Distributed Lag Models and Economic Growth: Evidence from Cameroon

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Abstract

This paper studies the intertemporal effects of various economic variables on the cameroonian growth. Using a Geometric Lag Model, we find out that 50% of the total effect of variables used is accomplished in less than half of a year. When we employ a Polynomial Distributed Lag, we find out that even if investment has a positive impact on growth in the current year, but in the presence of government expenditures, this effect becomes negative after one year due probably to the *eviction effect*. In addition, we find out that the consumption causes economic growth after three years whereas economic growth causes the consumption after only one year. The main lesson from this study is that any economic policy to sustain economic growth must boost in priority investment and foreign direct investment. The government should pursue policies that stimulate production instead to encourage consumption.

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1   Introduction

The issue of which factors affect economic growth is one of the most important that economists study since several years. As evidenced by the literature estimating growth models, the wide variation in results can be partly attributed to the different theories, samples and econometric methodologies. Initially, the key issue of those studies was to explain the difference in growth performance among economies (divergence/convergence) and later, to identify the determining factors economic growth.

There are two main theories that discuss the determinants of economic growth: the neoclassical growth model[1] of Solow (1956) and Swan (1956) which has emphasised the importance of investment and more recent, the theory of endogenous growth developed by Romer (1986), Lucas (1988) and Mankiw, Romer & Weil (1992)[2]. This theory has drawn attention to human capital and innovation capacity. Furthermore, important contributions on economic growth have been provided by Myrdal (1957) on cumulative causation theory[3], and by Krugman (1991) and Fujita & *alii*. (1999) on the New Economic Geography[4]. In addition, other explanations have highlighted the significant role of non-economic factors on economic performance. These developments gave rise to a discussion that distinguishes between "fundamental" and "proximate" sources of growth. The former refers to the issues such as accumulation of capital, labour and technology while the latter refers to the non-economic factors. This theoritical approach suggests the significant role of institutions (Jutting, 2003), social-cultural factors (Knack-Keefer, 1997), political determinants (Brunetti, 1997), geography (Gallup & *alii*., 1999) and climatic change (Hope, 2005; Stern, 2006).

Applied studies have identified many other determinants of economic growth. Fry (1978, 1980) has proposed that interest rates affect growth through investment, Gupta (1987) found a positive impact of inflation on economic growth but, Lahiri (1988) and Edwards (1995) suggested that this effect depends of the countries used in the sample. Acemoglu & Ventura (2001) found that an increase in the terms of trade may encourage accumulation and growth by increasing price factor. Balasubramanyan & *alii*. (1998) and Borensztein & *alii*. (1998) found that even if the positive correlation between Foreign Direct Investment (FDI) and economic growth is obvious, but in the context of Less Developed Countries (LDC's), this

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[1]The basic assumptions of their model are: constant returns to scale, diminishing marginal productivity of capital, exogenously determined technical progress and substitutability between capital and labour. This model assumes that growth is an inexorable exogenous process.

[2]This theory suggests that the introduction of new accumulation factors, such as knowledge, innovation are a significant source of the self-maintained economic growth.

[3]Essential of this theory is that initial conditions determine economic growth in a self-sustained and incremental way.

[4]The central assumption of this theory is that, economic activity tends to agglomerate in a specific region and choose a location with a large local demand resulting in a self-reinforcing process. The New Economic Geography is mainly concerned by the location of economic activities, agglomeration and specialization rather than economic growth analysis

relation occurs only under certain conditions (pursuing export promotion policies, sufficient human capital threshold). The last most important factor of economic growth can be the flux of trade, also called openness. Frankel & Romer (1999) found that openness, measured as a ratio of export plus import to GDP, has a positive impact on economic growth, but Romalis (2007) suggested that this result depends of the period used[5].

Numerous of empirical studies spawned by growth theory use cross-section regressions (Sala-i-Martin, 1997) or logitudinal analysis (Nerlove, 1996). In the last case, some results have been incured by a dynamic model, specially by including as explanatory variable, the lag of dependant variable -dynamic panel data regressions- (Presbitero, 2006). Another alternative approach of empirical studies of growth uses the times series modelling. This approach has been developed by Quah (1992) and Bernard & Durlauf (1995). Most of these studies assess the relationship between growth and its determinants only in the long-run process but none of them uses the distributed lag model. However, economic theory suggests that the effects of independent variables on dependent variables have a "dynamic" component. In concrete terms, these effects occur neither instantaneously nor solely in the long term but are spread, or *distributed,* over time.

The main contribution of this paper is to highlight the intertemporal effects of some determinants of Cameroon's economic growth because we have observed an erratic evolution of growth rate (figure 1). Pursuing this goal, our paper is organized as follows: in section 2, we present the econometric models. Section 3 describes the data used, section 4 presents and discusses the empirical results. Finally, in section 5, we conclude.

2   Econometric Models

Assess the intertemporal effects of the explanatory variables on dependant variable must be done by using Dynamic Models. These models can be divided into three categories:

a)- models lagging both independent and dependent variables[6] ,

b)- models lagging only dependent variable[7] and

c)- models lagging only independent variables[8] .

In this study, we will use only the last one called Distributed Lag Models (DLM). As we described above, there are three types of DLM: Geometric Dis-

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[5]Futhermore, Tsangarides (2005) and Presbitero (2006) found a negative link between debt (external debt) and growth.

[6]It's the case of Error Correction Models.

[7]For exemple, Partial Adjustment Models.

[8]Case of Geometric Distributed Lag Models (without koyck transformation), Arithmetic Distributed Lag Models and Almon Distributed Lag Models (or Polynomial Distributed Lag Models).

tributed Lag, Arithmetic Distributed Lag and Polynomial (Almon) Distributed Lag Models.

2.1 Arithmetic Distributed Lag Models

Algebraically, we can represent this lag effect by saying that economic outcome y_t is affected by the values of a change in a variable x not only at time t but also at time $t-1$, $t-2$, $t-3$ and so on. Then, we can write:

$$y_t = F(x_t, x_{t-1}, x_{t-2}, ...) \qquad (1)$$

Models like (1) describe the evolving economy and its reaction over time. The considered period depends of the length of the lag. In fact, we have infinitive distributed lag models and finitive distributed lag models. The inifitive distributed lag models represented in equation (1) portrays the effects as lasting, essentially, forever. In the finitive distributed lag model, represented in equation (2), we assume that the effect of variable x_t affects economic outcomes y_t only for a certain fixed period of time.

$$y_t = F(x_t, x_{t-1}, x_{t-2}, ...x_{t-L}) \qquad (2)$$

The general form of a distributed lag model can be written as follows:

$$y_t = \alpha + \text{V(B)}x_t + \epsilon_t \qquad (3)$$
$$\text{with} \quad \text{V(B)} = v_0 + v_1\text{B}^1 + v_2\text{B}^2 + ... + v_L\text{B}^L \qquad (4)$$

B is the lag operator.
Equation (3) can also be written as follows:

$$y_t = \alpha + \sum_{l=0}^{L} v_l x_{t-l} + \epsilon_t \qquad (5)$$

where α is the intercept, v_l is a parameter called a *distributed lag weight,* it measures the effect of x_{t-l} on y_t, all other things held constant. It's also called short run multiplier when one period is considered. ϵ_t is an uncorrelated error variable. We assume that $E(\epsilon_t) = 0$, $var(\epsilon_t) = \sigma^2$ and $cov(\epsilon_t\epsilon_s) = 0$. The main assumption of arithmetic distributed lag models is that the coefficients are supposed to decline arithmetically (on a straight line).

Equation (5) can be estimated by Ordinary Least Squares (OLS) if the error term has usual desirable properties. However, collinearity is often a serious problem in such models. For reducing the effects of collinearity, the Polynomial Distributed Lag Models (PDLM) imposes a shape on lag distribution.

