Military Expenditure and Economic Growth: The South American Case

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El Gasto Militar y el Crecimiento Económico: El Caso Suramericano

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Abstract: *The present article establishes an empirical approximation related to the influence of the military expenditure in the economic growth for the case of the countries of South America. The main theoretical framework is based in the approximation of the Augmented Solow model considering the effect of the share of military spending in the factor productivity as it was proposed by Knight et al.* (1996). *The methodology follows the estimation of a panel vector autoregressive model for the period of 1977-2016, considering all the variables as endogenous, within this, it is provided the Granger-causality tests among the equations. The results determinate that military expenditure is not statistically significant to explain the variation in the output of the economy, meanwhile it existed a causality relation between the savings of the economy and the military expenditure for this continent.*

Keywords: Military expenditure; economic growth; South America; Causality; Correlation Analysis.

JEL Classification: E23; E22; E60; F43; O54.

Resumen: *El presente artículo establece una aproximación empírica relacionada con la influencia del gasto militar en el crecimiento económico, en virtud de contribuir a la literatura empírica de los países en vías de desarrollo en relación con este tema. El marco teórico principal se encuentra basado en la aproximación del modelo Aumentado de Solow considerando el efecto de la participación del gasto militar en la productividad de los factores como fue propuesto por Knight et al.* (1996). *La metodología sigue la estimación de un modelo panel de vectores autorregresivos para el periodo de 1977-2016, considerando todas las variables como endógenas, junto a esto, se proveen las pruebas de causalidad en el sentido de Granger para las diferentes ecuaciones. Los resultados determinan que el gasto militar no es estadísticamente significativo para explicar la variación en el producto de la economía, mientras que existe una relación de causalidad entre los ahorros de la economía y el gasto militar para este continente.*

Palabras Clave: Gasto Militar; Crecimiento Económico; Sur América; Causalidad; Análisis de Correlación.

Clasificación JEL: E23; E22; E60; F43; O54.

Contents

Introduction

In the case of developing economies, which are merge in different types of problems[1], a set of reasonable questions arises related to the role of the military expenditure in the gross domestic production. Does it help to increase the output of the economy? It decreases it? Multiple interrogatives can emerge from this single topic, and the work of the economists is to find out what real impacts are derived from it.

The theoretical foundations go to both sides, this in terms of a positive impact or a negative impact. The South American case is worth to analyze since all of the countries of this continent are developing economies, however, it's a special case since its different from the cases of Asia or Africa. Aggregating the whole analysis to the world would result in a problem where the particularities of homogenous countries cannot be observable so easy, so the motivation to perform a study only for the South American continent is based on the fact that the economies are similar among then.

The present paper using the information of the Stockholm International Peace Research Institute -SIPRI (2018) links the share of the military expenditure for the South American economies using a Panel Vector Autoregressive -PANEL VAR- approach, derived from the theoretical foundations of the Augmented Solow model proposed by Mankiw, Romer & Weil (1992) and the transformation used by Knight, Loayza & Villanueva (1996) which includes the role of the military expenditure affecting the productivity factor of the economies. In order to provide the causality analysis, the Granger tests are used after the panel VAR estimation.

Literature Review

The research conducted by Castillo, Lowell, Tellis, Muñoz, & Zycher (2001) provides a differential aggregated value to the literature, where the whole purposes were focused to find the determinants of military expenditure and economic growth with rational motivations of

[1] Like income inequality distribution, armed conflicts, human capital deficiencies.

the States to pursuit it. Among the empirical determinations related to the economic growth, separated cases of analysis were perform with the countries of Germany, France, Russia, Japan, and the United States. The methodology considered standard procedures of correlation analysis and regressions with econometric models based on rational influences between the variables, with the addition of historical analysis to the results. They affirm that each country is unique and that a strong economic growth doesn't imply necessarily an expansion of the military expenditure over the period of 1870-1939. The results imply that perceived threats are the most influencing factors to increase the military expenditure, especially when the external environments appear to be highly unstable.

Sonmez Atesoglu & Emerson (1990) investigate the connection between the defense spending and the economic growth. In this approach, defense spending is a one side of the same coin of the military expenditure, since the idea is to protect the national interests & affairs. Within this study, a theoretical foundation was used with a model of two sectors inside the production function which resulted in econometrical exercises to prove the relationship between these variables. The results point out a positive and significant relationship of the military expenditure and the economic growth for the case of the U.S. economy, however, the authors state that the response of the economic growth regarding the increases of military expenditure is small, and in the long-run are not large.

W. Robert J. Alexander (1990) argues that there's an important amount of controversies whether if the military expenditure has a specific effect in the growth of the economy and also if the impact of this effect is positive or negative. This study presents two sides of the approaches used to examine the relationship between the variables, the sole based theory approach and the ad hoc justification regarding the variables for the empirical findings. He proposes a model with four sectors which allows a generalization of the externality effects across the different production functions for each sector. The conclusions confronted with the empirical validation states that the effect of the military spending is not entirely significant to explain the impacts on the growth of the economy, in fact, regardless the sign (positive or negative) it wasn't enough to proof a significant relationship existed with the growth.

An important research from DeGrasse (1983) establishes that the impact of military spending in the U.S economy is complex, since the existence of heterogenous contexts leads to asymmetrical results, some overall cases are that a theoretical decrease of the employment due to the reduction of the public sector related to the military expenditure tends to affect negatively the growth, but also periods military expenditure tends to produced inflationary rates which results in decreases of the production. The role of Keynesianism, impact the most on researchers and policymakers, and the military spending has then a double connotation related to the potential scenarios regarding its impact, where it can be a prosperity opportunity for a nation like it did to the United States during the World War II, and also as a serious potential damage related to price inflation to the economy.

Some empirical approaches can be found in Khalid & Alsalim (2015) and the studies of Ajmair, Hussain & Gohar (2018), both using Auto-Regressive Distributed Lag –ARDL- models for the U.S. economy in the period of 1970 to 2011, however the results are different for each study. In Khalid & Alsalim the country of analysis is the United States, this model includes the Gross Domestic Production -GDP-, the total amount of government expenditure, the expenditure of the military sector and the real interest rate, the results of their study indicate long-run relationships among the variables where the government expenditure and the variable of interest rate produces a positive impact in economic growth of the U.S while the military expenditure instead, tend to produce a negative impact in the growth. On the second study of Ajmair et al. (2018) in the country of Pakistan, the results established that military expenditure was statistically insignificant to explain the economic growth in this country in the long run, however, the short-run analysis establishes that military expenditure and persons engaged in this sector have a positive impact in the overall economic growth.

A different study for Pakistan with different results can be found in Sheikh, Akhtar, Abbas & Mushtaq (2017) bringing into the empirical findings, the consideration of inequality in the analysis but the results evidence a positive relationship between the military expenditure and economic growth in this case. The study differs from Ajmair et al. (2018) in terms of theorethical constructions and methodology, since it uses an augmented Solow growth model with Harrod-neutral technology and an econometrical application of Generalized Method of

Moments –GMM-. Concerning to inequality, this variable is negatively linked to the economic growth according to this study.

For countries like Egypt, Israel, and Syria the study of Abu-Bader & Abu-Qarn (2003) combines a Vector Error Correction -VEC- model with disaggregated expenditures of the public sector, the estimations reflected a double directional causality with a positive impact of the expenditure of the public sector and the economic growth. With the disaggregation of the public sector, the results established that military expenditure has a negative impact in the economic growth in the long-run. Another case for the countries in Africa is analyzed in the study of Biyase & Zwane (2014) where the methodology used panel data regression with fixed-effects and two-stage least squares regressions. The results establish that military expenditure is statistically insignificant to explain the growth.

Inside the South American continent, Herrera Lasso (1983) analyzes the relationship between the GDP growth, the war, and the defense spending. His comparative analysis reflects a heterogenous correlations in terms of proportions between the GDP and the military expenditure. This author concludes that stronger economies in the region (Brazil & Mexico) also tend to have a lower proportion of the military expenditure compared to other economies, while some Argentina and Chile have greater military spending even when the production levels are lower.

An interesting case in South America is the country of Colombia, some relevant studies can be found in Grautoff & Chavarro Miranda (2009) which analyze the public expenditure on defense and security. The particular methodology is a combination of macroeconomic and microeconomic approaches with considerations taken from dynamic and static optimizations, game theory and econometrics. The authors used the Hodrick-Prescott filter to calculate the cyclical behavior of defense expenditure, and one of the conclusions is that external effects are the ones which tends to influence the military expenditure. A Granger causality analysis was performed over the homicides to the spending in defense, but results indicate no causality as well.

Colombia, according to Vargas Pulido & Gody Estrella (2013) established that internal conflict has coincided in important changes leading to an increase in spending of defense in the recent years. The historical arguments can be divided in two main points; the first one is

related to 1993 and 2002 where the presence of illegal armed groups increased the overall insecurity and violence of the country. The second, is related to 2002 and 2012 where military operations reduced the violent actions developed by terrorist groups. The impact of military expenditure over the economic growth is analyzed with the GDP, foreign investment and labor force. Some conclusions of these authors establish a possible relationship between the following arguments; it exists a proven positive correlation between military expenditure with foreign investment, which, extends a positive externality that promotes the economic growth. The second period of analysis reaffirm this idea since this expenditure also encourages the occupation in the economy, however, the authors conclude it is not easy to establish a definitive relationship with positive or negative impacts, but it appears that internal threatens impulses an increase in military spending which tend to neutralize the negative effect over the economic growth in the long-run.

A complete study from Kollias, Paleologou, Tzeremes, & Tzeremes (2017) focus in the Latin American cases where an augmented granger causality test (with the approach of Toda Yamamoto) and non linear causality tests were performed. A directly time series analysis was used, in order to find for each of the countries in south America, how it is established the causality relationships of these countries (in terms of the output per capita and the military expenditure). Long-run relationships where established with all causality directions but depends on the particular country-case[2]. The conclusions of these authors is that a weak causal relationship exists between the military expenditure and the growth, since, in most cases no relationship could be established to be statistically significant.

