments of supply and demand. When the supply of young workers is large, they will compete strongly for a limited number of jobs but when supply is small they can choose between jobs and accept only those with high wages and opportunities for promotion. He also uses the relative income theory (that is to say the effect of wages and unemployment on fertility) to explain this. He states that the determinants of marriage and the fertility rate are the scope for income for the couple, their material aspirations and social aspects (religion, education and environment). The couple's relative income is the ratio of their possible income to their material aspirations. This figure is then estimated by the ratio of the man's present income (hoped-for earnings) to the past income of his parents (material aspirations). Easterlin puts forward that when the relative income increases, economic pressure on the couple decreases and so they are freer to marry and have children. He also considers that relative income also measures relative unemployment. Indeed, fertility movements can be linked to a relative employment indicator consisting of the ratio of average current unemployment, reflecting the experience of young couples on the labour market to average unemployment over a longer period; the latter reflects their parents' experience on the labour market and shows the aspirations and expectations of young couples. This ratio, this relative comparison of situations, means that couples decide to have more or fewer children, a more favourable situation meaning a larger number of children. We propose application of the same methodology to verify the truth of Easterlin's hypothesis as a mechanism subjacent to the relation between the economic and demographic spheres.

4.3. Mechanism subjacent to the relation

The GDP and the total population are used again in this last analysis, together with part of the youngest category of the population (POP1), whose importance has been shown in the preceding section, and also salaries (SAL) and unemployment (UNE) to incorporate the notion described above with regard to Easterlin's hypothesis and the regulation of fertility via the labour market, and, more specifically, incorporate the second part of Easterlin's theory seen above.

Figure 7: Time series



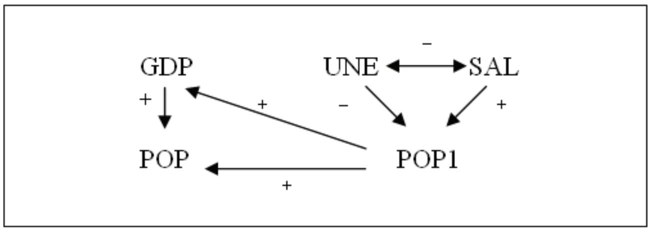
Analysis of the stationarity of the two new variables shows that the sets of figures are integrated of order 1 and so Johansen's method is to be used to verify the risk of cointegration.

Table 5: Johansen's cointegration test

Hypothesized	Eigenvalue	Statistic	5 Percent	1 Percent
None *	0.639023	36.68186	33.46	38.77
At most 1	0.477882	23.39505	27.07	32.24
At most 2	0.413422	19.20420	20.97	25.52
At most 3	0.239680	9.864554	14.07	18.63
At most 4 *	0.114790	4.389488	3.76	6.65
Max-eigenvalue test indicates no cointegration at the 1% level				

The null hypothesis is therefore accepted at the threshold of 1%. There is no cointegration relation between the sets of figures in this model. Application of a causality test on the optimal VAR model (VAR(1)) shows the following causality channel:

Figure 8: Causality



The causality channel shows that the growth rate of unemployment and salaries has a direct effect on fertility (that is to say growth of the population of 0-14-year-olds) and that this influence is positive within the framework of salaries and negative for unemployment, as is stressed in Easterlin's hypothesis. Furthermore, the feedback effect between the socioeconomic indicators unemployment and salaries confirms that relative income and relative unemployment can be considered as equivalent indicators.

5. Conclusion

Three approaches are used in our study on the relation between demography and economic growth, and more specifically on the importance of the demographic matrix for economic dynamics. We first set out to show using VAR modelling and its tools (Granger causality, impulse response functions and variance decomposition) that there is indeed a relation between economic growth and demography. Next, that this relation is established by means of a particular demographic phenomenon, fertility, that is to say growth of the young population. It thus appears that the youngest section of the population has stimulated the economy of our society since 1950 and that attention should be paid essentially to the birth rate and the factors that influence the decision to have children (Easterlin *et al.*). Finally, as is proposed in Easterlin's theory, the mechanism that underlies the evolution of fertility (that is therefore subjacent to the relation between the economic and demographic spheres) operates via the labour market through two complementary components—the relative size of the cohort and the relative income (relative employment).

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