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2.2 Polynomial Distributed Lag Models (PDLM)

The Polynomial Distributed Lag model also called Almon distributed lag model is a Lth-order distributed lag model with the following form:

$$y_t = \alpha + v_0 x_t + v_1 x_{t-1} + v_2 x_{t-2} + v_3 x_{t-3} + ... + v_L x_{t-L} + \epsilon_t \quad (6)$$

where the impulse–response function is constrained to lie on a polynomial of degree p. Requiring the impulse–response function to lie on a polynomial imposes $L - p$ constraints on the structural parameters of the model. Following Fomby & *alii*.(1984), it is possible to determine the form of the constraints. The first one concerns the effect of changes in x_{t-l} on expected $y_t - E(y_t) -$ is:

$$\frac{\partial E(y_t)}{\partial x_{t-l}} = v_l = \gamma_0 + \gamma_1 l + \gamma_2 l^2 + \gamma_3 l^3 + ... + \gamma_p l^p \quad \text{with } l = 0, ..., L \quad (7)$$

The futher constraint in considering equation (7) is:

$$p < L \quad (8)$$

Substituting the constraints (equation 7) into the finite-order distributed lag model (equation 6) yields a reduced form representation:

$$y_t = \alpha + \sum_{l=0}^{L} (\gamma_0 + \gamma_1 l + \gamma_2 l^2 + \gamma_3 l^3 + ... + \gamma_p l^p) x_{t-l} + \epsilon_t \quad (9)$$

Consistent and efficient estimates of the structural parameters, subject to the L- p constraints, can be obtained via Constrained Ordinary Least Squares (COLS). But according to Gujarati (2003), it is also possible to get consistent and efficient estimates by using OLS if the reduced form of equation (9) is used. To obtain this reduced form, we transform equation (9) as follows:

$$y_t = \alpha + \gamma_0 T_{0,t} + \gamma_1 T_{1,t} + \gamma_2 T_{2,t} + \gamma_3 T_{3,t} + ... + \gamma_p T_{p,t} + \epsilon_t \quad (10)$$

where

$$T_{0,t} = \sum_{l=0}^{L} x_{t-l}$$
$$T_{1,t} = \sum_{l=0}^{L} l x_{t-l}$$
$$T_{2,t} = \sum_{l=0}^{L} l^2 x_{t-l}$$
$$T_{3,t} = \sum_{l=0}^{L} l^3 x_{t-l} \quad (11)$$
$$..$$
$$..$$
$$T_{p,t} = \sum_{l=0}^{L} l^p x_{t-l}$$

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One of the important functional assumption of the PDLM is that the immediate impact might well be less than the impact after several years, quarters, or months. After reaching its maximum, the policy effect diminishes for the remainder of the finite lag. The main advantages of this model are flexibility and reduction of the multicollinearity issue. We also note that imposing restrictions on parameters leads to bias unless the restrictions are true. This type of restrictions also exists in the geometric distributed lag models.

2.3   Geometric Distributed Lag Models (GDLM)

The idea of this type of model was first introduced by Koyck (1954). This model is an infinite distributed lag model. In constrat to the equation (6), the general form of the infinite distributed lag models is:

$$y_t = \alpha + v_0 x_t + v_1 x_{t-1} + v_2 x_{t-2} + v_3 x_{t-3} + ... + \epsilon_t \qquad (12)$$

In that model, y_t is taken to be a function of x_t and all its previous values. Koyck (1954) assumes that all the coefficients $(v_0, v_1, v_2, v_3, ..., v_L)$ have the same signe and decline geometrically. That is

$$v_l = v_0 \lambda^l ; \quad |\lambda| < 1 \qquad (13)$$

λ is the rate of decay while $1 - \lambda$ represents the speed of adjustment. This model supposes that the most recent past weights are more heavily than the most distant past. By substituting equation (13) into equation (12), we obtain:

$$\begin{aligned} y_t &= \alpha + v_0 x_t + v_0 \lambda^1 x_{t-1} + v_0 \lambda^2 x_{t-2} + v_0 \lambda^3 x_{t-3} + ... + \epsilon_t & (14) \\ &= \alpha + v_0 (x_t + \lambda x_{t-1} + \lambda^2 x_{t-2} + \lambda^3 x_{t-3} + ...) + \epsilon_t & (15) \end{aligned}$$

This model has three parameters, $\alpha-$an intercept, v_0-a scale factor and $\lambda-$ which controls the rate at which the weight's explanatory variables declines.

Koyck transformation converts equation (15) to an autoregressive model. In concrete terms, Koyck multiplies the one period lag of equation (15) by λ, and substracts that result from the same equation (15) as follows:

$$y_t - \lambda y_{t-1} = \begin{bmatrix} [\alpha + v_0 (x_t + \lambda x_{t-1} + \lambda^2 x_{t-2} + \lambda^3 x_{t-3} + ..) \\ + \epsilon_t] - \lambda [\alpha + v_0 (x_{t-1} + \lambda x_{t-2} + \lambda^2 x_{t-3} \\ + \lambda^3 x_{t-4} + ..) + \epsilon_{t-1}] \end{bmatrix} \qquad (16)$$

After rearrangement, we obtain

$$y_t - \lambda y_{t-1} = \alpha(1 - \lambda) + v_0 x_t + (\epsilon_t - \lambda \epsilon_{t-1}) \qquad (17)$$

To solve y_t, we obtain the Koyck form of the geometric lag;

$$y_t = \alpha(1 - \lambda) + \lambda y_{t-1} + v_0 x_t + v_t \quad \text{where} \quad v_t = (\epsilon_t - \lambda \epsilon_{t-1}) \qquad (18)$$

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The *long-run mutiplier* is:

$$v_0(1 + \lambda + \lambda^2 + \lambda^3 + ...) = \frac{v_0}{1 - \lambda} \tag{19}$$

The combined effect before the end of considered period is called *interim multiplier*. For exemple $v_0\lambda + v_0\lambda^2 + v_0\lambda^3$. As we can observe, this model has two features: the first is that one of the explanatory variables is the *lagged dependent variable*, y_{t-1}. The second is that the error term v_t depends on e_t and on e_{t-1}. Consequently, y_{t-1} and the error term might be *correlated*[9], since equation (17) shows that y_{t-1} depends directly on e_{t-1}.

Despite the solving of the multicollinearity issue or the estimation of a few parameters, this model is very restrictive. Nevertheless, in this study, we will use

Almon and Koyck models

3 Empirical Pattern and Data analysis

3.1 Empirical Strategy

The theoritical models described in section 1 give us some tools to explain

why some countries growth faster than others. By indentifing the determining factors economic growth, the empirical literature showed that the direction but also the level of impact of those determinants depend on the considered sample. For our general pattern, we can write that the output (y_t) is function of its deteminants (x_t)−*vector of explanatory variables*-.plus a random term (ϵ_t).

$$y_t = \Gamma(x_t) + \epsilon_t \tag{20}$$

Due to the fact that our purpose is to estimate the spread (year after year) of the economic policy's variables on economic growth, we will take into account mainly, the variables used in the equation of goods and services market equilibrium. These variables are Consumption, Investment, Goverment expenditures, Exports, Imports and Gross Domestic Product. We will add merely two control variables: Foreign Direct Investment and Inflation. We decided to build our model with inflation and FDI because these two variables can affect economic growth in the short run[10]. Levine and Renelt (1992) list over 50 possibilities amont the range of controls appeared in the empirical literature. Following equation (3), our

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[9]We will discuss more about it in the fourth section (how to detect this serial corelation and how to solve it).