An interesting article performed by Dunne & Tian (2013) compares different types of studies which extends, synthetize and updates the literature regarding the relationship between military expenditure and economic growth. Among the studies and researches, there are substantial differences related to the theories and empirical findings, stating that theoretical foundations differ from the neoclassical perspective and the Keynesians approaches. In their words:

[2] An important note must be established, this study instead of this one, will go directly for a panel data study, considering just the short-run dynamics in order to synthetize the general behavior regarding the GDP and the military expenditure. Considering the ground theoretical formulation of the Augmented Solow model.

> *The absence of an agreed theory of economic growth means that there is no standard framework into which empirical work on military expenditure can be fitted. Yet, clearly, military expenditure, conflict, and economic capacity (e.g., education, governance, institutions, natural resources) all interact to influence growth.* (Dunne & Tian, 2013, pág. 6)

Implying that the form given by how the theoretical constructions are performed will indeed change the results from study to study. However, it could be arguably discussed that "Theory (should) precede empirics, but much of economic theory does not assign an explicit role for military expenditure as a distinctive economic activity" (Dunne & Tian, 2013, pág. 6) this from the basic statement of science that theory should explain reality and not vice versa. The empirics are a part of what is considered as reality, but in a real strictly sense, the way to proof empirics should be discussed along with the theory, instead of the empirical facts itself, since we're using non-experimental environments.

This is where the regression approach enters, and the statistical correlation analysis suggest or discard relationships among the variables[3]. In this case, theory cannot proceed empirics purely, since from the absence of agreement in the theory and also for the heterogeneity itself of the sample and the data, different results and correlations might be established. At this point, the researcher has the freedom to explain and describe empirical facts, and some of the credit of this labor would result in further developments of theories or empirical findings.

As an example, it cannot be expected to have the same relationships between military expenditure and economic growth in the different countries around the world. The case of Israel or Afghanistan are not going to have the same behavior regarding these variables as Uruguay or Norway, so it would be useful to have some sort of concordance among the studies, rather than go strictly direct for empirical correlations and inferences with statistical techniques.

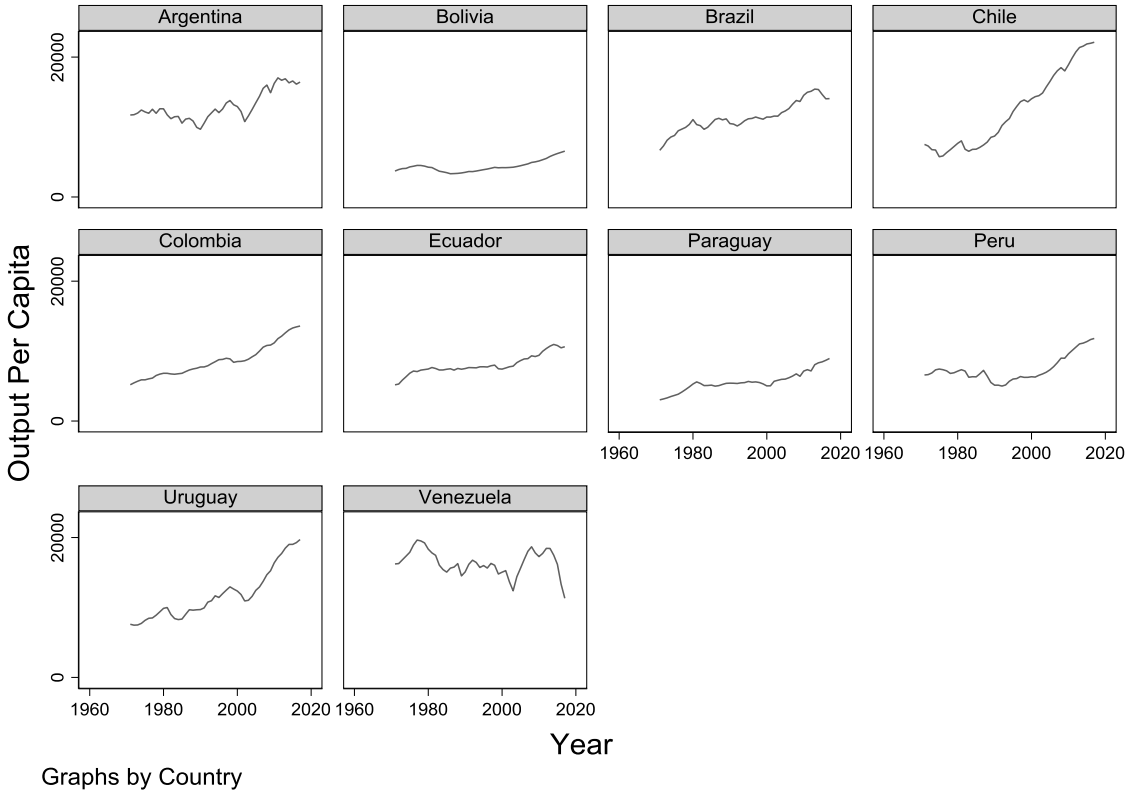
[3] Instead of establishing simple relationships, the causality analysis regarding this topic is indeed more hardly to prove empirically, even when the regression approach tries to model causality, one cannot be sure of this unless the assumptions of exogeneity is satisfied. Another approach can be the use of the Granger non-causality tests, where the past intends to explain the present with different variables considered as endogenous.

Empirical Facts

Real Output per capita of the continent.

Regarding the output per capita of the different South American economies, it can be established that the general pattern is in an upward-trend with the clear exception of Venezuela. Chile is by far, the country with the highest GDP per capita, seconded by Uruguay, the countries of Colombia, Ecuador, Paraguay and Peru are somewhat more homogenous related to the behavior of this variable.

Figure 1 Real Output Per Capita of the South American Economies (USD at Constant Prices of 2011)



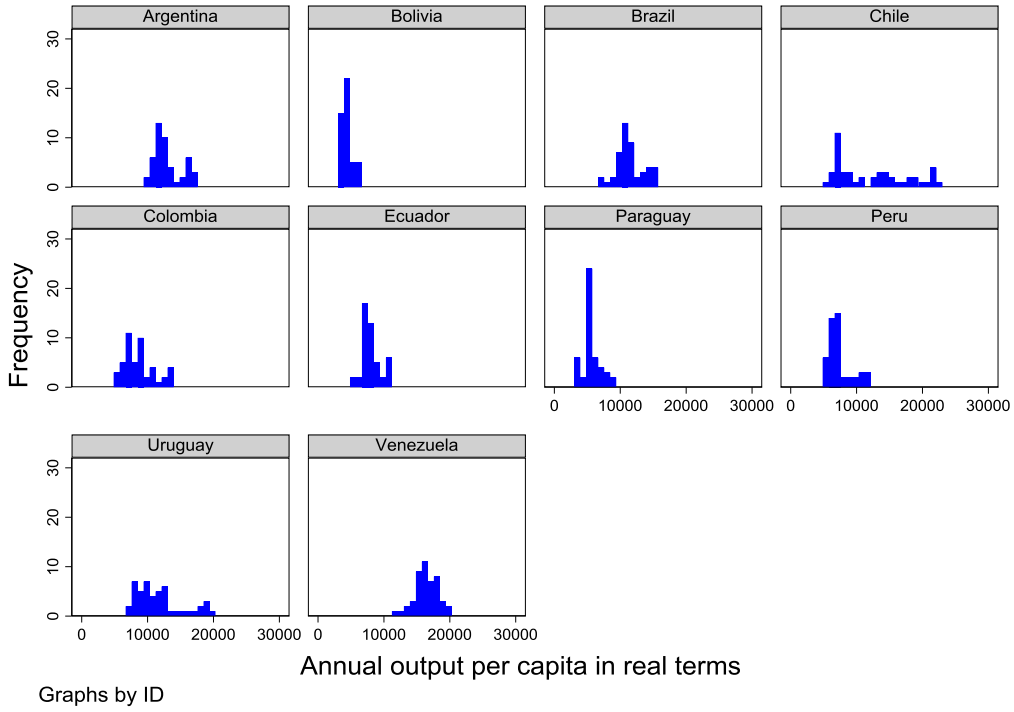
Source: Own Elaboration using information of the Penn World Table (Feenstra, Inklaar, & Timmer, 2015)

Venezuela during the final half of the XX century had an output per capita higher than the average but it started a decline in the XXI century, serious political issues can be associated

to this decline[4], but the overall trend behavior is downwards. Currently, it has a serious problem of inflation where in order to prevent higher escalates, the introduction of the Bitcoin into the economy was done without civil consent (Johnson, 2019). During the years of 2010 to 2016 countries like Argentina, Brazil, Ecuador are presenting a non-increasing income per capita. Meanwhile the countries of Colombia, Bolivia, Chile, Peru, Paraguay and Uruguay are having increases of the income per capita.

The distribution analysis of the output per capita suggest that Chilean economy is the one with higher consistent values of the income. Bolivia with Paraguay in this case is are lagging in comparison to the other economies.

