# Higher education and economic growth in France since the Second World War

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# Higher Education and Economic Growth in France since the Second World War

*Magali Jaoul**

**Abstract:** In the past century, education was no longer an area isolated from the rest of the economy but something more important.
The evolution of higher education in France reveals that the recent period was a turning point in the history of education. Indeed, the number of bachelor's degrees increased in an unprecedented growth in the past thirty and especially the past ten years. Although this increase was mainly the result of social demand, educational policy has been strongly guided by the fact that the development of higher education has a beneficial effect on the economy.
At the beginning of the twenty-first century, higher Education and the dissemination of knowledge depended essentially on the universities. It might therefore be of interest to address the issue of the links between higher education and economic growth, because the real direction of the correlation between these ones remains undetermined. Cliometric tools are used here to shed light on the relationship between higher education and economic growth in France after the Second World War.
The evolution of the education standard and its link with the growth process were examined quantitatively in order to verify the fore a causality relationship. Two approaches were used:

- an approach with diploma,
- a socio-economic approach.

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This article falls within the scope of a CNRS action (Aid for New Project), directed by Claude DIEBOLT, and entitled "Analyse cliométrique de la relation éducation-croissance en Europe aux 19ème et 20ème siècles".

The results of the analysis using original statistics for France show a high correlation between education and economic success.

## Introduction

The development of higher education in France reveals that the recent period has been a turning point in the history of education. Indeed in the last 30 years, and especially in the last 10 years the number of Bachelor's degrees has grown in an unprecedented manner.

Although this increase is mainly the result of social demand, educational policy is strongly guided by the fact that the development of higher education has a beneficial influence on the economy. This influence is the result of the fact that greater skills are sought in occupations as the result of the development of technology. People therefore require a higher level of qualification.

The development and growth of a nation today seem to be dependent upon its scientific and cultural standards and also upon the quality of its higher education, but the input into the system of higher education and the use of higher education have been improved, so that it is expected, that the use of higher education should be different from that of the last century. Today, these improvements concern four essential points:

- enhancing progress and passing on knowledge,
- adapting to the occupations of the future,
- enabling people to reach their best level,
- contributing to the progress of social justice.

At the beginning of the twenty first century, education and the dissemination of knowledge depends essentially on the universities. It is therefore of interest to examine the links between higher education and economic growth. Cliometric tools are used here to shed light on the relationship between higher education and economic growth in France after the Second World War. The evolution of the standard of education and its link to the growth process is examined using quantitative data to demonstrate a relationship of causality. Two approaches are used:

- a diploma approach (Part 1),
- a socio-economic approach (Part 2).

# 1. Analysis of the Relationship Between Economic Growth and the Number of Bachelor 's Degrees

The interest and the consequences of the increase in academic standards are recurrent problems for economists. These questions concern educational returns (LÉVY GARBOUA & MINGAT, 1970; PETIT, 1975) and links with the production system (GALLAND & ROUAULT, 1996; THÉLOT & VALLET, 2000). The latter approach is examined in particular here. The question is, whether first degrees in France might have a positive effect on GDP, that is to say whether an increase in the number of first degrees might habe positive effects on economic growth. The variables used are the GDP and the number of persons with four levels of education 1977 to 1996:

- no qualification (SANS).
- BEP[1] or CAP[2] (CAPBEP).
- *baccalauréat* (BAC).
- Bachelor's degree (SUP).

## 1.1 Methods

### *1.1.1. Principal Components Analysis*

This is used to study data in a 'person/character' table and is done in three stages:

- eigenvalue analysis: each eigenvalue of the correlation matrix represents a quantity of information; we have to keep a number of eigenvalues in order to have at least 75 % of information. The number of eigenvalues is also the number of axes for the graphic study;
- contribution analysis: there are different sorts of contribution. Absolute contribution represents the importance of the variable in the appearance of axes; relative contribution is the quality of representation of a variable upon an axis; the quality of representation is the representation upon the system. The break-even points are respectively [0.1; 0.5], 0.3 and 0.5, that is to say if the quality of representation of a variable is 0.3 it is not well represented by the system of axes and it must be removed from the analysis;
- graphic analysis: this is the analysis of the correlation circle in order to represent opposed or linked groups of variables. Correlation between two variables X and Y is positive, negative or nil if cos (XoY) equals to 1, -1 or 0 (0 is the centre of the circle) respectively.

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1 Diploma awarded after short technical school training.
2 Diploma awarded to a skilled workman.

### *1.1.2. Multiple Factor Analysis*

This analysis is generally used for the study of qualitative data or for the quantitative data taken under qualitative form. The principal characteristic of this type of analysis is to prove non-linear relationships.