[10]This paper consciously avoids an evaluation of political factors and education because we wanted to concentrate our analysis only on the variables of economic policy.

empirical pattern can be written as follows:

$$\Delta \ln gdpr_t = \begin{bmatrix} \alpha + \sum_{l=0}^{L} v_{1,l} \ln cpi_{t-l} + \sum_{l=0}^{L} v_{2,l} \ln invest_{t-l} \\ + \sum_{l=0}^{L} v_{3,l} \ln gov_{t-l} + \sum_{l=0}^{L} v_{3,l} \ln trbal_{t-l} \\ + \sum_{l=0}^{L} v_{4,l} \ln fdi_{t-l} + \sum_{l=0}^{L} v_{5,l} \ln cons_{t-l} + \epsilon_t \end{bmatrix} \qquad (21)$$

where $gdpr_t$ is the real GDP (dollar of 2000). cpi is the consumption price index, $invest$ is the investment, gov is the government expeditures, $trbal$ is the trade balance, fdi is the foreign direct investment. The last variable is $cons$ which represents the consumption. ϵ_t is the random disturbance term which is assumed to follow the standard assumptions of classical linear regression model. α is the intercept.

In fact, the specification used depends of the structure of distributed lag. In the case of polynomial distributed lag (PDL), the specification used is the same as equation (21) but with equation (7) as a constraint. As we said above, the PDL is a finite distributed lag model, for that, we must determine the maximum length of lag (L). To solve this issue, we use Akaike Information Criterion (AIC) to assess the goodness of fit for lag lengths. In accordance with this criterion, we found 2 as a maximum length of lag[11]. To respect the constraint which suggests that the degree of polynomial must be lesser than the number of lag (equation 7), we choose 1. Equation (7) can be rewritten as follows:

$$v_l = \gamma_0 + \gamma_1 l$$

$$\text{with } l = 0, ..., 2 \qquad (22)$$

Finally, the empirical equation used in the case of PDL is as follows:

$$\Delta \ln gdpr_t = \begin{bmatrix} \alpha + \sum_{l=0}^{2} (\gamma_0 + \gamma_1 l\,) \ln cpi_{t-l} + \sum_{l=0}^{2} (\gamma_0 + \gamma_1 l\,) \ln invest_{t-l} \\ + \sum_{l=0}^{L} (\gamma_0 + \gamma_1 l\,) \ln gov_{t-l} + \sum_{l=0}^{2} (\gamma_0 + \gamma_1 l\,) \ln trbal_{t-l} \\ + \sum_{l=0}^{2} (\gamma_0 + \gamma_1 l) \ln fdi_{t-l} + \sum_{l=0}^{2} (\gamma_0 + \gamma_1 l) \ln cons_{t-l} + \epsilon_t \end{bmatrix}$$

$$(23)$$

According to the econometric theory, consistent and efficient estimates of the structural parameters of equation (23) can be obtained with COLS-(McDowell, 2004). An alternative approach to obtain consistent estimators of PDL is to apply first, OLS in equation (24) which is the reduced form of equation (23). After that, it's possible to compute the estimated Almon distributed lag weights (coefficients,

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[11]We follow the sequential testing procedure proposed by Alt (1942).

standard errors, statistics tests and significance level) by using the *delta method* (Appendix B).

$$\Delta \ln gdpr_t = \alpha + \gamma_0 T_{0,t} + \gamma_1 T_{1,t} + \epsilon_t \tag{24}$$

where

$$T_{0,t} = \begin{bmatrix} \sum_{l=0}^{2} \ln cpi_{t-l} + \sum_{l=0}^{2} \ln invest_{t-l} + \sum_{l=0}^{2} \ln gov_{t-l} \\ + \sum_{l=0}^{2} \ln trbal_{t-l} + \sum_{l=0}^{2} \ln fdi_{t-l} + \sum_{l=0}^{2} \ln cons_{t-l} \end{bmatrix}$$

$$T_{1,t} = \begin{bmatrix} \sum_{l=1}^{2} l\left(\ln cpi_{t-l}\right) + \sum_{l=1}^{2} l\left(\ln invest_{t-l}\right) + \sum_{l=1}^{2} l\left(\ln gov_{t-l}\right) \\ + \sum_{l=1}^{2} l\left(\ln trbal_{t-l}\right) + \sum_{l=1}^{2} l\left(\ln fdi_{t-l}\right) + \sum_{l=1}^{2} l\left(\ln cons_{t-l}\right) \end{bmatrix} \tag{25}$$

If the lags are geometrically distributed, the specification presented below sterns from Koyck transfomation:[12]

$$\Delta \ln gdpr_t = \alpha(1 - \lambda) + \lambda \ln gdpr_{t-1} + v_0 \ln x_t + v_t \tag{26}$$

The empirical pattern of Koyck model is:

$$\Delta \ln gdpr_t = \begin{bmatrix} \alpha(1 - \lambda) + \lambda \ln gdpr_{t-1} + v_{1,0} \ln cpi_t \\ + v_{2,0} \ln invest_t + v_{3,0} \ln gov_t + v_{4,0} \ln trbal_t \\ + v_{5,0} \ln fdi_t + v_{6,0} \ln cons_t + v_t \end{bmatrix} \tag{27}$$

v_0 is a scale factor, $\lambda-$ which controls the rate at which the weight declines, $1 - \lambda$ is the speed of adjustment. $v_t = (\epsilon_t - \lambda \epsilon_{t-1})$, it is the error term.

3.2 Data analysis

As we described above, all the variables are expressed in logarithm and are divided by the GDP except cpi (consumption price index). Due to the presence of negative values in trade balance and foreign direct investment (FDI), they have been transformed before using the logarithm function. The equation used is $x_t^{Tr} = x_t + \mid k \mid +1$ with $k = \min x_t$ if $x_t \in [0, -\infty]$. x_t is the original variable, x_t^{Tr} is the new variable. Figures 1 and 2 show that the sequences of the change of FDI and trade balance are not modified. The consumption price index in base 2000 has been computed by using *retropolation method*[13] from the data of World Developpement Indicators. The data of the rest of variables also come from World Development Indicators for the period from 1960 to 2007.

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[12]We will dwell upon the methods of estimation used in the next section.

[13]For more details, see Gómez V. & Maravall A. (1994).

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4   Results and Discussion

Before running our regressions, we analyze first the correlation between all the variables. The correlation matrix presented in appendix A shows the significant and high correlation between government expenditures and consumption (0,91). This result suggests that, if we run a regression with these two variables, estimators obtained will have a bias.

Another problem which arises in any economic time series analysis concerns the non-stationarity of the variables. Many empirical studies have found that key macroeconomic variables such as GDP, inflation are often non stationary. Regressions involving non-stationary variables may result in spurious results. Szeto (2001) notes that there are three solutions to the problem of spurious regression. The first approach is to determine the stationarity of the variables before estimating. The second approach is to add the lagged value of the dependent variable. The last method is to consider the cointegration approach. We employ the first two approaches in this paper. Thus, in the case of Koyck model (3.1), we don't need to determine the stationarity of the variables, but before using the polynomial distributed lag model, we ran the unit root tests of the variables. This has been done using the Augmented Dickey-Fuller tests (ADF), for that, we used the strategy of Dickey & Pantula (1987). We found out that: consumption, inflation and government expenditures are I(1) while investment, FDI, trade balance and growth rate are I(0). Moreover, Gujarati (2005) showed that the hypothesis of cointegrated variables is not crucial in the case of distributed lag models. The details of the unit root tests are presented in appendix C.

4.1   Estimates based on the Koyck transformation

The obtained results from running Koyck model are displayed in Table 1. We have ran two regressions, in the first one (Model 1), we include consumption, in the second one (Model 2), we take off this variable and we include government expenditures. Due to the presence of lagged dependent variable such as explanatory variables, we have performed the *Durbin h-test* to analyze the serial correlation of the error term. The null hypothesis of no autocorrelation have been rejected in the two models suggesting that OLS can be used. We have also performed the *Cook-Weisberg test*, we found out that the null hypothesis of constant variance of disturbances have been accepted in Model 1 but rejected in Model 2; this latter has been regressed by using OLS with robust variance estimates.

