Economic Growth and the Rate of Profit in Colombia 1967-2019: A VAR Time-Series Analysis

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Abstract

In recent decades there has been a growing literature dealing with the empirical estimation of the rate of profit and other Marxian variables in several countries. Nonetheless, there has been a paucity of econometric research about the impact of those Marxian variables on the growth rate in developing countries. This paper seeks to evaluate the rate of profit and the rate of accumulation as determinants of the growth rate in Colombia during 1967-2019, using a VAR model. We find that both variables are statistically significant and, in concordance with Marxian theory predictions, affect positively the growth rate. We also identify direct impacts of growth rate over the profit rate and the accumulation rate as well as an inverse relationship between these last variables.

JEL Classification: B51, C22, O54

Keywords: Marxian political economy, rate of profit, time-series analysis, Colombia.

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1. Introduction

In Marxian political economy, the dynamics of growth, and accumulation of capital are fundamentally driven by profitability. In recent decades there has been a growing interest in the Marxian literature in the estimation of the rate of profit, the analysis of its dynamic behavior, and the study of its impact on several economic phenomena. This literature has been also focused on the estimation and analysis of other relevant Marxian ratios as the rate of accumulation, the rate of surplus-value, and the organic composition of capital.

Within the most influential Marxian empirical literature about the rate of profit we find the works of Wolff (1979), Weisskopf (1979), Moseley (1991), and Shaikh (1992) for the US economy; the contribution of Cockshott, Cottrell, & Michaelson (1995) for the UK economy and the analysis of Mariña and Moseley (2000) for the Mexican economy. This literature has been expanded with estimations and analysis of the rate of profit in Spain (Cámara 2007), France (Clévenot, Guy, and Mazier 2010), Greece (Maniatis and Passas 2013), China (Gaulard 2018), South Korea (Jeong and Jeong 2020), Brazil (Marquetti, Maldonado Filho, and Lautert 2010), Argentina (Maito 2012) and Chile (Maito 2012), among other contributions and countries. The majority of these works have covered the postwar period and have been focused on the debate around the falling rate of profit.

In spite of the remarkable findings made by this literature, the empirical techniques employed have been mainly exploratory and descriptive statistics without a rigorous econometrical time-series analysis (Basu 2017). There are notable exceptions. Basu and Manolakos (2013) find evidence of the falling rate of profit for the US economy using an ARIMA model. Tapia (2013) uses Granger causality tests to find evidence of a causal direction from profits to investment in the US economy. Finally, Cámara (2005) uses a cointegration analysis to find evidence of two phases in the growth long wave for the Mexican economy in the postwar period.

The objective of this paper is to evaluate the rate of profit and the rate of accumulation as determinants of the growth rate in Colombia during 1967-2019, using a Generalized Vector Autoregressive (VAR) model, i.e., a VAR model with generalized impulse-response functions. The rest of this paper is organized as follows. Section 2 briefly reviews Marxian models of accumulation and growth. Section 3 describes the empirical model, the construction of the variables, and the data employed. Section 4 presents the descriptive statistics for the variables and a brief historical context. Sections 5 report the estimates obtained from the multivariate time-series model; this section also includes the integration analysis. Finally, section 6 sets out the conclusions.