The first and second of the four stages of analysis are the same as in principal components analysis; only the threshold values are changing. The quantity of information must reach 60 % of the information; the break-even point of the relative contribution is 0.2.

In graphic analysis, modalities are represented by the centre of gravity of individuals who possess them and are interpreted by groups. Polynomial lines are plotted to underscore correlations between variables. If lines are parallel, there is a correlation; if they are orthogonal, the lines are independent. The direction of the lines indicates a correlation. If the lines go in the same direction, the correlation is positive; if not, it is negative.

## 1.2. Results

The first analysis (PCA) reveals two groups of negatively related variables: on the one side, persons who have a CAP, a BEP or no qualifications and on the other the number of bachelor's degrees, *baccalauréat* holders and GDP which would be linked positively to high standards of qualifications and negatively to the group with low or no qualifications (Figure 1). The following are observed:

Cos (SANS, O, CAPBEP) = 1
Cos (PIB, O, BAC) = 1 and Cos (SUP, O, BAC) ≈ Cos (SUP, O, PIB) → 1

The same results are found with multiple factor analysis. Variables are in qualitative form. Three modalities (1 to 3) are designated for each variable representing respectively a low, middle and high level of the variable. For example: GDP1 ⇔ low level of the GDP.

It is used a two-factor-solution explaining more than 80% of the information with two eigenvalues greater than 1, so the result can be represented with two axis. If polynomial lines are drawn, it is possible to show an identical correlation as the Principal Components Analysis (Figure 2).

It can be seen that the number of *baccalauréat* holders, bachelor's degrees and the level of the GDP go from right to left and unqualified persons or holders of a CAP or a BEP go from left to right.

Three groups appear in three different periods (Figure 3):

- SANS3, CAPBEP3, BAC1, PIB1 from 1977 to 1981.
- SANS2, CAPBEP2, BAC2, PIB2, SUP2 from 1982 to 1987.
- SANS1, CAPBEP1, BAC3, SUP3, PIB3 since 1988.

Figure 1: Correlation circle

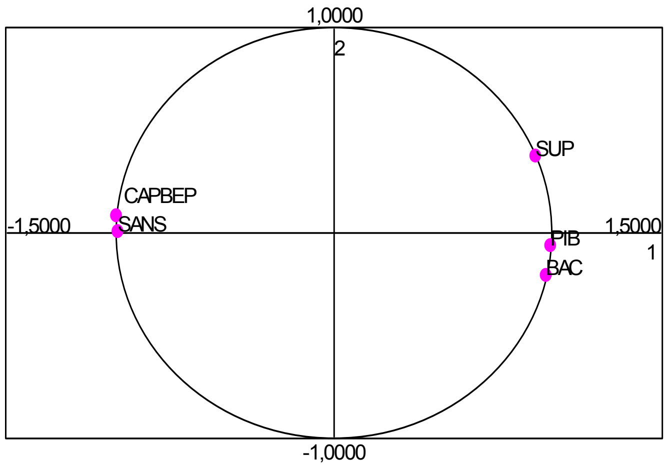



Figure 2: Polynomial Lines

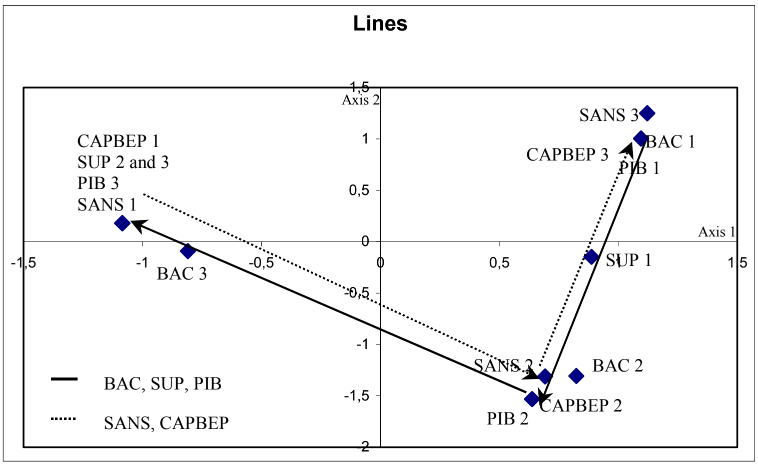
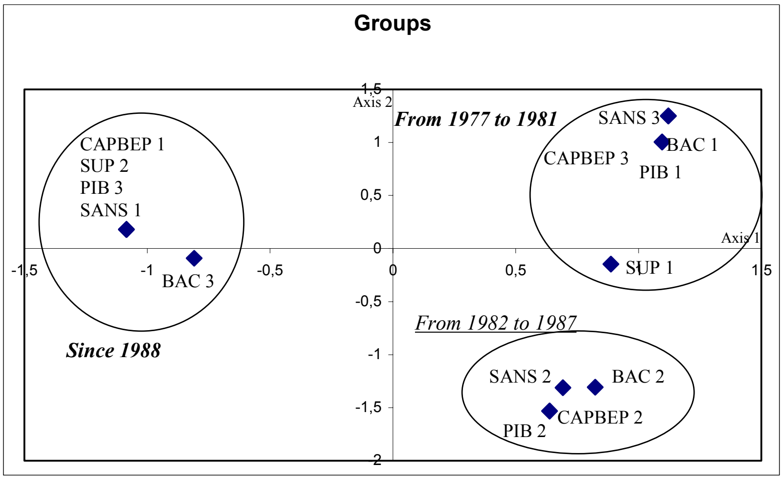