The first lesson from Table 1 is that the rate of decay is very small suggesting a high speed of adjustment of the effects of explanatory variables on economic growth[14]. This result shows that the effects of the determinants of economic growth disappear quickly. The computation of Median Lag[15] shows that 50 % of the total effect of explanatory variables is accomplished in less than half of a year. For

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[14]The average rate of decay is 0.065 point.

[15]Median Lag (Med Lag)$=-\frac{\log 2}{\log \lambda}$

example, concerning the variable of investment, more than 90% of the total effect of this variable disappears after the current year. In this way, the potential growth becomes certainly weak.

The second lesson from Table 1 is that all the significant variables have the same sign in the two models except Balance of Trade. This variable is positive in the presence of government expeditures but negative when we considered consumption. With this result, we can assume that in the presence of consumption, trade balance bears negatively upon economic growth, the magnitude of total effect is -0.62 %[16]. The Model 1 of Table 1 also shows that the consumption as a self-powered variable doesn't have a significant impact on economic growth[17]. This latter result contributes probably to the weakness of growth effect of the previous period (lagged independent variable). This effect is about 9 % in the model with government expenditures, but when we take into account consumption, this effect is shortned to 3.5%. The two models of Table 1 show that investment and consumption price index have a positive impact on economic growth, the total effect (in average) of price index on growth rate is 5.8%, whereas the average total effect of investment is 12.4%. In Model 2, we observe that the effect of government expenditures is significant and negatively correlated with economic growth. This effect is high since an increase of 1% of the ratio of government expenditures to GDP runs down growth rate about 19.4%. In the short run analysis, we observe that an increase of 1% of the ratio of government expenditures to GDP decreases the current annual growth rate about 17.6 % . This result could lead one to conclude that the orientation of cameroonian government expenditures is not enough efficient[18]. Table 1 also shows that Foreign Direct Investment (FDI) is not significant despite that its sign is always positive.

In spite of the help of Koyck model to capture the received effect of economic growth from the previous year, this model remains restrictive because it imposes that the lagged effects of explanatory variables must have the same sign as the current effect, and they must be geometrically damped as lags increase. That's why, we will present in the next sub section the results obtained by using a Polynomial Distributed Lag Model which has more flexible assumptions.

4.2 Estimates using an Almon lag structure

Table 2 summarises the results of Almon polynomial coefficients from running equation (10). Table 3 gives the results of Almon first order distributed lag obtained by applying the *delta method* on the estimators of equation (10). We run two regressions, the first one takes into account consumption, in the second one we take it off and we use government expenditures. As we said above, the com-

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[16]we found this result by using equation (19): $v_0\left(\frac{1}{1-\lambda^l}\right)$.

[17]We are a little bit flabbergasted by this result, that's why we will discuss more about it later.

[18]Barro (1989, 1990) and Kormendi & Meguire (1985) showed that the public expenditures could have a positive impact on economic growth, but this effect depends of their direction (infrastructures, education, public health).

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bination of lag lengths which gave the minimum value of the Akaike Information Criterion (AIC) was chosen as the preferred model[19]. We have performed the *Park-test*, as observed in the Koyck model, the null hypothesis of constant variance of disturbances have been accepted in Model 1 but rejected in Model 2; this latter is regressed by using OLS with robust variance estimates.

The results presented in Table 3 show that the investment variable has a positive and significant impact on economic growth only in the short run. But after one year, this effect becomes no significant in the first model, but changes the sign bluntly in the second model . This result strengthens the analysis we have done above with the Koyck model showing that the total effect (long run multiplier) of investment disappears quickly. The fact that negative effect of investment comes faster in the presence of government expenditures (Model 2) is probably due to the presence of the *eviction effect*.

The price evolution seems to have a positive effect on economic growth in the current year, but after one year, this effect changes the sign and becomes negative. This result reflects the response function of cameroonian economy. It suggests that an increase of consumption price index will have a negative and significant impact on economic growth two years later (*hysteresis effect*). The Model 2 from Table 3 also shows that the effect of the ratio of government expenditures to GDP on economic growth is negative and significant after one year; its current effect is positive but not significant. This result shows that government expenditures could have a positive impact on economic growth. However, its interim effect after two years remains negative and equals to -2.1 %[20].

Table 3 shows that the ratio of Foreign Direct Investment (FDI) to GDP affects positively and significantly economic growth whatever the model used. But in Model 1, this effect is significant only for the current period while it's significant for all the periods in Model 2. We can observe that FDI is the only variable in our model which doesn't change the sign over the years, this result suggests that this variable could be an important channel to sustain cameroonian economic growth. About trade balance, Table 3 shows that this variable affects negatively economic growth; we also observed that this negative effect comes faster in the presence of consumption. That's why we decided to analyze how the consumption could affect trade balance, thus we ran a simultaneous equation. The first equation analyzes the impact of consumption on import which is one of the component of trade balance, the second equation analyzes the impact of imports on growth[21]. By using three-stage least squares, we found out that more than half of the increase of consumption is heading toward imports[22]. In concrete terms, if the consumption increases by 1%, imports will increase by 0.58% (Table 4). This result leads one to conclude that any policy to increase demand reinforces the shortage of trade balance.

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[19]Whatever the considered model, the maximum of lag lenghts doesn't change.

[20]$\sum v_l = v$ represents the interim effect. $v = 0.006 + (-0.007) + (-0.02) = -0.021$

[21]Due to the constraint of identification of system of equations, we have used only one explanatory variable as Wacziarg & Welch (2008).

[22]The second equation is not significant.

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Moreover, Table 3 shows that the effect of consumption is still non significant even if the sign becomes postive after two years. To explain this result, we computed the contribution of consumption in the growth year per year. The results presented in figure 8 show indeed that during many years, while the evolution of economic growth is positive, the contribution of consumption in the growth[23] decreases; we can observe this phenomenon in 1976, 1978, 1980 or in 2004. This result doesn't mean that consumption affects negatively growth, but rather that consumption affects growth with a lag. The figure 9 which displays the growth of consumption and economic growth shows that the sequences of the evolution of consumption growth are the same as the evolution of economic growth but with a lag. To assess econometrically the causal relationship between these two variables (consumption and growth), we performed the Granger causality test[24] which the results are displayed in Table 5.

According to this test, the consumption Granger-causes economic growth after three years but economic growth Granger-causes consumption after one year. We observe that in the couple economic growth-consumption, growth affects consumption first. We could conclude that in the case of Cameroon, consumption follows economic growth.

5   Conclusion

This paper examined how the effects of various variables of economic policy spread on cameroonian growth over the years. With a geometric lag structure, we found out that the speed of adjustment was very high showing that the propagation of the variables' effects of our model disappears quickly; this harms the long-run growth. Thus, we have assessed that 50% of the total effect of all the explanatory variables (investment, index of price, foreign direct investment, consumption, government expenditures and balance of trade) is accomplished in less than half of a year.

What ever the model used, we found that investment and foreign direct investment (FDI) had a positive impact on economic growth. The effect of FDI is seemed significant only with polynomial distributed lag model. We also found out that in the presence of governement expenditures, the effect of investment on growth is appeared negative after one year due probably to the existence of *eviction effect*. In addition, our estimations showed us that the couple inflation-growth is indecisive. However, we saw that the impact of inflation on economic growth was generally positive in the current period, but it became negative in the following years. This result can be explained by the concept of *backward-loocking rule* used by Cagan (1956) concerning the analysis of adaptative expectations models.