2. Literature Review

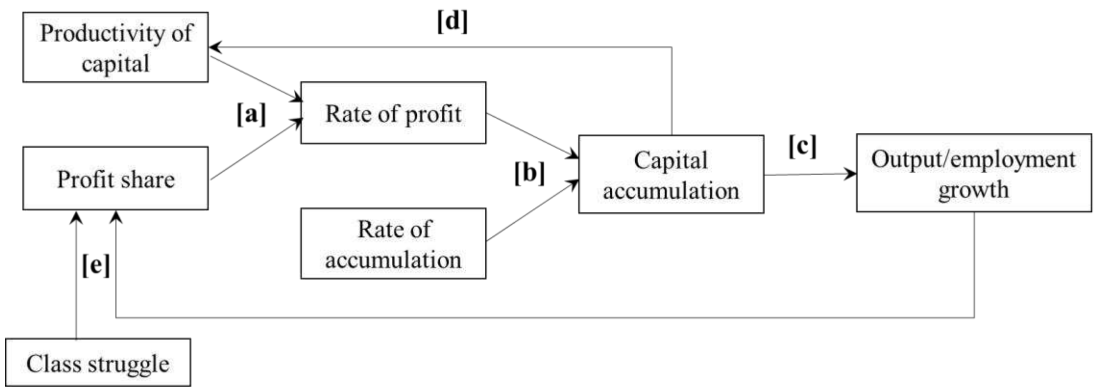
Since the 1980s, several Marxian macroeconomic models dealing with the representation of the aggregate dynamics of capitalism have been elaborated, including the relationship between the rate of profit and the growth rate. Foley (1986), in a model based on the circuit of capital (M-C…P…C´-M´), arrives at the *Cambridge equation*, where the growth rate is equal to the profit rate multiplied by the rate of accumulation (the share of profits accumulated). More recently, Basu (2014) presented a discrete version of Foley's model in which he also arrived at the Cambridge equation. According to this author, "the rate of expansion of the system is directly impacted by the rate of profit, and the rate of profit, in turn, is affected by both social and technological factors" (Basu 2014, 170). The Cambridge equation is also present in the Marxian growth models suggested by Laibman (1978), Harris (1983), Shaikh (1989; 2016), Duménil and Lévy (1999), Foley, Michl, and Tavani (2019), among others .

Shaikh (1989) presents a macroeconomic model where the aggregate supply and demand are fluctuating erratically around a cyclical growth path with an endogenous trend. Within this theoretical framework, Shaikh differentiates between a relatively fast adjustment process, related to the investment in circulating capital, and a relatively slow adjustment process, related to the investment in fixed capital. In both processes, profitability plays a key role. Accordingly, in a recent and enhanced presentation of his model, Shaikh (2016, 615) holds that "production is always initiated on the basis of prospective profit. Prospective profit is in turn regulated by actual profitability… circulating investment may be positive or negative, depending on estimated profits. In turn, fixed investment may expand or contract capacity, also dependent on individual prospects of profit over a longer time horizon." Thus, both short-run and long-run growth rates are positively determined by the rate of profit. A similar exposition can be also found in Duménil and Lévy (1999) and Cámara (2010; 2005).

On the other hand, Duménil and Lévy (1999), Shaikh (1989), and other Marxian authors share two levels of analysis: the (Keynesian) short run and the (classical) long run. In both levels, there is a positive relationship between the rate of profit and the growth rate, but the causal relation is different. In the short run, investment can determine both the growth rate and the rate of profit. However, in the long run, investment and growth are determined by the rate of profit that, in turn, is determined by both the technology and distributional issues (Duménil and Lévy 1999). The short run impact of economic growth on the rate of profit is also treated by Weisskopf (1979) and Cámara (2013) in the context of economic cycles. During an economic crisis, when the economic growth is negative, the fall in capacity utilization and the greater rigidity of wages in relation to profits generate a decline in the profit rate (Cámara 2013). On the contrary, a positive economic growth can generate an increase in the capacity utilization as in the profit share increasing the profit rate. Therefore, in a short run context, the growth rate and the profit rate can be viewed as endogenous variables.

Following Duménil and Lévy (2003), figure 1 summarizes the *general* relationships between economic growth and the Marxian ratios. The productivity of capital (the ratio between the income and the stock of capital) and the profit share in the income determine the rate of profit [a]; in turn, the rate of profit and the rate of accumulation determine the magnitude of capital accumulation [b]. Given the technical conditions of production, the accumulation of capital gives rise to a growth in output and employment [c]. In addition, the accumulation of capital induces a technical change that modifies the productivity of capital (and its ulterior profitability) [d]. Finally, the economic growth and the class struggle determine the ulterior dynamic in profit share [e].

FIGURE 1 General relationships of determination in a growth model



Source: Prepared by the author on the basis of Duménil and Lévy (2003), and Marquetti and Porsse (2014).

The dynamic interaction between the Marxian ratios and the economic growth is also related to the *technical change*. In figure 1, we can see that technical conditions of production change with the accumulation of capital: the increase of capital stock usually involves the adoption of new machinery and equipment, products, production techniques, and labor organization methods (Marx 1867). As a result, the productivity of labor and capital intensity tend to change affecting, in turn, the productivity of capital and the rate of profit (Blecker and Setterfield 2019; Foley, Michl, and Tavani 2019). These specific changes have been classified in different types of technical change (Harrod-neutral, Marx-biased, Solow-neutral, etc.) that affects the profit rate in different ways. On the other hand, the profit rate is, in turn, a crucial variable in the choice of technology since the capitalists choose technologies that maximize their profit rate (Marx 1894; Duménil and Lévy 2003). Finally, the (changing) technical conditions of production determine the degree to which accumulation translates into output and employment growth.