Figure 2 Distributions of the Military Expenditure as a Share of the GDP



Source: Own Elaboration using information of the Penn World Table (Feenstra, Inklaar, & Timmer, 2015)

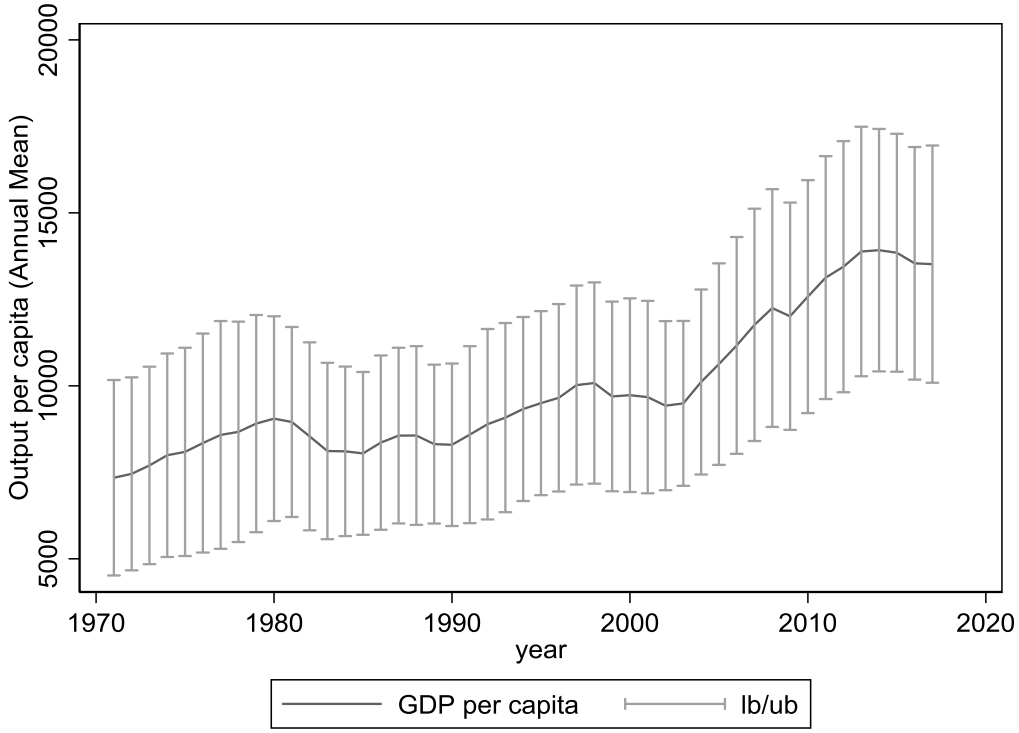
[4] As an example of this, Álvarez (2007) states that the critical juncture of this country is explained by the drastic political changes and the main focuses of the productive activities associated to the oil exploitation. The implementation of the "Socialism of the XXI century" also affected the overall productivity of the economy, where a smooth transition into the new system wasn't performed and the society was forced to be merged within this economic model.

As a consequence of the higher income per capita of the last century, Venezuela reports a better concentration of the annual output with higher values compared to Colombia, Ecuador and Paraguay. The problem is that while Colombia, Ecuador and Paraguay are reporting positive trends in the future, Venezuela might not have this behavior since it has a decreasing pattern from 1980 to the present.

The mean output per capita across countries by year is presented ahead, and it reflects some shifts at different decades of the XX & XXI centuries. From 1980 to 200, an evident shift in the trend is visible due to the liberalization of the South American economies into the international market. This represented a shock to the economies which were finalizing their industrializing process in their economies (also known as the Import Substitution Model[5]), however the international competition signified a problem to the national productivity which lead to some recessions over this decades. The new century provides an upward trend better than the last decade of the XX century, but the trend of the mean of the output per capita in annual terms for South America is decreasing in the last decade of 2010-2020.

[5] Some problems which explain the failure of the Import Substitution Model in South America are related to the in heritage of the Spanish colony, in fact, land distribution and continuous social conflict were causes of inequality among the population of this continent. Also, the existence of corruption across the different governments of the south American republics tend to constitute inefficient institutions, which instead of facilitating the socioeconomical development, led to the build of strong problems in the economies and the societies. The Colombian case explained by Misas (2002) provides a good example of the causes related to the failure in the Import Substitution Model, more associated to the state incapacity to attend the social problems and the construction of monopolies which lagged the industry during the implementation of the model.

Figure 3 Mean Output per capita of South America 1970-2016 (USD Values at constant prices of 2011)



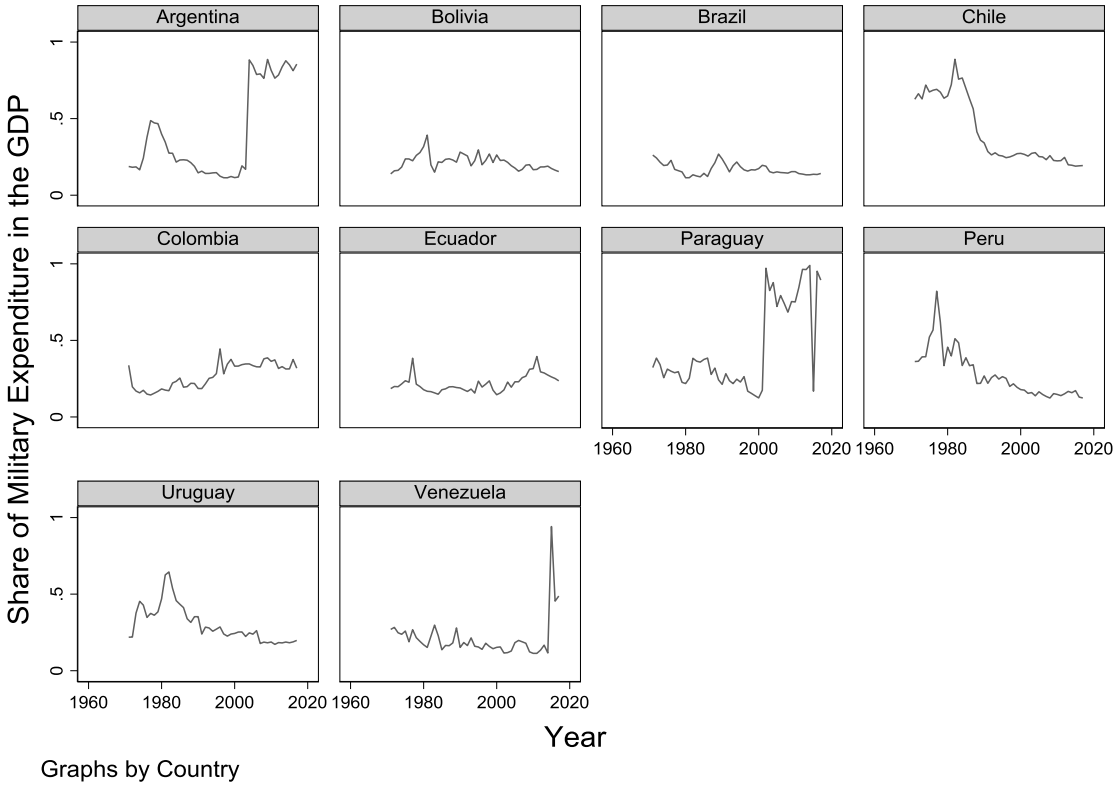
Source: Own Elaboration

There are no reasons to believe that radical variations exists related to the differences of the output per capita across countries by year, it appears that differences are meaning somewhat constant among time, however, starting the year 2000 there's an increase of the dispersion across countries with this variable in per capita terms which wasn't present in the last century.

Shares of military expenditure

Regarding the military expenditure as a share of the GDP for each one of the South American economies, we can detect drastic changes for Argentina, Paraguay and lately Venezuela. The higher increase of this military expenditure is given in the years of 2005 to 2020 for these economies, however an heterogenous behavior can be found among the economies. Chile, Peru and Uruguay are following a decreasing trend of the share of this military expenditure, instead of countries like Bolivia, Brazil and Ecuador which follow a constant pattern without increases or decreases. The Colombian share is having an upward trend, but no significant changes in comparison to the trends of Argentina, Paraguay & Venezuela.

Figure 4 Share of Military Expenditure in the GDP for South America, 1970-2016



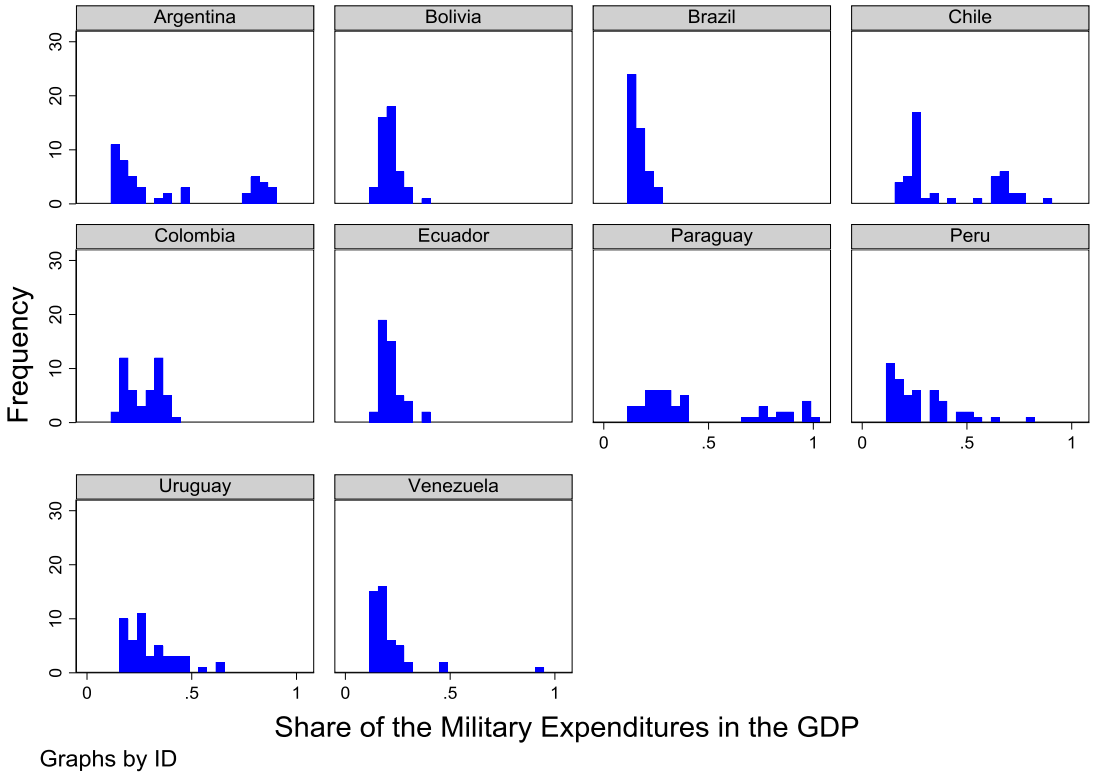
Source: Own Elaboration using information of the SIPRI (2018)

It is important to note that none of these economies over the time of analysis, has or it had a military expenditure higher than 10% of their GDP. However, the sudden change closer to the year 2000 for Argentina and Paraguay suggest an heterogenous behavior regarding the continental pattern. Venezuela, however, it's a different case since is subject of international attacks from diverse fields. Economic sanctions and a recently coup d'etat attempt by the opposition provides a rational explanation of this sudden increase in the military expenditure.