Figure 3: Groups




Movement of he GDP is similar to that of the number of graduates but is negatively related to the number of persons who have lesser or no qualifications. The assumption that economic growth should be a function of its human capital thus appears to be proved.

This means that an economic policy for the development of higher education development would be favourable for economic reflation. Furthermore, as this analysis has been carried out with people, a policy, which will promote the achievement of higher degrees in the population as for example the *baccalauréat* would have the same effect. This might be an explanation for the increase in the level of qualifications in France for the past decade or so and raise questions concerning the future essentially with scrapping projects in education[3].

These two analyses show relationships between the GDP and higher education but the interaction is not determined. Moreover, other socio-economic factors may play a role in economic growth.

The evolution of the GDP and various factors in France are therefore examined below in order to demonstrate a relationship of causality.

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3 For example, Claude Allégre, (French minister of education) proposed a plan called U3M in 1999. It predicted that only the Bachelor Degree, post graduate research degree, post graduate professional degree and doctorate will be recognised.

# 2. Causality Analysis

Economists were long unaware of the influence of knowledge upon the growth process. With theories of human capital (SCHULTZ, 1961; BECKER, 1962) and theories of endogenous growth (LUCAS, 1988; ROMER, 1990; REBELO, 1991), knowledge gained a central position in the growth process. Education appears in theories of human capital as indispensable for economic growth and in theories of endogenous growth the link between economic growth and human capital is very explicit.

However, this has not been proved in many industrialised countries and various authors such as Benhabib & Spiegel (1993), Jones (1995) or, more recently, Diebolt & Monteils (2000) have weakened the results presented by Lucas and Romer. The nature of the relations between education and growth is therefore far from having been perfectly determined today. The aim here is to clarify the relation by using the notion of causality developed by Granger.
Six variables[4] since 1949 are considered:

- the number of *baccalauréat* holders (BAC),
- spending on higher education (SPEND),
- the number of Bachelor's degree (LICEN),
- population (POP),
- the number of students (STUDENT),
- gross domestic product (GDP)

The results of the causality analysis advises to use a certain type of modelling: VAR (Vector Auto Regressive) model which permits to envisage all causality relationships between two variables without prejudicing the exogeneity of one of them. This involves certain hypotheses. First of all, it is necessary to work with stationary data.

## 2.1. Stationarisation, Cointegration Test and VAR Model

A process Xt is stationary if its first and second order moments are finite. The two sorts of non-stationary processes are Trend Stationary processes (TS) with deterministic non-stationarity and Difference Stationary processes (DS) with stochastic non-stationarity. Processes are stationarised respectively by a divergence from the trend and with first differences. In this case, series are integrated of order 1 [5] and the existence of a cointegration relation is possible.

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4 The data are from two principal sources: INSEE and Works of quantitative history of C. Diebolt.

5 This means the variable is non-stationary in level but stationary after differentiation.

Variables were *stationarised* :

- taking into account a trend for the population,
- with first differences for other series.

For these five variables, there is perhaps a problem of *cointegration.* The two series, Xt and Yt are cointegrated if:

- Xt and Yt are integrated at the same order "d"[6],
- a linear combination of these series gives a new series integrated at a lower order, that is to say: Xt $\rightarrow$ I(d) and Yt $\rightarrow$ I(d), as (a.Xt + b.Yt) $\rightarrow$ I(d-b), $d \geq b \geq 0$. This is noted (Xt, Yt) $\rightarrow$ CI (d, b).