3. Model and Data

3.1. The Model

According with the previous literature review, the following general growth equation is estimated:

$$g = f_1(r, a) \tag{1}$$

where:

g = Growth rate of per capita Colombian GDP.

r = Rate of profit.

a = Rate of accumulation (or rate of capitalization of surplus-value)

Equation (1) relates the growth rate with the rate of profit and the rate of accumulation (see figure 1). According with the Marxian macroeconomic models reviewed in the previous section, we expect to find that, *ceteris paribus,* an increase in the rate of accumulation or in the profit rate will increase the growth rate. In section 5, equation (1) is estimated by a recursive VAR model which allow us to identify the dynamic response of growth rates to changes in the Marxian ratios.

3.2. Variables and Data

The empirical estimation of Marxian categories has been a controversial issue. Some authors have argued that Marxian ratios cannot be estimated from conventional national accounts since Marxian ratios are based on values that are abstract and unquantifiable by nature (Althusser, Balibar, and Brewster 1970). Nonetheless, there are several reasons that justify the use of conventional price-based statistics in the estimation of Marxian ratios. On the one hand, according to Cockshott, Cottrell, and Michaelson (1995) the Marxian ratios are dimensionless numbers, i.e., they are not expressed in value-labor or monetary units. Consequently, “since monetary ratios are *dimensionally* compatible with value ratios, using the former as an estimate of the latter is legitimate” (Cockshott, Cottrell, and Michaelson 1995) due to the close empirical lineal relation between labor values and prices (Shaikh 1998).

On the other hand, several authors have pointed out the monetary nature of Marx’s economic theory (Moseley 2016; Bellofiore 2005; Foley 1982; 2000; Kliman and McGlone 1999; Freeman 1996; de Brunhoff and Foley 2007). According to Bellofiore (2005): “In Volume I, capitalism as generalized commodity exchange is presented as an essentially monetary economy. Hence, it is impossible to have any dichotomy between the analysis of value and the theory of money. Value finds its necessary form of manifestation in money as the universal equivalent, which is at first linked to money as a commodity”. Furthermore, according to Moseley (2016, 9): “the central concept in Marx’s theory is the concept of capital, which is defined in terms of money, i.e., money advanced into circulation in order to withdraw more money from circulation”. Thus, constant capital, variable capital and surplus-value are also monetary magnitudes. In this paper, we adhere to this last approach.

The *rate of profit* is defined by Marx (1991, 133) as the ratio of the surplus-value to the total capital invested. Still, in Marxian literature, there are several methods to estimate the rate of profit from the national accounts data. Although a fuller treatment on this topic is out of the scope of this study, we briefly mention some critical issues. First, most authors only use the *stock* of fixed capital in the denominator (Mariña and Moseley 2000; Moseley 1991; Cámara 2007; Maito 2015; Shaikh and Tonak 1994). Second, some authors embrace the unproductive/productive labor debate and, consequently, subtract the unproductive wages from the surplus-value (Mariña and Moseley 2000) or only calculate the rate of profit for productive sectors (Jeong and Jeong 2020). Third, some authors use fixed capital calculated at historical costs (Carchedi and Roberts 2013) while the majority use fixed capital calculated at replacement costs (Duménil, Glick, and Rangel 1987; Moseley 1991; Marquetti, Maldonado Filho, and Lautert 2010). Finally, the Marxian literature registers two methods to deal with the *mixed income* (income from small unincorporated enterprises owned by households and self-employed workers, i.e., non-capitalist commodity production). Some authors divide that income into wages and profits (Shaikh and Tonak 1994; Marquetti, Maldonado Filho, and Lautert 2010) while others do not include it in the estimation of the Marxian ratios (Guerrero 1989; Mariña and Moseley 2000). In this paper, we adhere to this last approach as we explain later.