If we observe the distributions of the annual share of military expenditure, it can be noticed that Chilean economy over the period of study had some significant spikes up to 8% of share of the GDP regarding this military expenditure. Argentina and Paraguay are following some high patterns like Chilean economy but with lesser frequencies over time, and finally Peru. Countries like Bolivia, Brazil, Colombia, Ecuador & Uruguay didn't increase the share of this period more than 6% of the share in the national income. A special note on Brazil must

be appointed, which according to the distributions, had a concentrated share around 0.2% of the GDP destinated to the military expenditure.

Figure 5 Distributions of the Share of Military Expenditure in the GDP for South America



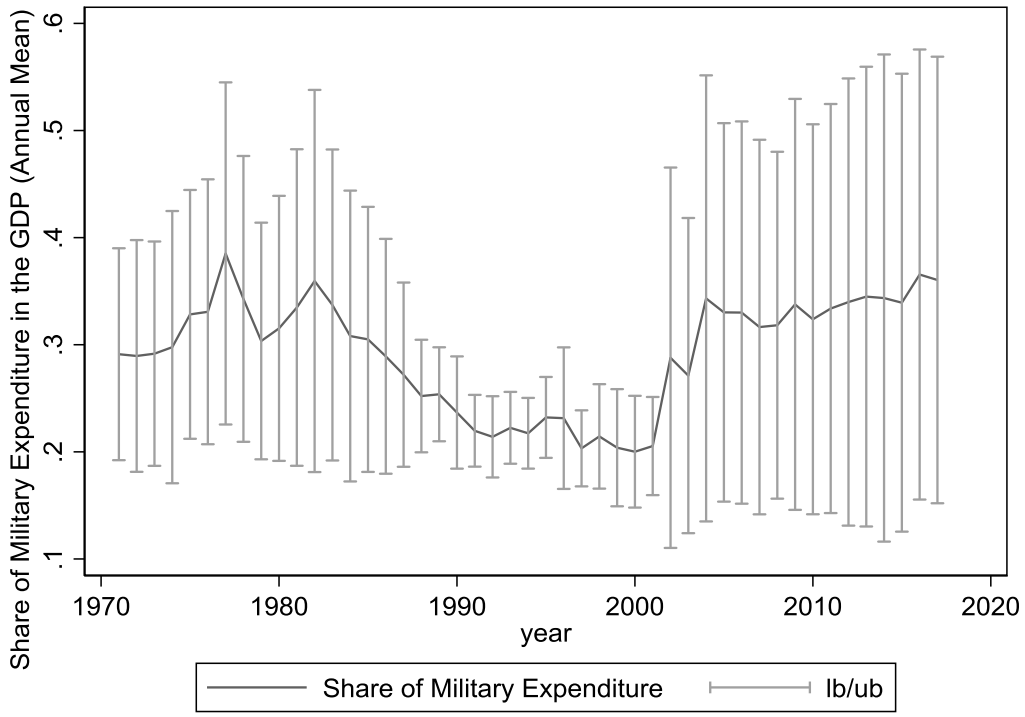
Source: Own Elaboration using information of the SIPRI (2018)

It should be appointed that the share of military expenditure related to the GDP, it's only a reference point, since some higher values can be found or each economy because the GDP's of the countries in this continent are somewhat heterogenous, and some other factors like population and economic development.

In terms of the annual mean dedicated to the share of the military expenditure for the economies, some highly variations can be observed among the continent. From 1970 and 1988, the dispersion of the shares in the military sector remained somewhat constant around the continent, however from 1989 to 2001, it existed a notably reduction of the dispersion of the share across the countries, probably due to the liberalization process of the different economies of this decade which forced to rationalize resources. In terms of economies, multiple countries faced recessions phases caused by the overwhelming power of the

international market which was introduced in forms of products and services with lower prices, discouraging the national production. This led to a reduction also of the overall shares of the military expenditure in the continent over the mean value of 2.4%. In the year 2000 and the finals of 2020 the shares in the GDP's of the different economies started to rise reaching a mean value of shares of 3.5% and the dispersion also got amplified where which reflects a pattern not seeing before in the new millennium.

Figure 6 Mean of the Share of the Military Expenditure in the GDP, 1970-2016

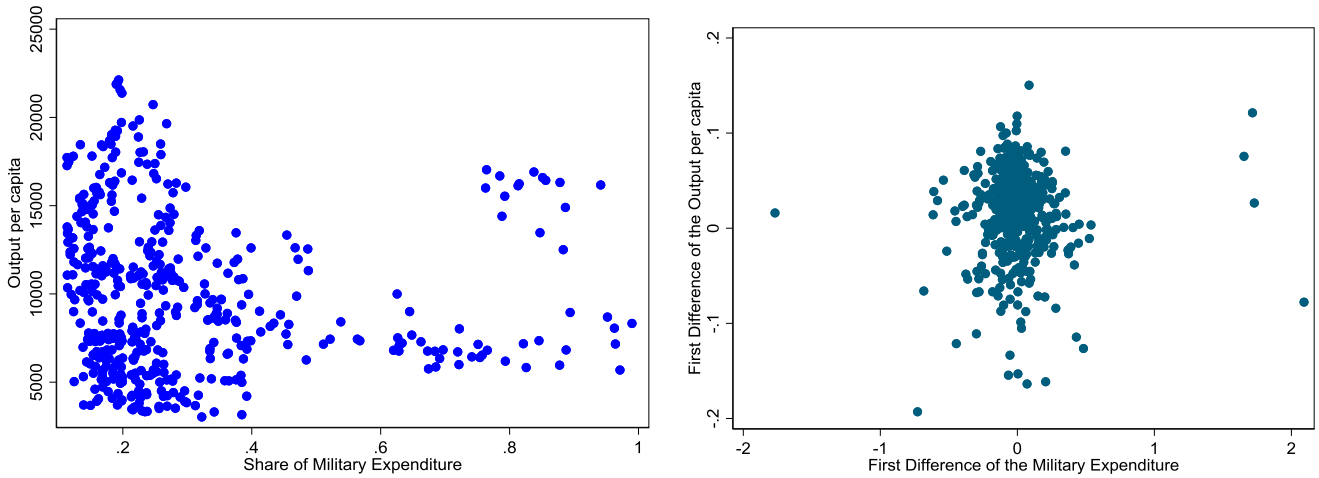


Source: Own Elaboration

Correlation Analysis

The graphical dispersion of the series of the GDP per capita and the share military expenditure in levels, suggest a decreasing pattern where when the military expenditure goes higher, it exists a reduction of the output per capita, however, this relation is not significant since there are evidence of high values of the annual income per capita and the share of this expenditure. The decreasing pattern mentioned before roughly indicates a negative relationship between the output per capita and the share of military expenditure.

Figure 7 Dispersion of the Output Per Capita and the Military Expenditure (Levels and First Differences)



Source: Own Elaboration

At this point, if we analyze the dispersion of the first differences of both variables, we cannot find a significant pattern, in fact, no correlation can be observed since the graph reflects a cloud of points without any visual patterns.

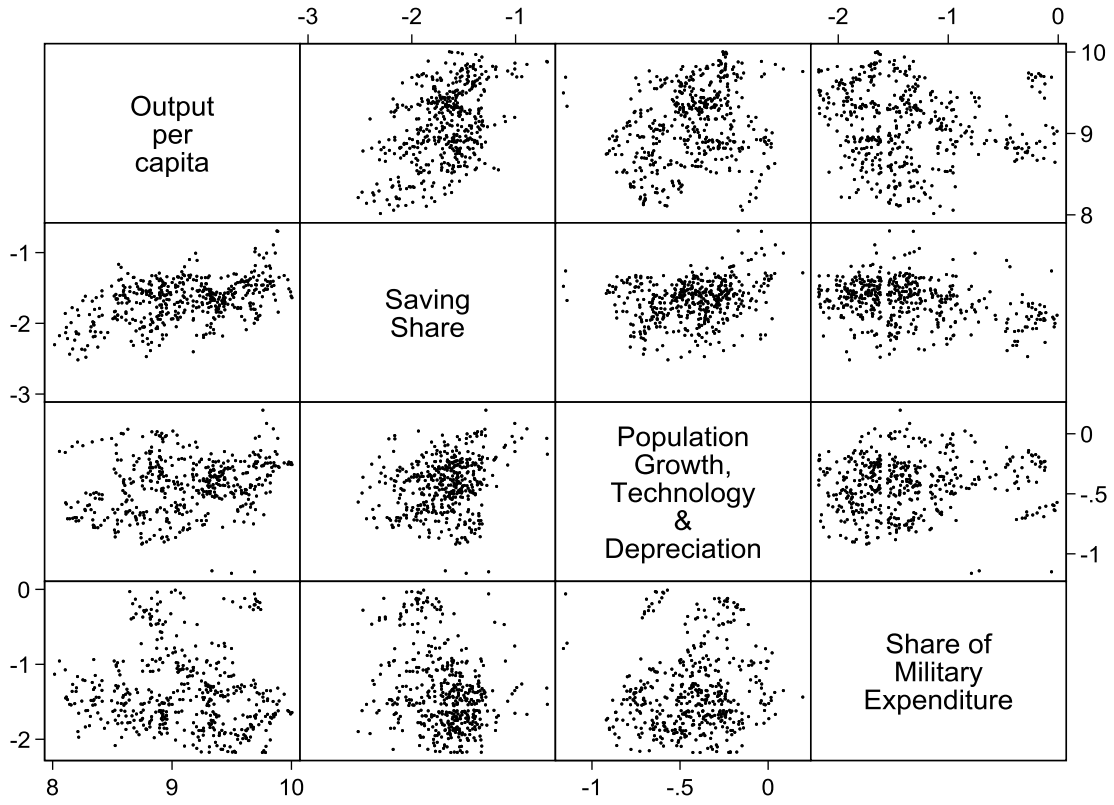
The first differences correlations are free of inertial effect given by unit-roots of the series, which could be a misleading approach since variables may appear correlated when they're spurious correlated.