The problem induced by cointegration is the spurious regression due to the linear combination and so all cointegrated relations must first be eliminated.
Moreover, the existence of cointegration between variables implies that the framework within which the causality is examined is modified with a VECM (Vector Error Correcting Model).

The Johansen test is generally used to test cointegration. This test excludes alternative hypotheses concerning the number r of cointegration relations. First, one test of Ho: r = 0 against $H_1$: r >0. If Ho is accepted, the test stops; if not the next stages is H'o r = 1 against r > 1. This process continues along Ho is rejected. If testing Ho: r = k against r >k, and rejecting Ho, this means that the series are not cointegrated.

A VAR (Vector Auto Regressive) model is constructed after verification that there are no cointegrating relationships. This makes it possible on the one hand to analyse the effects of variables simulating random shocks and on the other to perform a causality analysis. A VAR model with k variables and p lags, VAR(p) was written as follows:

$$Y_t = A_0 + A_1 Y_{t-1} + A_2 Y_{t-2} + \ldots + A_p Y_{t-p} + v_t \Leftrightarrow A(D) Y_t = A_0 + v_t$$

where Yt is a vector (k,1) and $v_t$ is a random.
Here, lag p is 4. This lag minimizes Akaike and Schwarz criteria.
The model used is: $Y_t = A_0 + A_1 Y_{t-1} + A_2 Y_{t-2} + A_3 Y_{t-3} + A_4 Y_{t-4} + v_t$ , where :

$$Yt = \begin{bmatrix} BAC_t \\ SPEND_t \\ LICEN_t \\ GDP_t \\ POP_t \\ STUDENT_t \end{bmatrix}$$

## 2.2. Analysis of the Dynamics of the Model

Various tools are used to analyse the dynamics of the model:

- impulse response, measuring the impact of a shock on the variable;
- variance decomposition of the expected error of each variable in relation to a shock. If a shock on the expected error of $Y_t$ does not affect the variance error of $X_t$, $Y_t$ is independent and therefore exogenous).

The *impulse response functions* show that when GDP residuals change significantly (Graph 4), the shock analyses on bachelor's degrees reveal a negative influence in the first year and become very small in the following years. The other variables (*baccalauréat* holders, spending and the number of students) are only affected positively in the second year but population is not. This is only affected positively in the sixth and the seventh years.

For the other variables (*baccalauréat* holders, spending and the number of students), the influence on the number of students becomes negative on the third year and disappears. Impacts on spending and *baccalauréat* holders have the same way during the four first years and are opposed after. The impacts on GDP differ from one variable to another. First, it is affected in the first year only with impacts on population (graph 5) or number of students (graph 6). The effect is the same in both cases. It is positive in the beginning and then becomes negative in the third year and is positive again from the seventh year. Spending influence GDP only on the second year (graph 2); this negative impact goes absorbing during next years. bachelor's degree have a negative influence on the second year too but their impacts become positive and fluctuate. *Baccalauréat* holders do not have a clear influence on GDP (graph 1). It is sometimes positive (years 2 and 4) and sometimes negative (years 3, 5 and following). It is also noted that educational variables, especially *baccalauréat* holders and spending, are very sensitive to shocks upon population (graph 5).

*Variance decomposition* shows that the variance of GDP is to 45% due to its personal impact and to 53% to the bachelor's degree impact. However, the variance of these ones is due at 77 % to their personal impacts and at 14 % to ones of spending. So, a shock on bachelor's degree has more importance on GDP than a shock on GDP has an importance on bachelor's degree. Spending variance is due at 75 % to its personal variations and at 23 % to *baccalauréat* holders shocks. The variance of *baccalauréat* holders only depends on its variations. A shock on spending has more importance on *baccalauréat* holders that these ones have on it and a shock on *baccalauréat* holders has more impact on others variables than these ones have on them. It can also be seen that population is sensitive to shocks on graduates and on GDP and that the number of students is sensitive to impacts on *baccalauréat* holders, GDP and population.

[6] A variable is integrated of order d if it is necessary to differenciate it d times to stationarise it.

## 2.3. Causality Test

Effects on variables can be described using the causality notion developed by Granger (1969). The concentration on causal relationships gives more information about economic phenomena.