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[23]The formula used is:
$\left[\frac{\Delta cons_t}{gdp_{t-1}} \right] * 100$. See the following link www.insee.fr
[24]The method used for this test has been used by Thurman & Fisher (1988).

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The suprise result is certainly the non-significant impact of consumption on economic growth after two years, but we found out that this result was probably due to the fact that consumption Granger-causes growth after three years whereas growth Granger-causes consumption after one year.

The main conclusion of this paper is that any economic policy to sustain economic growth must boost in priority investment and foreign direct investment. Cameroon should pursue policies that stimulate production instead to encourage consumption.

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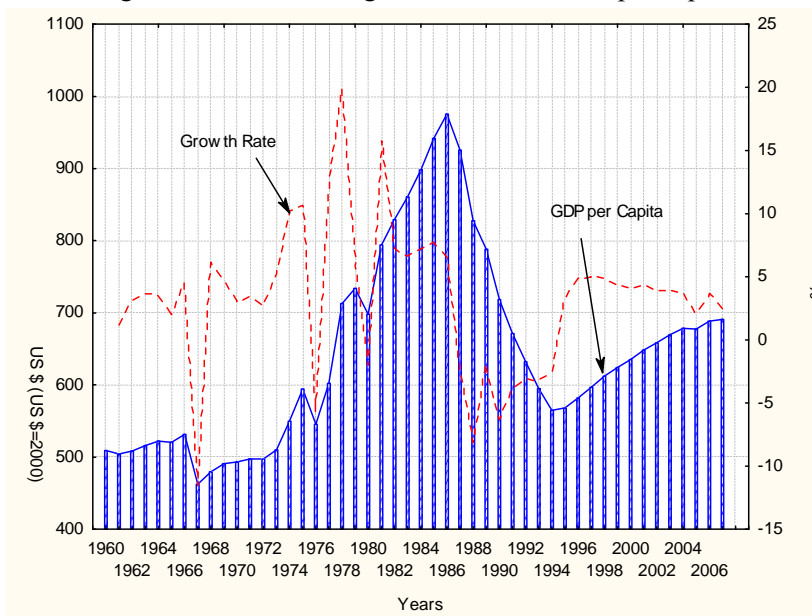Figure 1: Evolution of growth rate and GDP per capita

Table 1: Results from the estimations based on the Koyck Transformation

Variables[a]	Model 1		Model 2	
	Estimates	Std.Error	Estimates	Std.Error
Intercept	-0.194*	0.096	-0.220**	0.092
lncpi$_0$	0.056**	0.020	0.053***	0.012
lncpi: Total effect[b]	0.058**	0.021	0.059***	0.013
lninvest$_0$	0.049*	0.027	0.179***	0.022
lninvest: Total effect	0.051*	0.028	0.198***	0.024
lngov$_0$			-0.176***	0.025
lngov:Total effect			-0.194***	0.0281
lncons$_0$	-0.218	0.43		
lncons: Total effect	-0.226	0.45		
lntrbal$_0$	-0.006***	0.002	0.022***	0.007
lntrbal: Total effect	-0.006***	0.002	0.0249***	0.008
lnfdi$_0$	0.003	0.002	0.002	0.001
lnfdi: Total effect	0.003	0.002	0.002	0.001
$\Delta \ln gdpr_{(-1)}$	0.035*	0.035	0.095*	0.021
Adj.-R^2	0.58			
Prob>F			0.000	
N.obs.	33		32.	
$Durbin\ h\text{-}test$: ($Prob$>F)	0.153		0.752	
$Cook - Weisberg\ test$ ($Prob$>F)	0.153		0.003	

Note: * significant at 10%; ** significant at 5%; *** significant at 1%

a)- Except *cpi* , the other variables are divided by GDP

b)- Estimates and significance levels for lagged variables have been
calculated by using *the delta method*.

Table 2: Estimated (Almon) Polynomial Coefficients

	Model 1		Model 2	
	Estimates	Std.Error	Estimates	Std.Error
Variables[a]				
Intercept	0.055	0.154	1.035	0.156
$Tln\text{cpi}_0$	0.139	0.138	0.183***	0.031
$Tln\text{cpi}_1$	-0.130	0.130	-0.184***	0.030
$Tln\text{invest}_0$	0.075**	0.036	0.018*	0.009
$Tln\text{invest}_1$	-0.064**	0.026	-0.033***	0.006
$Tln\text{gov}_0$			0.006	0.009
$Tln\text{gov}_1$			-0.013	0.007
$Tln\text{con}_0$	-0.184	0.051		
$Tln\text{con}_1$	0.146	0.044		
$Tln\text{trbal}_0$	-0.005***	0.001	-0.001	0.0008
$Tln\text{trbal}_1$	0.003***	0.001	0.0006	0.0005
$Tln\text{fdi}_0$	0.003*	0.001	0.003***	0.0004
$Tln\text{fdi}_1$	-0.001	0.001	0.0005*	0.0002
Adj.-R^2	0.69			
$Pr\,ob{>}F$			0.000	
N.obs.	31		30	
$Park-test : (\,\text{Prob}{>}F)^b$	0.49		0.04	

Note: * significant at 10%; ** significant at 5%; *** significant at 1%

a)- Except *cpi*, the other variables are divided by GDP

b)- This test has been used to test heteroskedasticity.

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Table 3: Results from the Regressions using Almon first order distributed lags

Variables[a]	Model 1		Model 2	
	Estimates	Std.Error	Estimates	Std.Error
Intercept	-0.055	0.154	-0.060	0.043
$ln\text{cpi}_0$	0.139	0.138	0.183***	0.031
$ln\text{cpi}_{(-1)}^{b}$	0.008	0.011	-0.001	0.002
$ln\text{cpi}_{(-2)}$	-0.122	0.122	-0.185***	-0.185
$ln\text{invest}_0$	0.075*	0.032	0.018*	0.009
$ln\text{invest}_{(-1)}$	0.010	0.018	-0.014***	0.004
$ln\text{invest}_{(-2)}$	-0.053*	0.027	-0.048***	0.006
$ln\text{gov}_0$			0.006	0.009
$ln\text{gov}_{(-1)}$			-0.007**	0.003
$ln\text{gov}_{(-2)}$			-0.02**	0.007
$ln\text{con}_0$	-0.184	0.051		
$ln\text{con}_{(-1)}$	-0.037	0.017		
$ln\text{con}_{(-2)}$	0.108	0.043		
$ln\text{trbal}_0$	-0.005***	0.006	-0.001	0.0008
$ln\text{trbal}_{(-1)}$	-0.001	0.001	-0.0008*	0.0004
$ln\text{trbal}_{(-2)}$	0.002	0.283	-0.0002	0.0002
$ln\text{fdi}_0$	0.003*	0.001	0.003***	0.0004
$ln\text{fdi}_{(-1)}$	0.001	0.001	0.002***	0.0003
$ln\text{fdi}_{(-2)}$	0.0006	0.001	0.002***	0.0005
Adj.-R^2	0.69			
$Pr\,ob{>}F$			0.000	

Note: * significant at 10%; ** significant at 5%; *** significant at 1%

a)- Except *cpi* , the other variables are divided by GDP

b)- Estimates and significance levels for lagged variables have been calculated by using the *delta method*.