The correlation analysis is also extended including the natural logarithm of the variables of the share of savings in the economies, the extended depreciation curve (which is the sum of depreciation, population growth, and technological rates as stated in the Solow Augmented model), with the share of the military expenditure, also in natural logarithms.

In terms of the natural logarithms, the output of the economies is positively correlated in levels with the variables of the savings, the extended depreciation curve[6] and roughly negatively correlated with the share of military spending.

[6] It is useful to remind at this point that Solow (1956) & Swan (1956) model in the augmented version by Mankiw et al.(1992), the growth depends now on the rate of the technological change, where this rate affects the growth rate of the capital accumulation per capita, the consumption and the growth itself of the output per capita (See Sala-I-Martin & Barro (2004, pág. 55) for further information in this topic).

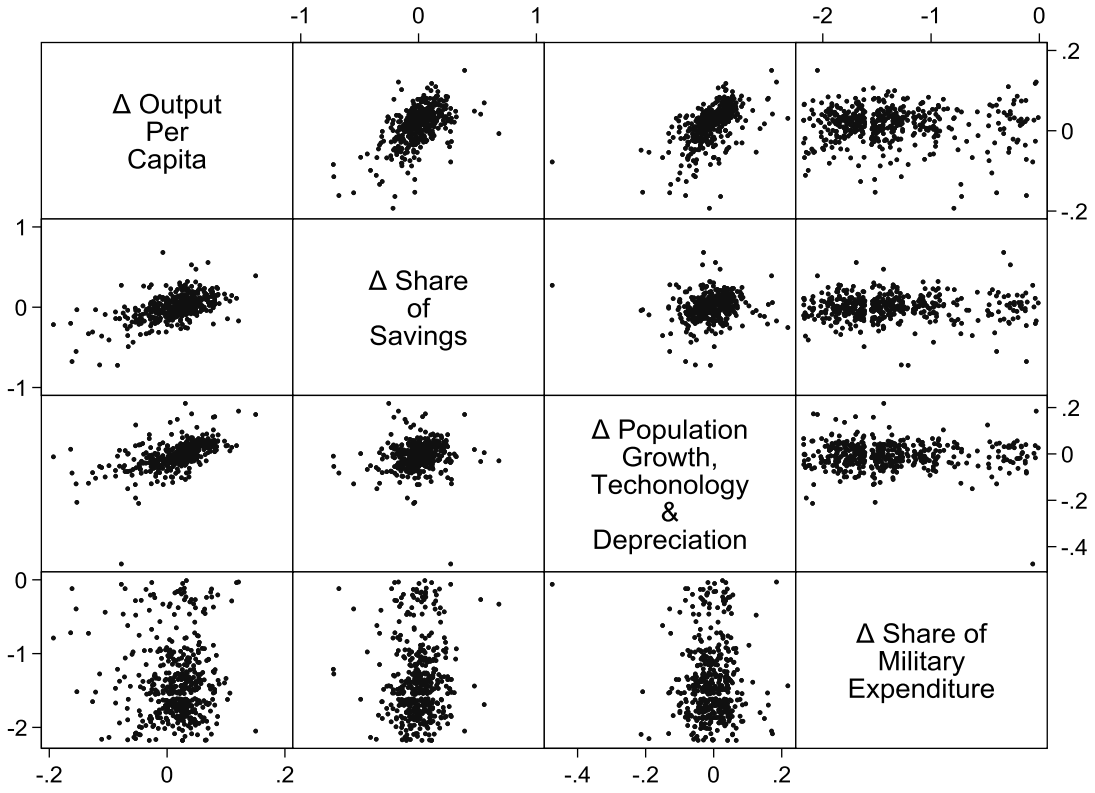
Figure 8 Graphical Correlations of Macroeconomic Variables & The GDP



Note: Values are in natural logarithms. Source: Own Elaboration

Among the other variables, some correlations are observable, in fact savings seems to be positively correlated with the extended depreciation curve, the output per capita and roughly negatively correlated with the share of the military expenditure. Other than that, no significant correlations are observable with the variables in levels in their logarithm form.

Figure 9 Growth Rates of Macroeconomic Variables and the Military Expenditure



Note: The growth rates were calculated as the first differences from the variables in natural logarithms.
Source: Own Elaboration

Considering now the growth rates as an approximation of the differences among the logarithms transformations, it's observable that the growth of the output per capita in the South American economies are positively correlated with the growth in the savings and the extended depreciation curve, in fact, this last variable (which is the sum of the population growth, the rate of technological change given by the change on the total factor productivity and the depreciation in average) is as positively correlated with the like output. On the other hand, the growth in the share of the military expenditure across the economies doesn't appear to have a significant (positive or negative) correlation with any of the variables.

Table 1 Descriptive Statistics

Variable	Obs	Mean	Std.Dev.	Min	Max
y	470	9892.851	4361.826	3029.937	22122.59
m	470	2.93%	.191	.113	.99
inv	470	1.94%	.057	.081	.5
n	460	0.17%	.007	-.001	.029

g	470	6.13%	.148	.265	1.156
d	470	0.4%	.009	.025	.063

Source: Own Elaboration using Stata 16

According to the descriptive statistics, the mean value of the South American economies regarding the output per capita in annual terms is around $9.892 USD in prices of 2011, this involves a monthly earning on average around $824 USD during 1977-2016. The mean value of the share in military expenditures in the GPD's of the economies was 2.93%, the share of saving/investment was 1.94% indicating that in average across time, more of the income was distributed in the military expenditure than the productive process of investment/savings. The growth-rate of the population in average across countries was 0.17% and the technological rate of change was 6.13% with a depreciation of 0.4% in average during the whole period across countries. Within this, it must be appointed that technological rate is one of the most consistent variables in the extended depreciation curve, and its established as one of the factors with positive correlation in the growth of the output per capita of the economies.

Theoretical Framework

According to Mankiw et al. (1992), a starting point can be allocated in the aggregate neoclassical production function Cobb-Douglas, which in the Augmented Solow model has a variation relative to the role of the Labor on the technology. In sum the production function is expressed as:

$$Y_t = K_t^{\alpha}[A_t L_t]^{1-\alpha} \quad (1)$$

The expression called the labor-augmenting technological progress provides the inclusion of the technology A_t associated to the labor L in a time t where the aggregate output Y will have as the production factors the capital K and the labor, α represents the elasticity of the aggregated capital stock of the economy in the production function.

The key assumption which points out Knight et al. (1996) is that the parameter A is going to evolve in time as a function of the exogenous growth rate of the technology and the share of the military expenditure in the output. Defining the share of the military expenditure in the

gross domestic production as $m_t = \frac{M_t}{Y_t}$ we have the proportion of the military spending over the total income for a specific time. Including this share in the function where the technology evolves, its expressed as:

$$A_t = A_0 e^{gt} m_t^{\theta} \quad (2)$$

In equation (2) the current technology level is explained by an initial point of the technology A_0, g as the Harrod-neutral rate of technical exogenous progress and the share of military expenditure in the output of the economy m_t at a certain time. θ can be interpret as the elasticity of the military expenditure related to the technology.

It is useful to remind that according to Mankiw et al. (1992) the saving rate of the economy is exogenous and it is derived from the assumption that the aggregate investment I equals the aggregate saving S of the economy, so $I = S$ considering a propensity of consumption related to the output in the form of $I = sY = S = (1 - c)Y$ since what is not consumed it's saved and therefore invested. The rates of saving are defined as s, the growth rate of the labor force is n, and it exists a rate of capital depreciation d. The effective capital-labor relation is $k_e = \frac{K}{AL}$ and the variation of the capital per capita over time is defined as $\dot{k} = \frac{dk}{dt}$. Considering this and following Dunne, Smith, Willenbockel (2005), the dynamics of the capital accumulation are given by the usual law of the capital accumulation with the augmented depreciation curve, expressed as:

$$\dot{k_e} = sk_e^{\alpha} - (g + n + d)k_e \quad (3)$$

A linearization of this equation as pointed by Dunne et al. (2005) will result in:

$$\frac{\partial \ln k_e}{\partial t} = (\alpha - 1)(g + n + d)[\ln k_t - \ln k^*] \quad (4)$$

The natural logarithm of the economy output in per capita terms can be expressed as $\ln y_e = \ln\left(\frac{Y}{AL}\right) = \alpha \ln k_e$ which in this case it will lead to the equation of transitory dynamics.

$$\frac{\partial \ln y_e}{\partial t} = (\alpha - 1)(g + n + d)[\ln y_e - \ln y_e^*] \quad (5)$$

And the steady-state referred to the production in terms of effective labor unit will be:

$$y_e^* = \left[\frac{s}{g+n+d}\right]^{\frac{\alpha}{1-\alpha}} \quad (6)$$

The suggestion to proceed with empirical applications as Dunne et al. (2005) appoints, involving the integration procedure forward $t-1$ to t which would result in:

$$\ln y_t = e^{\gamma} \ln y_{t-1} + (1-e^{\gamma})\left\{\ln A_0 + \frac{\alpha}{1-\alpha}[\ln s - \ln(n+g+d)]\right\} + \theta \ln m_t - e^{\gamma}\theta \ln m_{t-1} + (t-(t-1)e^{\gamma})g \quad (7)$$

With $\gamma = (\alpha-1)(n+g+d)$. Now the steady-state of the production per capita evolves as:

$$\ln y_t^* = \ln y_e^* + \ln A_0 + \theta \ln m^* + gt \quad (8)$$

In equation (8) the meaning of θ refers to the elasticity in the steady-state related to the income in the long-run expenditure share. In this point, the military expenditure is considered exogenous in its determination, however, it could be pointed out that the share of military expenditure in an economy is closely related to the level of income, and the motivation to provided resources to this sector, a possibly motivation could be the rate of crimes and conflicts per year, which also influence the next year.