Consider the VAR model:

$$\underset{(i*1)}{\left[y_{i,t}\right]} = \underset{(i*1)}{\left[Ao\right]} + \underset{(i*i)}{\left[A_1^i \; B_1^i\right]}\underset{(i*1)}{\left[y_{i,t-1}\right]} + \underset{(i*i)}{\left[A_2^i \; B_2^i\right]}\underset{(i*1)}{\left[y_{i,t-2}\right]} + \ldots + \underset{(i*i)}{\left[A_p^i \; B_p^i\right]}\underset{(i*1)}{\left[y_{i,t-p}\right]} + \underset{(i*1)}{\left[\varepsilon_{i,t}\right]}$$

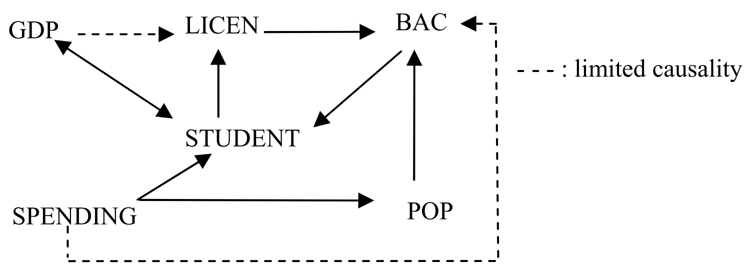
The Granger test is divided into two steps:

- Ho: $y_{2t}$ does not cause $y_{1t}$, that is to say the coefficients of matrix blocks 'B' are zero;
- H'o: $y_{1t}$ does not cause $y_{2t}$, that is to say coefficients of matrix blocks 'A' are zero.

If $H_1$ and $H'_1$ are accepted, there is a feedback effect.
The variable Xt Granger cause Yt if forecasting Yt is improved using information about Xt and its past that is to say if past values of Xt contain information that are not contained in the past of Yt but which significantly improve its forecasting.

A causal relationship is accepted if the calculated statistic (F-statistic) is beyond the tabulated value, that is to say if the value of the first specie risk exceeds the value of the probability for a causal relationship. Using a first specie risk of 10 % the table shows different causality relations, (prob < 0.1) which are in bold black lines. The causality circulation is as follows (Figure 4):

Figure 4: Causality circulation




First, it underscores the central place of the number of students in the economic system. It is therefore directly influenced by GDP, spending and *baccalauréat* holders or indirectly by bachelor's degree and population.

However, the GDP seems to remain isolated from the system and is linked only to the number of students. As the number of students has a central place, all impacts on GDP would be caused through higher education, as for example the influence of the variables Spending or *baccalauréat* holders.

But the more important fact is the feedback effect between GDP and students. As stated by many economists (Lucas, Romer, etc.), the number of students influences the GDP as stated by a lot of economists but it is also influenced. In this case, higher education appears as an essential factor of the economic system; it permits a crisis or an improvement to pass on all socio-economic factors. Higher education therefore appears to be a growth-driven accompanying investment. It is both the cause and the consequence of economic growth.

# Conclusion

The use of original statistics for France makes it possible to show that higher education and GDP are correlated. This gives three important results:

- the movement of GDP is positively linked to the number of bachelor's degrees and negatively to the number of unqualified persons;
- the number of students has a direct influence on GDP and an indirect influence of *baccalauréat* holder and spending devoted to higher education;
- a feedback effect between the number of students and GDP agreeing with the idea whereby education might be a growth-driven accompanying investment .

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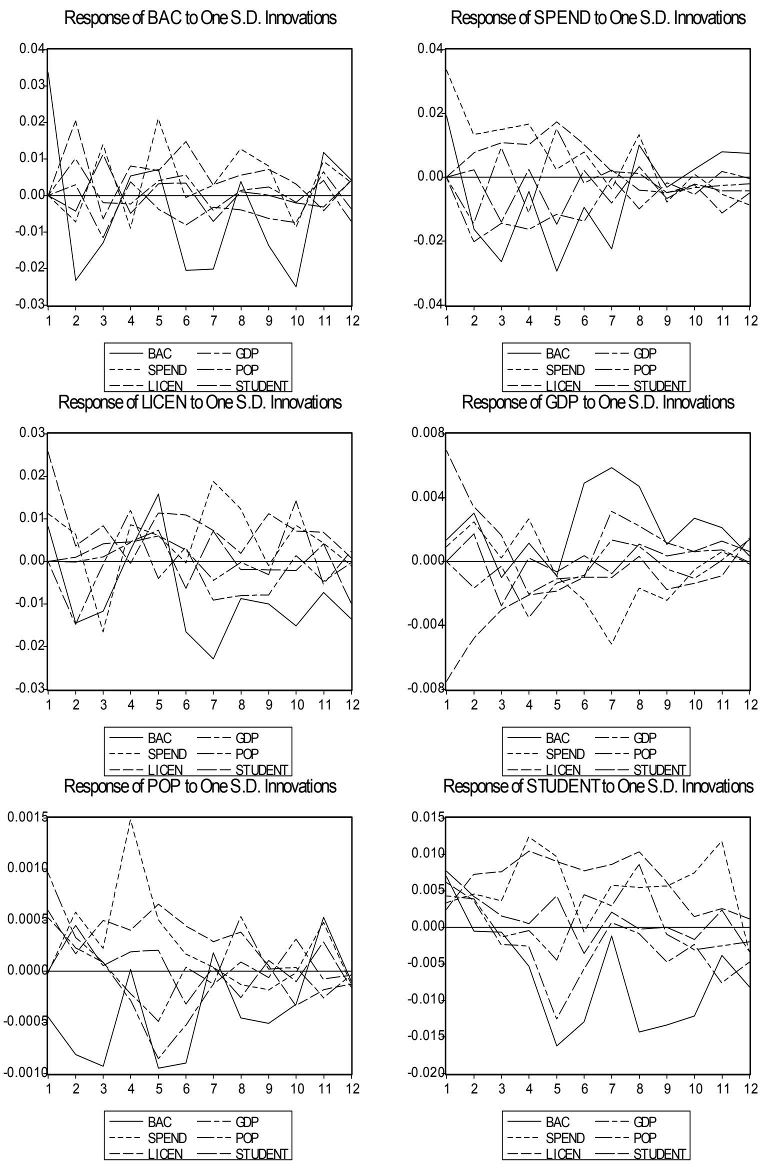
Impulse response functions