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Table 4: Results of Simultaneous equation of Imports and consumption

Variables[a]	Equation 1		Equation 2	
	lnimp		$\Delta \ln gdpr$	
	Estimates	Std.Error	Estimates	Std.Error
Intercept	7.757***	0.855	0.309	0.352
$\ln cons$	0.588***	0.038		
lnimp			-0.013	0.016
$\Pr ob$>F	0.000		0.432	
Adj.-R^2	0.84		-0.016	
N.obs.	42		42	

Note: * significant at 10%; ** significant at 5%; *** significant at 1%

a)- We use three-stage least squares

Figure 2: Compared evolution of original and Transformed values' FDI
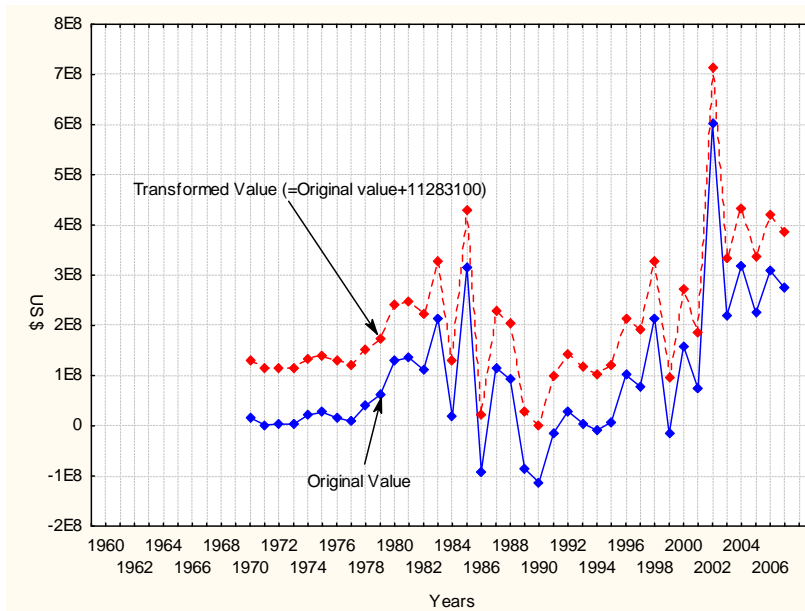
Figure 3: Compared evolution of original and Transformed values' Trade Balance
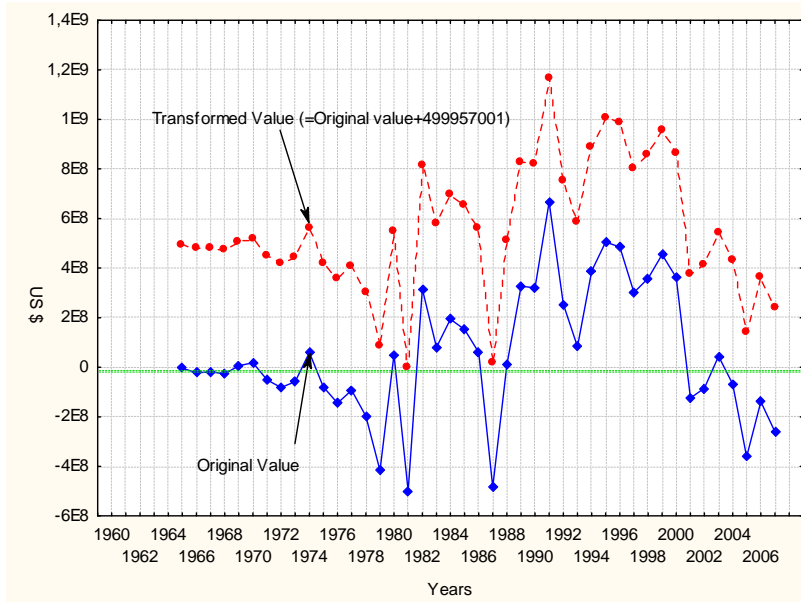

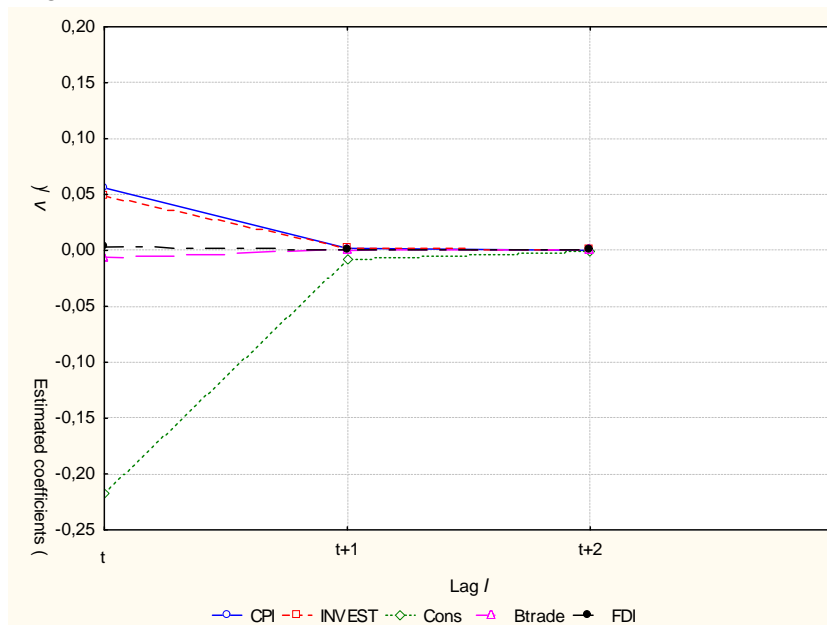Figure 4: Estimated coefficients by using Koyck Transformation (Model 1)

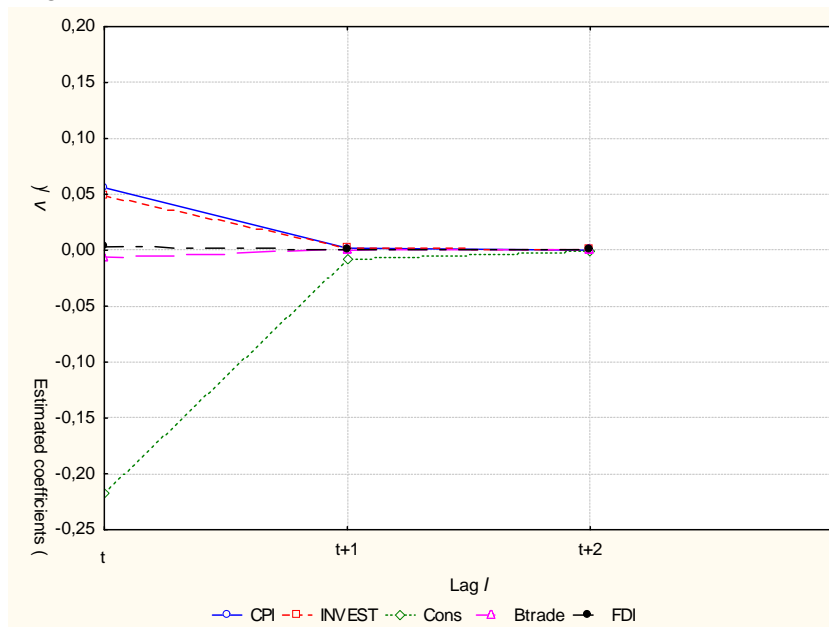Figure 5: Estimated coefficients by using Koyck Transformation (Model 2)