Even though the government hasn't been included in this theoretical framework, one could possibly relate the share of the military expenditure as a function of the total income taken by the government τY where τ is a tax rate, and a logical assumption is that the military sector is influence by the rate of crimes/conflicts in the country φ per year and its first lag of this rate (which motivates the spending of the next year) therefore roughly one could state $m_t = f(\tau Y, \varphi_t, \varphi_{t-1})$. This implies the share m is no longer exogenous and it becomes endogenous and possible correlated with the income per capita in a closed economy, or an open economy without indebtedness policies related to this sector. Since the military share of the GDP is only constrained to the whole income of the economy, therefore is logical to expect that the military expenditure can only be a part of the tax collection highly motivated by the rate of crimes and conflicts in the country (with the strict assumption of absence of debt to amplifies the military expenditure).

In fact, Dunne et al. (2005) stated from another focus this kind of problems, with the relationship written as the form of the next simultaneous equations:

$$y_t = \beta_1 m_t + \gamma_i \delta_t$$
$$m_t = \beta_2 y_t + \gamma_2 \rho_t \quad (9)$$

Where δ_t are the factors that determine the levels of out per capita (possibly attained to the income, lagged values of the income, productivity factors, etc., including the error term), while ρ_t includes the factors that determine the military expenditure.

This approximation points out an endogeneity problem that may arise when the empirical findings are performed, and it might happen during the estimation of the output equation, where it is usually included the military expenditure to contrast its significance to explain the production, however, this expenditure is explained by the income too, leading to suggest that some empirical estimations might possess a bias problem without this consideration.

Methodology

Using the information regarding the share of military expenditure in the Gross Domestic Production (SIPRI, 2018) and the data obtained from the Penn World Table (Feenstra, Inklaar, & Timmer, 2015), the estimations are performed for the countries of Argentina, Bolivia, Brazil, Chile, Colombia, Ecuador, Paraguay, Peru, Uruguay and Venezuela in the period 1977 - 2016.

According to Dunne et al. (2005), the conclusions of the augmented Solow model with the military expenditure can be estimated with the next expression:

$$\Delta \ln y_t = B_0 + B_1 \ln y_{t-1} + B_2 \ln s + B_3 \ln(n + g + d) + B_4 \ln m_t + B_5 \ln m_{t-1} + \varepsilon \quad (10)$$

The equation in (10) will be estimated with fixed and random effects for comparative purposes. In order to provide a deeper analysis with the panel VAR approach and to avoid problems of endogeneity and serial correlation, the system of equations would be introduced with the variables in stationary state, deriving in:

$$\Delta \ln y_{i,t} = \sum_{t=1}^{p} a_i \Delta \ln y_{i,t-p} + \sum_{t=1}^{p} b_i \Delta \ln s_{i,t-p} + \sum_{t=1}^{p} c_i \Delta \ln(g^*)_{i,t-p} + \sum_{t=1}^{p} \omega_i \Delta \ln m_{i,t-p} + e_{it} \quad (11)$$

$$\Delta \ln s_{i,t} = \sum_{t=1}^{p} b_i \Delta \ln s_{i,t-p} + \sum_{t=1}^{p} a_i \Delta \ln y_{i,t-p} + \sum_{t=1}^{p} c_i \Delta \ln (g^*)_{i,t-p} + \sum_{t=1}^{p} \omega_i \Delta \ln m_{i,t-p} + e_{it}$$

$$\Delta \ln g^*_{i,t} = \sum_{t=1}^{p} c_i \Delta \ln g^*{}_{i,t-p} + \sum_{t=1}^{p} a_i \Delta \ln y_{i,t-p} + \sum_{t=1}^{p} b_i \Delta \ln s_{i,t-p} + \sum_{t=1}^{p} \omega_i \Delta \ln m_{i,t-p} + e_{it}$$

$$\Delta \ln m_{i,t} = \sum_{t=1}^{p} \omega_i \Delta \ln m_{i,t-p} + \sum_{t=1}^{p} a_i \Delta \ln y_{i,t-p} + \sum_{t=1}^{p} b_i \Delta \ln s_{i,t-p} + \sum_{t=1}^{p} c_i \Delta \ln g^*{}_{i,t-p} + e_{it}$$

Where $g^* = n + g + d$, the coefficients a, b, c, and ω are estimated with GMM technique for each equation as a VAR system with the Panel Vector Autoregression package for Stata 16 developed by Abrigo & Love (2016). The transformation of the variables in first differences (equivalent to the growth rates) is done in order to ensure the stationarity among the estimations and provide relations without spurious results.

All the variables are tested for unit-roots with the Levin–Lin–Chu test (2002) and the Im–Pesaran–Shin (2003) test with the ideal lag selection given by the Akaike's Information Criteria -AIC (Hansen, 1982). Granger causality will also be presented for each equation in order to obtain information about the dynamics over time of all the variables. With this approach the dynamics between variables can be captured through the coefficients in the regression, if the coefficients of ω for all equations are positive, it can be established a positive impact related to the short-run effect in the dependent variables, otherwise if $\omega < 0$ it would imply that the share of military spending is not contributing as the theoretical model is concluding. The individual hypothesis testing regarding the estimator ω is pretty much important in order to establish whether the military expenditure has a statistically significant relation among the variables or not, providing evidence of the empirical relevance of the variable.

Results

Considering the possibility of the presence of unit-roots in the variables, first differences of the natural logarithms are used, since this transformation is stationary according to the tests, which allows the panel VAR estimation. The ideal lag selection was allocated in 3 lags for

the panel estimation, and the criteria used was the coefficient of determination which explain the percentage of variance explained by the model (see Appendix A).

The regressions with random and fixed effects of equation (10) accounting for heteroskedasticity and serial correlation suggest that doesn't exists a significant impact (at least statistically confirmable) related to the role of military expenditure in the growth of the South American economies.

Table 2 Random & Fixed Effects Regressions

VARIABLES	RE Model $\Delta \ln y$	FE model $\Delta \ln y$	FE Model $\Delta \ln y$
$\Delta \ln y_{t-1}$	-0.0253***	-0.0230*	-0.0779***
	(0.00817)	(0.0121)	(0.0187)
$\ln s$	0.0475***	0.0631**	0.0558***
	(0.0145)	(0.0209)	(0.0144)
$\ln g^*$	0.0325	0.0206	0.0856**
	(0.0214)	(0.0212)	(0.0326)
$\ln m$	0.00560	0.00308	0.00584
	(0.00792)	(0.00958)	(0.00952)
$\ln m_{t-1}$	-0.00392	-0.00552	-0.00822
	(0.00739)	(0.00871)	(0.00706)
Constant Term	0.341***	0.335**	0.825***
	(0.0697)	(0.138)	(0.184)
Time Dummy Variables	No	No	Yes
Observations	460	460	460
Number of ID	10	10	10
R-squared within	0.1179	0.129	0.4728
R-squared between	0.2915	0.0529	0.4354
R-squared overall	0.1219	0.1089	0.4017
Prob> Chi2	0.000	0.000	0.000

Robust standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

Source: Own Elaboration

The second fixed effects model includes time dummy variables in order to capture important characteristics of the time, the goodness of fit the model tends to increase with this approach. The main conclusion at this point is that the natural logarithm of the military expenditure is

not significant to explain the variation in the natural logarithm of the output per capita of the economies. Regarding the signs, the contemporaneous value of the military expenditure seems to have a positive impact related to the variation in the output per capita, and the second lags tends to reduce the variation of the output, however, none of them are statistically significant to explain the output per capita with a 10% level of significance.

The estimation using the panel VAR approach of the system expressed in equations (11) confirms the previous result in the case of the first difference of the natural logarithm of the output per capita of the economies, which is that the military expenditure is not statistically significant to explain the growth.