Variance decomposition

| Variance Decomposition of BAC: | | | | | | | |
|---|---|---|---|---|---|---|---|
| Period | S.E. | BAC | SPEND | LICEN | GDP | POP | STUDENT |
| 1 | 0.033674 | 100.0000 | 0.000000 | 0.000000 | 0.000000 | 0.000000 | 0.000000 |
| 2 | 0.047683 | 73.58612 | 2.320980 | 18.38028 | 0.381962 | 4.538239 | 0.792417 |
| 3 | 0.054195 | 62.61109 | 8.422181 | 15.62045 | 4.832102 | 3.650516 | 4.863658 |
| 4 | 0.056165 | 59.21411 | 10.38219 | 16.60360 | 4.945077 | 3.573196 | 5.281828 |
| 5 | 0.061118 | 51.35410 | 20.66445 | 15.24989 | 4.548598 | 3.442893 | 4.740069 |
| 6 | 0.066984 | 52.15202 | 17.21094 | 17.58456 | 5.277680 | 3.562624 | 4.212181 |
| 7 | 0.070607 | 55.06087 | 15.65530 | 16.00680 | 4.951999 | 3.532063 | 4.792971 |
| 8 | 0.072179 | 52.97280 | 18.07578 | 15.90099 | 5.026848 | 3.417137 | 4.606444 |
| 9 | 0.074544 | 53.03459 | 18.09118 | 15.81979 | 5.429215 | 3.306470 | 4.318755 |
| 10 | 0.079588 | 56.41783 | 17.06833 | 14.03691 | 5.668787 | 2.955033 | 3.853114 |
| **Variance Decomposition of SPEND:** | | | | | | | |
| **Period** | **S.E.** | **BAC** | **SPEND** | **LICEN** | **GDP** | **POP** | **STUDENT** |
| 1 | 0.038718 | 24.78706 | 75.21294 | 0.000000 | 0.000000 | 0.000000 | 0.000000 |
| 2 | 0.051189 | 24.28933 | 49.74732 | 2.223806 | 15.58901 | 7.944236 | 0.206292 |
| 3 | 0.064402 | 32.16596 | 36.80495 | 4.197869 | 14.87450 | 7.077946 | 4.878770 |
| 4 | 0.070314 | 27.37763 | 36.50961 | 5.611198 | 17.88654 | 8.406601 | 4.208426 |
| 5 | 0.081844 | 33.08298 | 27.04480 | 8.641714 | 15.21264 | 9.660891 | 6.356976 |
| 6 | 0.084561 | 32.22204 | 26.19003 | 9.547787 | 16.91730 | 9.097299 | 6.025542 |
| 7 | 0.087974 | 36.25596 | 24.37045 | 8.860487 | 15.63168 | 8.468282 | 6.413144 |
| 8 | 0.090254 | 35.69726 | 25.33758 | 8.433755 | 16.05505 | 8.245782 | 6.230574 |
| 9 | 0.091162 | 35.10583 | 25.56501 | 8.554407 | 15.77061 | 8.359184 | 6.644965 |
| 10 | 0.091482 | 34.93711 | 25.39734 | 8.560914 | 16.01640 | 8.435384 | 6.652857 |
| **Variance Decomposition of LICEN:** | | | | | | | |
| **Period** | **S.E.** | **BAC** | **SPEND** | **LICEN** | **GDP** | **POP** | **STUDENT** |
| 1 | 0.029235 | 7.815004 | 14.61408 | 77.57092 | 0.000000 | 0.000000 | 0.000000 |
| 2 | 0.036558 | 20.68624 | 12.33280 | 50.60000 | 16.31049 | 0.001332 | 0.069140 |
| 3 | 0.042812 | 22.51027 | 23.78814 | 40.71435 | 11.91779 | 0.060602 | 1.008857 |
| 4 | 0.045824 | 19.99257 | 24.33765 | 35.54890 | 17.21779 | 1.013961 | 1.889125 |
| 5 | 0.051198 | 25.58163 | 20.85214 | 33.41421 | 14.40316 | 2.166786 | 3.582071 |
| 6 | 0.055404 | 30.68771 | 17.81209 | 32.41547 | 12.66186 | 2.077193 | 4.345680 |
| 7 | 0.064421 | 35.31680 | 21.65004 | 25.23587 | 11.34415 | 2.017083 | 4.436065 |
| 8 | 0.066689 | 34.64785 | 23.59798 | 23.62771 | 12.02322 | 1.883305 | 4.219951 |
| 9 | 0.068914 | 34.53900 | 22.12040 | 24.76688 | 12.57428 | 1.965673 | 4.033776 |
| 10 | 0.072857 | 35.21441 | 21.14214 | 23.10263 | 11.28637 | 5.558459 | 3.695994 |