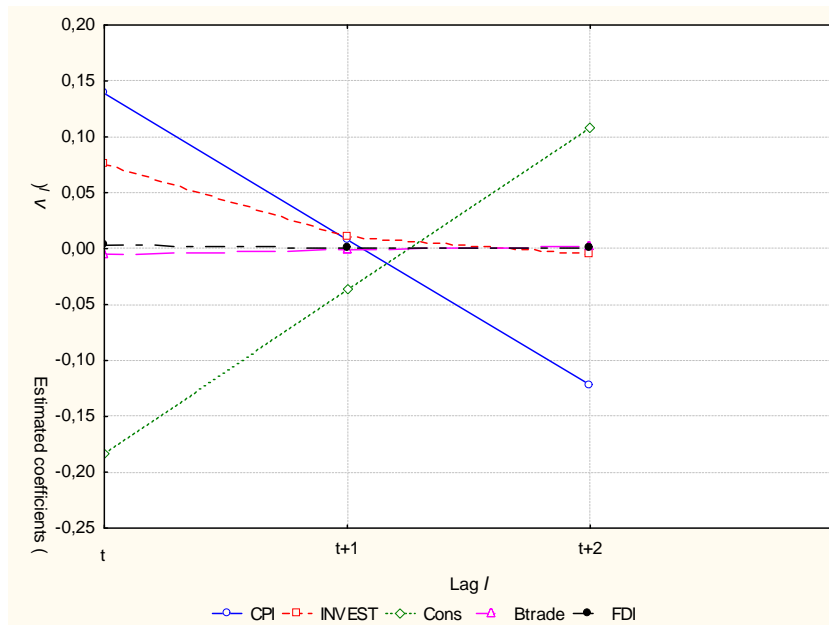Figure 6: Estimated coefficients by using a Polynomial distributed lag (Model 1)

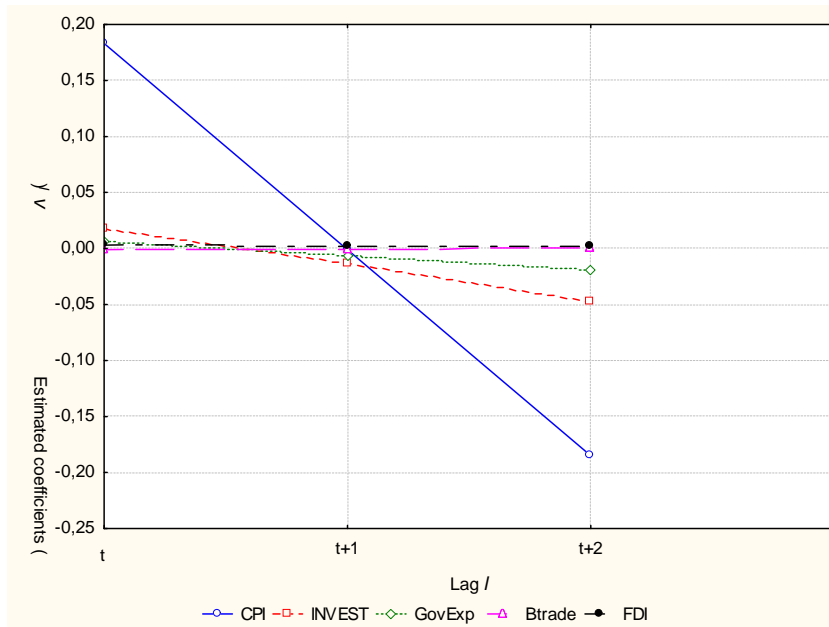Figure 7: Estimated coefficients by using a Polynomial distributed lag (Model 2)

Figure 8: Evolution of economic Growth and the contribution of consumption in the growth
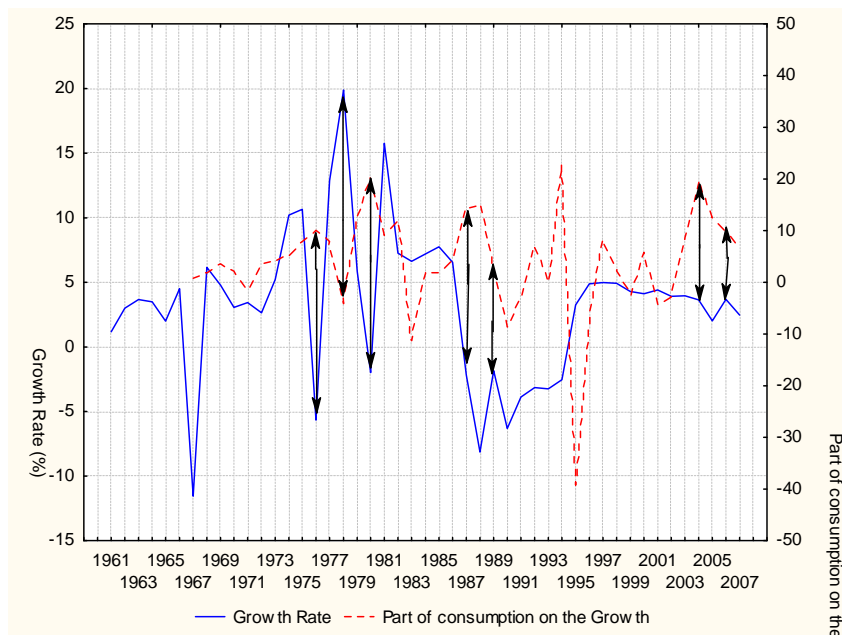
Table 5: Granger causality tests

Part 1: Does growth Granger-cause consumption?

The following equation was estimated by OLS:

$$\ln cons_t = \mu + \sum_{i=1}^{L} \alpha_i \ln cons_{t-i} + \sum_{j=1}^{L} \beta_j \Delta \ln gdpr_{t-j} + \varepsilon_t$$

$H_0 : \beta_1 = 0......\beta_L = 0$ (Growth does not cause consumption).

$L =$n$_0$ of Lag	$F-$statistic	$P-$value	Adj.-R^2
1	5.75	0.021*	0.981
2	...	...	...
3	...	...	...

Part 2: Does consumption Granger-cause growth ?

The following equation was estimated by OLS:

$$\Delta \ln gdpr_t = \mu + \sum_{i=1}^{L} \alpha_i \Delta \ln gdpr_{t-i} + \sum_{j=1}^{L} \beta_j \ln cons_{t-j} + \varepsilon_t$$

$H_0 : \beta_1 = 0......\beta_L = 0$ (consumption does not cause Growth).

$L =$n$_0$ of Lag	$F-$statistic	$P-$value	Adj.-R^2
1	0.77	0.385	0.056
2	0.96	0.391	0.036
3	3.33	0.031*	0.313

* 5% is the threshold of the decision

Note: The data are annual, 1960-2007

Figure 9: Compared evolution of Economic Growth and Consumption Growth
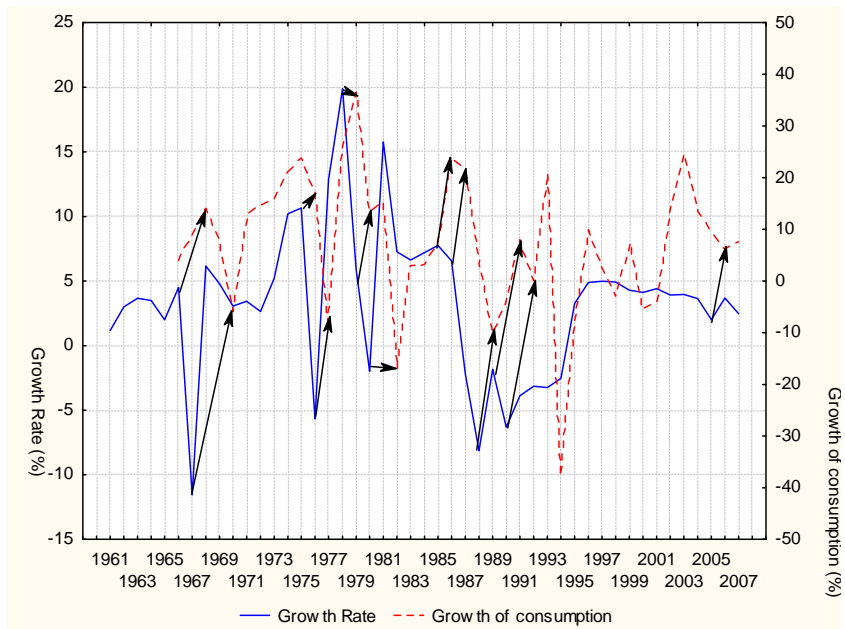
Appendix A: Matrix of correlation