Table 3 Panel Vector Autoregressive Estimation

VARIABLES	(1) $\Delta \ln y$	(2) $\Delta \ln s$	(3) $\Delta \ln g^*$	(4) $\Delta \ln m$
$\Delta \ln y_{t-1}$	0.409***	1.070***	0.0876	0.429
	(0.0904)	(0.303)	(0.131)	(0.539)
$\Delta \ln y_{t-2}$	-0.0427	-0.174	-0.0414	-1.941**
	(0.0837)	(0.292)	(0.124)	(0.909)
$\Delta \ln y_{t-3}$	0.0560	0.0517	0.0215	-0.0328
	(0.0916)	(0.333)	(0.103)	(0.443)
$\Delta \ln s_{t-1}$	-0.0617***	-0.200***	-0.0379	0.209*
	(0.0208)	(0.0765)	(0.0267)	(0.109)
$\Delta \ln s_{t-2}$	-0.0146	-0.151**	-0.0132	0.339***
	(0.0161)	(0.0721)	(0.0226)	(0.122)
$\Delta \ln s_{t-3}$	-0.0100	-0.0177	-0.0225	0.0808
	(0.0155)	(0.0654)	(0.0216)	(0.0903)
$\Delta \ln g^*_{t-1}$	0.107**	0.103	0.340***	-0.0520
	(0.0415)	(0.178)	(0.120)	(0.491)
$\Delta \ln g^*_{t-2}$	-0.00587	0.0118	-0.0117	0.0374
	(0.0569)	(0.192)	(0.0811)	(0.424)
$\Delta \ln g^*_{t-3}$	-0.0273	-0.104	-0.00378	0.288
	(0.0581)	(0.226)	(0.0742)	(0.286)
$\Delta \ln m_{t-1}$	-0.00191	-0.0712**	0.0116	-0.218***
	(0.00953)	(0.0304)	(0.0155)	(0.0754)
$\Delta \ln m_{t-2}$	-0.00725	-0.0462	-0.0122	0.0262
	(0.00930)	(0.0316)	(0.0136)	(0.0704)
$\Delta \ln m_{t-3}$	-0.00986	-0.0514	-0.0163	-0.00628
	(0.00980)	(0.0332)	(0.0134)	(0.0478)
No. of panels	10	10	10	10
Ave. no. of T	41.000	41.000	41.000	41.000
Observations	410	410	410	410
Instruments	Lags (1/3). ($\Delta \ln y$, $\Delta \ln s$, $\Delta \ln g^*$, $\Delta \ln m$)			
Initial weight matrix: Identity. GMM weight matrix: Robust				
Standard errors in parentheses				
*** p<0.01, ** p<0.05, * p<0.1				

Source: Own Elaboration

By analyzing the other equations, it can be detected that the military expenditure has a significant relation at 5%, with the variation of natural logarithm of the share of the savings in the economies. With an increase of the share of the military expenditure in the economies, the variation in the share of savings tends to be reduced.

The variation of the military expenditure for South America is negatively explained by the second lag of the variation of the output per capita and the first lag of the military expenditure, leading to believe that as soon as we have an increase in the military expenditure for one year, the variation will decrease for the next year. Also, regarding the output per capita, it indicates that when this output increases, the military expenditure is reduced, this could be explained by the fact that the real production is a discouragement for military expenditure. The positive relation is found with the savings of the economies, it appears that if the first difference of the natural logarithm savings increases in South America, the difference of the military expenditure is positive. Its highly likely to believe that with bigger savings in the economies, the military expenditure tend to increase over time.

In order to understand these results better, the granger causality tests with the panel VAR approach are presented ahead. The variables that Granger-cause the variation in the natural logarithm of the output per capita are the savings at 5% of significance and the extended depreciation curve which involves technical progress, depreciation and growth rate of the population at 10% of significance. The first difference of the natural logarithm of the military expenditure does not Granger-cause the output per capita.

Table 4 Granger-Causality Tests of the Panel VAR Regression

Equation	Excluded	chi2	df	Prob > chi2
$\Delta \ln y$				
	$\Delta \ln s$	9.102	3	0.028
	$\Delta \ln g^*$	7.573	3	0.056
	$\Delta \ln m$	1.474	3	0.688
	ALL	24.719	9	0.003
$\Delta \ln s$				
	$\Delta \ln y$	14.027	3	0.003
	$\Delta \ln g^*$	0.715	3	0.870
	$\Delta \ln m$	8.759	3	0.033
	ALL	33.444	9	0.000
$\Delta \ln g^*$				
	$\Delta \ln y$	0.639	3	0.887
	$\Delta \ln s$	2.536	3	0.469
	$\Delta \ln m$	2.578	3	0.461
	ALL	4.436	9	0.880
$\Delta \ln m$				
	$\Delta \ln y$	5.530	3	0.137
	$\Delta \ln s$	10.786	3	0.013
	$\Delta \ln g^*$	1.367	3	0.713
	ALL	18.185	9	0.033

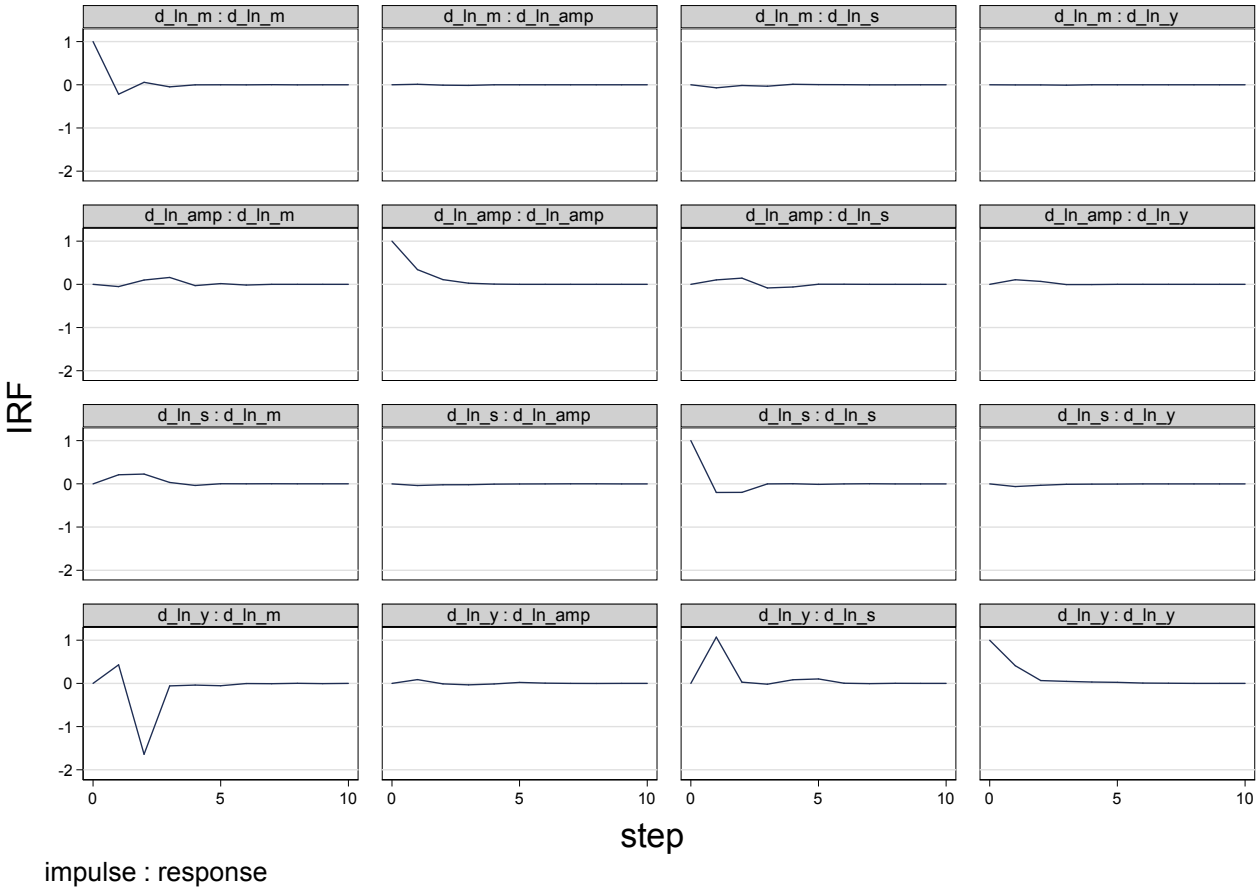
Ho: Excluded variable does not Granger-cause Equation variable
Ha: Excluded variable Granger-causes Equation variable

Source: Own Elaboration

The savings are Granger-caused by the output per capita and the military expenditure at a 5% of significance, this causation is negative since the military expenditure affects negatively the savings according to the panel VAR estimation. Finally, the variation of the natural logarithm of the military expenditure has a Granger-cause the variation in the savings at a 5% level of significance. This causality, according to the PANEL VAR, is positive and as there exists a positive variation in the savings of the South American economies, the military expenditure tends to increase within this positive variation in the short-run. The panel VAR model satisfies the condition of stability and no perfect multicollinearity and cross-sectional dependence (See appendix B).

The impulse-response function -IRF analysis provides the same interpretation performed in the regressions of the system in (10).

Figure 10 Impulse-Response Function of the Panel VAR estimation



Source: Own Elaboration

Considering all variables related to first differences of their natural logarithms; we can establish that the military expenditure has an own decreasing effect on itself which vanish in time. The extended depreciation curve which involves technical progress has the same effect on its own but in a smoother pattern over time. Same behavior it's observable to the savings and the output per capita.

According to the impulses, the output per capita tends to stimulate at first the military expenditure, but after one period of time, this effect becomes negative and more significant in terms of proportion which is correlated with a decrease of the military expenditure. The savings are stimulated at first by the output per capita, however, this effect is absorbed through time. The military expenditure doesn't have any significant influence regarding either the extended depreciation curve, the savings and the output, meanwhile the savings have a short-run stimulus over the military expenditure, but this effect doesn't prevail longer in time.

Discussion

The military expenditure in the analysis for the South American countries is not statistically significant to explain the economic growth. The signs of the regression approaches differ from the fixed & random effects with the panel VAR estimation, in sum, related to the economic growth the following behavior can be seen:

Figure 11 Impacts and Significance of the Military Expenditure

Variable	Transformation:	Sign	Significant	Method
$\ln m$	In levels	+	No	Fixed & Random Effects
$\ln m_{t-1}$	In levels	-	No	Fixed & Random Effects
$\ln m$	First Differences	+	No	Panel VAR
$\ln m_{t-1}$	First Differences	+	No	Panel VAR

Note: The analysis corresponds to the impact in the growth of the output per capita. Source: Own Elaboration

It is evident that the role of military expenditure regarding the impact on the GDP per capita differs from the used empirical methods. The Fixed & Random effects models stated that in

levels the contemporaneous impact is positive, while within its first lag is negative to the production, the results changes in the panel VAR approach regarding the first lag of the expenditure. Although neither of them is statistically significant, this reflects that according to the empirical method used, the result is sensitive as stated in the research of Dunne & Tian (2013).