**Variance Decomposition of GDP:**

| Period | S.E. | BAC | SPEND | LICEN | GDP | POP | STUDENT |
|---|---|---|---|---|---|---|---|
| 1 | 0.010360 | 1.708282 | 0.809097 | 52.62511 | 44.85751 | 0.000000 | 0.000000 |
| 2 | 0.012775 | 6.757019 | 4.279351 | 48.73032 | 36.63237 | 1.738672 | 1.862269 |
| 3 | 0.013562 | 6.537992 | 3.824126 | 48.24436 | 33.95477 | 1.584434 | 5.854309 |
| 4 | 0.014599 | 6.253407 | 6.613335 | 43.70220 | 31.24204 | 7.117943 | 5.071069 |
| 5 | 0.014888 | 6.381552 | 6.743437 | 43.56387 | 30.57726 | 7.674371 | 5.059510 |
| 6 | 0.015953 | 15.00061 | 8.211370 | 38.33209 | 27.02060 | 6.974752 | 4.460578 |
| 7 | 0.018128 | 22.08741 | 14.45009 | 29.99276 | 23.89783 | 5.941546 | 3.630362 |
| 8 | 0.018991 | 26.27336 | 13.93770 | 27.35599 | 23.14104 | 5.659062 | 3.632852 |
| 9 | 0.019303 | 25.74030 | 15.08597 | 27.30990 | 22.77145 | 5.543072 | 3.549300 |
| 10 | 0.019596 | 26.88968 | 14.70714 | 26.98663 | 22.19130 | 5.672127 | 3.553120 |

**Variance Decomposition of POP:**

| Period | S.E. | BAC | SPEND | LICEN | GDP | POP | STUDENT |
|---|---|---|---|---|---|---|---|
| 1 | 0.001320 | 11.39560 | 0.012245 | 20.12615 | 15.55350 | 52.91251 | 0.000000 |
| 2 | 0.001769 | 27.56976 | 10.64321 | 12.12610 | 10.33602 | 32.87823 | 6.446668 |
| 3 | 0.002076 | 40.11371 | 8.907381 | 14.49010 | 7.677310 | 24.05659 | 4.754916 |
| 4 | 0.002612 | 25.34668 | 37.68052 | 11.52462 | 6.015764 | 15.89830 | 3.534108 |
| 5 | 0.003070 | 27.90283 | 29.96049 | 12.92434 | 12.14640 | 14.05388 | 3.012065 |
| 6 | 0.003292 | 31.69000 | 26.31594 | 13.04963 | 13.14316 | 12.23708 | 3.564203 |
| 7 | 0.003315 | 31.55115 | 25.96174 | 13.62849 | 13.11239 | 12.21958 | 3.526657 |
| 8 | 0.003424 | 31.36733 | 24.48680 | 14.03086 | 12.36327 | 13.88430 | 3.867436 |
| 9 | 0.003469 | 32.71005 | 24.13840 | 13.69242 | 12.07398 | 13.52842 | 3.856722 |
| 10 | 0.003516 | 32.68888 | 23.49795 | 14.25053 | 12.54477 | 13.17823 | 3.839634 |