	$\Delta \ln gdpr$	$\ln cpi$	$\ln invest$	$\ln gouv$	$\ln con$	$\ln trbal$	$\ln fdi$
$\Delta \ln gdp$	1						
	–						
$\ln cpi$	-0.27	1					
	0.12	–					
$\ln invest$	0.04	-0.003	1				
	0.80	0.98	–				
$\ln gouv$	-0.66***	0.52***	0.39**	1			
	0.00	0.00	0.02	–			
$\ln con$	-0.60***	-0.69***	0.28	0.91***	1		
	0.00	0.00	0.10	0.00	–		
$\ln trbal$	-0.34*	-0.14	-0.26	0.04	-0.03	1	
	0.05	0.42	0.13	0.79	0.86	–	
$\ln fdi$	0.31*	0.01	-0.06	-0.26	-0.10	-0.08	1
	0.07	0.93	0.726	0.13	0.54	0.63	–

Note: * significant at 10%; ** significant at 5%; *** significant at 1%

Appendix B: Details of Delta Method

The delta method is a more general method for computing confidence intervals. This method takes a function that is too complex for analytically computing the variance (e.g., $Var\left[\exp\left(\widehat{X\beta}\right)\left\{1+\exp\left(\left(\widehat{X\beta}\right)\right)\right\}\right]$ creates a linear approximation of the function, and then computes the variance of the simpler linear function that is used for large-sample inference. While we illustrate this approach with a simple one-parameter example, the approach generalizes readily to the case with multiple parameters.

Let $F(x\beta)$ be the estimator of interest, for example, $F(x\beta) = \Pr(x\beta) = \Phi(x\beta)$, where Φ is the cumulative density function for the standard normal distribution. The first step is to use a Taylor expansion to linearize the function evaluated at $\widehat{\beta}$:

$$F(x\widehat{\beta}) \approx F(x\beta) + \left(\widehat{\beta} - \beta\right) f(x\beta)$$

where $f(\beta) = F'(\beta)$ is the derivative of F evaluated at β. Then we take the variance of both sides of the equation:

$$Var\left\{F(x\widehat{\beta})\right\} \approx Var\left\{F(x\beta) + \left(\widehat{\beta} - \beta\right) f(x\beta)\right\}$$

We can easily simplify the right-hand side:

$$Var\left\{F(x\beta) + \left(\widehat{\beta} - \beta\right) f(x\beta)\right\} = Var\left\{F(x\beta)\right\} + Var\left\{\left(\widehat{\beta} - \beta\right) f(x\beta)\right\}$$
$$= +2\, Cov\left\{F(x\beta), \left(\widehat{\beta} - \beta\right) f(x\beta)\right\}$$
$$= 0 + Var\left\{\left(\widehat{\beta} - \beta\right) f(x\beta)\right\} + 0$$
$$= \{f(x\beta)\}^2 + Var\left(\widehat{\beta} - \beta\right)$$
$$= \{f(x\beta)\}^2 + Var\left(\widehat{\beta}\right)$$

where we use the fact that β, $f(x)$, and $F(x\beta)$ are constants. To make our example concrete, consider binary probit where $\Pr(x\widehat{\beta}) = \Phi(x\widehat{\beta})$ and x is any specific value. The linear expansion is

$$\Phi\left(x\widehat{\beta}\right) \approx \Phi\left(x\beta\right) + \left(\widehat{\beta} - \beta\right) \frac{\partial \Phi(x\beta)}{\partial \beta} \quad \text{where } \frac{\partial \Phi(x\beta)}{\partial \beta} = x\phi\left(\beta x\right)$$

Then $Var\left\{\Phi(x\beta) + \left(\widehat{\beta} - \beta\right) \phi(x\beta)\right\} = \{x\phi\left(\beta x\right)\}^2 Var\left(\widehat{\beta}\right)$ which leads to the symmetric con dence interval

$$\left[\Pr\left(x\widehat{\beta}\right) - z\sqrt{\left\{x\phi\left(x\widehat{\beta}\right)\right\}^2 Vare\left(\widehat{\beta}\right)}\right] \leq \Pr\left(x\beta\right) \leq \left[\Pr\left(x\widehat{\beta}\right) + z\sqrt{\left\{x\phi\left(x\widehat{\beta}\right)\right\}^2 Vare\left(\widehat{\beta}\right)}\right]$$

Unlike the asymmetric con dence interval based on endpoint transformations, this confidence interval could include values less than 0 or greater than 1.

Next consider a discrete change $\Pr\left(x_a\widehat{\beta}\right) - \Pr\left(x_b\widehat{\beta}\right) = \Phi\left(x_a\widehat{\beta}\right) - \Phi\left(x_b\widehat{\beta}\right)$ where x_a and x_b are two values of x. The linearization is

$$\Phi\left(x_a\widehat{\beta}\right) - \Phi\left(x_b\widehat{\beta}\right) \approx \{\Phi\left(x_a\beta\right) - \Phi\left(x_b\beta\right)\} + \left(\widehat{\beta} - \beta\right) \frac{\partial\{(x_a\beta) - \Phi(x_b\beta)\}}{\partial \beta}$$

Taking the variance of the right-hand side and simplifying:

$$Var\left[\{\Phi\left(x_a\beta\right) - \Phi\left(x_b\beta\right)\} + \left(\widehat{\beta} - \beta\right)\frac{\partial\{(x_a\beta) - \Phi(x_b\beta)\}}{\partial\beta}\right]$$

$$= Var\left[\left(\widehat{\beta} - \beta\right)\frac{\partial\{(x_a\beta) - \Phi(x_b\beta)\}}{\partial\beta}\right]$$

$$= \left[\frac{\partial\{(x_a\beta) - \Phi(x_b\beta)\}}{\partial\beta}\right]^2 Var\left(\widehat{\beta}\right)$$

$$= \left\{x_a^2\phi\left(x_a\beta\right)^2 + x_b^2\phi\left(x_b\beta\right)^2 - 2x_a\phi\left(x_a\beta\right)x_b\phi\left(x_b\beta\right)\right\}Var\left(\widehat{\beta}\right)$$

To evaluate it, we simply replace β with $\widehat{\beta}$.

Appendix C: Unit root tests of the variables

The unit root tests used in this study are the Augmented Dickey-Fuller tests. The optimal lag length has been chosen using Akaïke criterion. All variables were tested first to ascertain whether the trend or the constant should be included in the unit root test. We used the the strategy of Dickey & Pantula (1987).

The equation used to perform the Augmented Dickey-Fuller tests is

$$\Delta y_t = \mu + \rho y_{t-1} + \beta t + \sum_{j=1}^{p} \alpha_j \Delta y_{t-j} + \epsilon_t$$

p is the lag length .

The null hypothesis: $H_0 : \rho = 1$, presence of unit root

If we don't reject the null hypothesis, we take the first difference of the series and rerun the test. But, before we perform the ADF test, we must check the optimal lag length, then we run our equation. after that, we verify if the trend and the constant can be included in the unit root tests.

Table 6: Results of Augmented Dickey-Fuller tests

Unit Root tests				
Variables	Lag	t-statistic		Integration
	order	Level	first difference	order
Inflation	1	-1.373	-3.356**	1
Investment	1	-3.692**	...	0
Consumption	0	-1.783	-5.110***	1
Government expenditures	0	-1.788	-5.767***	1
Trade balance	0	-6.460***	...	0
FDI	0	-5.286***	...	0
GDP	1	0.993	-3.771***	1

Note: * significant at 10%; ** significant at 5%; *** significant at 1%