Another interesting discussion emerges in the panel VAR regression, where the growth rates of the variables presented a substantial causality relationship with the savings and the military expenditure. In general, it was assumed from the theoretical framework, that the aggregated savings of the economy were equal to the aggregate investments[7]. In the regression, this assumption was crucial since no data was available of savings and it cannot be found for the South American continent in this period of time, instead of that, the investment shares of the GDP were used as the savings.

The question now involves a subsequent fact, an existing causality relationship between the growth rate of the share of the military expenditure in the GDP and the growth of saving/investment variables. A strictly rational real-life approximation, involves that all of the savings are not spent in investment activities during an exact period of time, sometimes, savings can go beyond this period and be used to investment (or consumption) in the future, thus the assumption of the augmented Solow model just makes easier the interpretations of the determinants of growth, but the assumption becomes unrealistic if the savings are not used for investment. The approaches of Ramsey (1928), Cass (1965) Koopmans (1965) explain better the decision of the individuals to obtain utility and savings with the returns on assets, however, this might not be the case for the households of the South American continent, whose in difference of the developed economies, aren't constituted in general as Ricardian households. Regardless this, the investment process would be established by the marginal propensity of consumption which is optimized with the individual utility.

In this case, considering the econometric approach used, it's better to work with the interpretation of savings as the "effective investment"[8], since, the data of savings is not

[7] The assumption of $I = S$, which is part of the construction itself of the Solow (1956) and Swan (1956) foundations.

[8] Notice it is not referred as the net investment, since effective investment defined here, represents the share of annual money dedicated to the private investment in the GDP, which is different of the net investment that

available. Therefore, the causality detected in the panel VAR should be understood as causality of the military expenditure to the share of investment in the economy. The statistical inference of the dynamics related to the growth rates of investment and military expenditure suggest a negative relationship.

By increases of the growth of the military expenditure in one year, it exists a decrease in the growth of the shares of investments of the next year in the economies significant at a 5%, leading to believe that among these variables, a cost of opportunity exists regarding the decision of where the productive resources ligated to investments go at the expense of the resources dedicated to the military sector. A similar conclusion is reached by Dunne & Smith (2013) when they affirm that "What does seem increasingly clear is that military expenditure does in general come at an economic cost." (p, 8), suggesting in this research, that the economic cost associated to the military expenditure is the investment.

Conclusions

This article explored the empirical relationship between the military expenditure and the economic growth for the South American case, it involved in the analysis the countries of Argentina, Bolivia, Brazil, Chile, Colombia, Ecuador, Paraguay, Peru, Uruguay and Venezuela during the period of 1977 to 2016.

The theoretical framework was based on the Augmented Solow model of economic growth with the assumption of exogenous technological, the empirical correlation in levels and in first differences (growth rates) of the variables of output per capita, share of savings, population growth, technical change, depreciation rate, and share of military expenditure suggest the absence of any correlation of the growth with this last variable.

The regression analysis with fixed & random effects suggest that there's no evidence that the military expenditure is able to explain the growth in the output per capita, the estimators associated to the contemporaneous value in levels and the first lag of the military expenditure

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accounts for depreciation. The term used as "effective investment" is derived from the national accounts which registers the investment in terms of amount of money of the private sector.

weren't statistically significant among the regressions, and the fixed effects model with time-dummy variables represented the best goodness of fit inside the estimations.

The case of the panel VAR regression with the growth rates suggest the absence of statistical evidence to establish that the military expenditure (and its lags) determines the economic growth. Nevertheless, a causality relationship was found with the variables of the growth rates of savings and the military expenditure. This causality lead to a discussion of how the savings are measure and the theoretical foundation of the augmented Solow model regarding the assumption that investment equals the aggregate savings.

In conclusion, a causality relationship between of the growth of the investment and the growth in the military expenditure aroused, and the main conclusion regarding the discussion is that the military expenditure represents a cost of opportunity for the investment process in the economies, leading to suggest that military expenditure comes with an economic cost. Further research is necessary in other to analyze the relationships between the overall output of the economies, the share of private investment and the military expenditure, also the analysis for country-levels separately is reasonable to perform in other to obtain more information with empirical findings. The main conclusion remains that the military growth is not significant (statistically speaking) to explain the economic growth among the countries of the South American continent.

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Appendix A

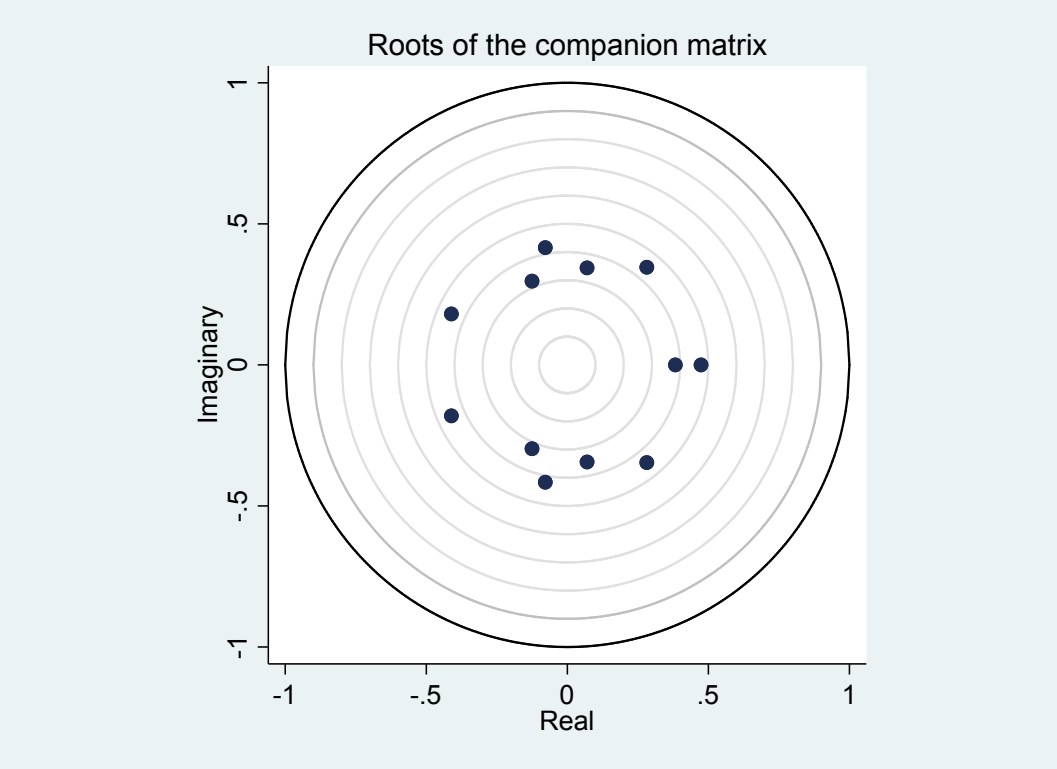
Lag- Selection Order Criteria

Panel VAR lag order selection on estimation sample Selection order criteria. Sample: 1977 - 2016			
lag	CD		
1	.4303646	No. of obs	400
2	.4774154	No. of panels	10
3	.4849749*	Ave. no. of T	40.000
4	.4355703		

Unit-root tests

Variable	Levin-Lin-Chu Adjusted t Statistic	Im-Pesaran-Shin W-t-bar Statistic	Conclusion
d_ln_y	-10.0542 P-Value: 0.0000	-10.0717 P-Value: 0.0000	Stationary
d_ln_s	-15.4856 P-Value: 0.0000	-17.0292 P-Value: 0.0000	Stationary
d_ln_amp	-11.6889 P-Value: 0.0000	-11.2649 P-Value: 0.0000	Stationary
d_ln_m	-23.6892 P-Value: 0.0000	-22.6434 P-Value: 0.0000	Stationary
Ho: All panels contain unit roots Ha: Panels are stationary Panel means: Included			

Appendix B



Eigenvalue	stability	condition
Real	Imaginary	Modulus
.4738398	0	.4738398
.4109701	.1805737	.4488912
.4109701	-.1805737	.4488912
.2816976	.3461975	.4463252
.2816976	-.3461975	.4463252
.0781909	-.415828	.4231155
.0781909	.415828	.4231155
.3828591	0	.3828591
.0700014	-.3440198	.3510696
.0700014	.3440198	.3510696
.12517	.2970661	.3223597
.12517	-.2970661	.3223597

Correlation matrix

	L.	L2.	L3.	L.	L2.	L3.	L.	L2.	L3.	L.	L2.	L3.
	d_ln_y	d_ln_y	d_ln_y	d_ln_s	d_ln_s	d_ln_s	d_ln_amp	d_ln_amp	d_ln_amp	d_ln_m	d_ln_m	d_ln_m
d_ln_y												
L1.	1.000											
L2.	0.3579	1.000										

L3.	0.0910	0.3508	1.000									
d_ln_s												
L1.	0.5994	0.1346	-0.1006	1.000								
L2.	0.0027	0.5709	0.0932	-0.0732	1.000							
L3.	-0.0424	0.0241	0.5683	-0.2005	-0.0547	1.000						
d_ln_amp												
L1.	0.5806	0.1933	0.0272	0.2025	0.0103	-0.0315	1.000					
L2.	0.3853	0.5917	0.2119	0.1912	0.1644	0.0012	0.2847	1.000				
L3.	0.1164	0.3321	0.6018	0.0080	0.1518	0.1999	0.0423	0.3125	1.000			
d_ln_m												
L1.	0.0473	0.0711	-0.1063	0.0839	0.0673	0.0047	-0.0894	0.0423	-0.0748	1.000		
L2.	-0.0856	0.0100	0.0542	-0.1297	0.0770	0.0763	0.0416	-0.0968	-0.0075	-0.2701	1.000	
L3.	0.0157	0.0143	0.0571	-0.0088	-0.1142	0.0416	-0.0177	0.0467	0.0736	0.0276		