**Variance Decomposition of STUDENT:**

| Period | S.E. | BAC | SPEND | LICEN | GDP | POP | STUDENT |
|---|---|---|---|---|---|---|---|
| 1 | 0.013465 | 26.71034 | 6.280528 | 3.466347 | 20.79029 | 10.17285 | 32.57964 |
| 2 | 0.017346 | 16.18062 | 10.73508 | 19.48477 | 16.93702 | 11.19216 | 25.47035 |
| 3 | 0.019545 | 12.86026 | 11.83215 | 30.51433 | 14.80657 | 9.295063 | 20.69163 |
| 4 | 0.026072 | 11.37218 | 29.21609 | 33.19868 | 9.296879 | 5.249575 | 11.66659 |
| 5 | 0.036235 | 25.89153 | 22.22932 | 23.39796 | 16.74469 | 4.260807 | 7.475693 |
| 6 | 0.040063 | 31.58140 | 18.20827 | 22.85179 | 15.72278 | 4.726525 | 6.909236 |
| 7 | 0.041559 | 29.42601 | 18.82569 | 25.55474 | 14.63306 | 4.890960 | 6.669532 |
| 8 | 0.046305 | 33.27022 | 16.53615 | 25.59016 | 11.82099 | 7.407564 | 5.374916 |
| 9 | 0.049157 | 36.90976 | 16.00639 | 24.26763 | 11.43573 | 6.611070 | 4.769417 |
| 10 | 0.051377 | 39.37385 | 16.77603 | 22.29945 | 10.66990 | 6.408071 | 4.472702 |

Granger causality test

| Pairwise Granger Causality Tests<br>Lags: 4 | | | |
|---|---|---|---|
| **Null Hypothesis:** | **Obs** | **F-Statistic** | **Probability** |
| SPEND does not Granger Cause BAC | 33 | 2.18982 | **0.10061** |
| BAC does not Granger Cause SPEND | | 0.86354 | 0.49989 |
| LICEN does not Granger Cause BAC | 33 | 3.22029 | **0.02993** |
| BAC does not Granger Cause LICEN | | 1.63886 | 0.19710 |
| GDP does not Granger Cause BAC | 33 | 1.23108 | 0.32410 |
| BAC does not Granger Cause GDP | | 0.86972 | 0.49638 |
| POP does not Granger Cause BAC | 33 | 2.80380 | **0.04841** |
| BAC does not Granger Cause POP | | 1.36663 | 0.27497 |
| STUDENT does not Granger Cause BAC | 33 | 0.42840 | 0.78665 |
| BAC does not Granger Cause STUDENT | | 3.40757 | **0.02422** |
| LICEN does not Granger Cause SPEND | 33 | 1.31099 | 0.29421 |
| SPEND does not Granger Cause LICEN | | 1.58699 | 0.21004 |
| GDP does not Granger Cause SPEND | 33 | 0.86606 | 0.49846 |
| SPEND does not Granger Cause GDP | | 0.62762 | 0.64744 |
| POP does not Granger Cause SPEND | 33 | 0.12580 | 0.97170 |
| SPEND does not Granger Cause POP | | 5.15625 | **0.00383** |
| STUDENT does not Granger Cause SPEND | 33 | 0.72531 | 0.58330 |
| SPEND does not Granger Cause STUDENT | | 4.72168 | **0.00593** |
| GDP does not Granger Cause LICEN | 33 | 2.16210 | **0.10405** |
| LICEN does not Granger Cause GDP | | 0.42361 | 0.79004 |

| | | | |
|---|---|---|---|
| POP does not Granger Cause LICEN | 33 | 1.53304 | 0.22439 |
| LICEN does not Granger Cause POP | | 0.77939 | 0.54958 |
| STUDENT does not Granger Cause LICEN | 33 | 3.71592 | **0.01719** |
| LICEN does not Granger Cause STUDENT | | 1.91046 | 0.14134 |
| POP does not Granger Cause GDP | 33 | 0.97991 | 0.43703 |
| GDP does not Granger Cause POP | | 0.98747 | 0.43318 |
| STUDENT does not Granger Cause GDP | 33 | 3.45188 | **0.02305** |
| GDP does not Granger Cause STUDENT | | 2.25900 | **0.09255** |
| STUDENT does not Granger Cause POP | 33 | 0.43678 | 0.78072 |
| POP does not Granger Cause STUDENT | | 0.32203 | 0.86040 |