Following the majority of literature, we estimate the average rate of profit *before taxes,* r_t, for the overall Colombian economy as follows:

$$r_t = \frac{P_t}{K_t} \tag{2}$$

$$P_t = Y_t - W_t - MI_t - CFC_t \tag{3}$$

Where:

P_t = Estimated aggregated profits

K_t = Estimated stock of fixed capital

Y_t = Colombian GDP.

W_t = Employee compensation

MI_t = Mixed income (income from small non-capitalist commodity production)

CFC_t = Consumption of fixed capital

Colombia has no official measurement of capital stock and depreciation. Therefore, the Colombian fixed capital stock, K_t, from 1967 to 2019 was estimated from Colombian National Accounts data (DANE 2020) following the perpetual inventory method broadly used in the economic literature (Mariña 2001; Mariña and Moseley 2000; Harberger 1972). This method requires the series of fixed capital formation, assumptions over the annual depreciation rate for each kind of fixed capital, and an estimate of the initial capital stock. We obtained the fixed capital formation series from official Colombian statistics (DANE, 2020). Following other similar works in Mexico and Latin America (Mariña 2001), we assumed that non-residential buildings and other construction depreciate at 1/60 percent per year, while machinery and equipment depreciate at 1/15per year. Thus, we assumed service life of 60 years for buildings and 15 years for machinery and equipment. Finally, due to the lack of information initial, capital stock (year 1967) was estimated employing the method suggested by Harberger (1972) and also employed in other estimations of the fixed capital Stock in Colombia (Galeano et al. 2018). Within the fixed capital stock, we only included non-residential buildings and machinery and equipment. Residential buildings were excluded due to their non-capitalist nature, i.e., they are not fixed capital advanced to obtain surplus-value (Cámara 2007). Furthermore, as residential buildings are the main fixed asset in small non-capitalist sector, its exclusion allows us to adjust the fixed capital stock in coherence with the exclusion of mixed income (see equation 3). The fixed capital stock series was estimated at constant prices and, then, converted to current prices employing implicit price deflators for the fixed capital formation calculated from Colombian official statistics (DANE 2020).

The Colombian GDP and the employee compensation (both at current prices) were also obtained from official Colombian National Accounts data (DANE 2020). The consumption of fixed capital was estimated from the depreciation of the estimated fixed capital stock. Finally, the 'mixed-income', which is the income from small non-capitalist commodity production (like peasants, craftsmen, and peddlers), was obtain from Colombian official statistics for the 1995-2019 period while the mixed-income from 1967 to 1994 was estimated using the average share of the mixed-income in GDP during the 1995-2019 years. In the appendix, we report the series estimated for Y_t, P_t, K_t and other relevant variables employed in this study.

Following Marx (1990, 770) the *accumulation rate,* a_t*,* is the share of profits that is accumulated. This variable is also known as the *rate of capitalization of surplus-*

value (Foley 1982) or the *propensity to invest* in Post Keynesian literature. Mathematically:

$$a_t = \frac{I_t}{P_t} \tag{4}$$

Where, I_t is the gross fixed capital formation (excluding residential buildings), obtain from Colombian official statistics and P_t are the aggregate profits previously estimated, both variables in current prices. On the other hand, the growth rate, g_t, corresponds to the annual percentage growth rate of Colombian GDP per capita, y_t, on constant prices, obtained also from Colombian official statistics (DANE, 2020):

$$g_t = \frac{y_t - y_{t-1}}{y_{t-1}} \tag{5}$$

For descriptive purposes, we also calculate the decomposition of the rate of profit into the *profit share* and the *productivity of capital:*

$$r_t = \frac{P_t}{K_t} = \left(\frac{P_t}{Y_t^c}\right)\left(\frac{Y_t^c}{K_t}\right) \tag{6}$$

Where,

$$Y_t^c = Y_t - \ MI_t - CFC_t \tag{7}$$

As we exclude mixed income previously (see equation 3), both the profit share, P_t/Y_t^c, and the productivity of capital, Y_t^c/K_t, are calculated in relation to *the capitalist new value* (equation 7) which is the GDP less the mixed income and the consumption of fixed capital. The profit share reflects the impacts of *distributive* factors in the rate of profit while the productivity of capital (also known as the potential maximum rate of profit) reflects the impacts of *technological* factors in the rate of profit.

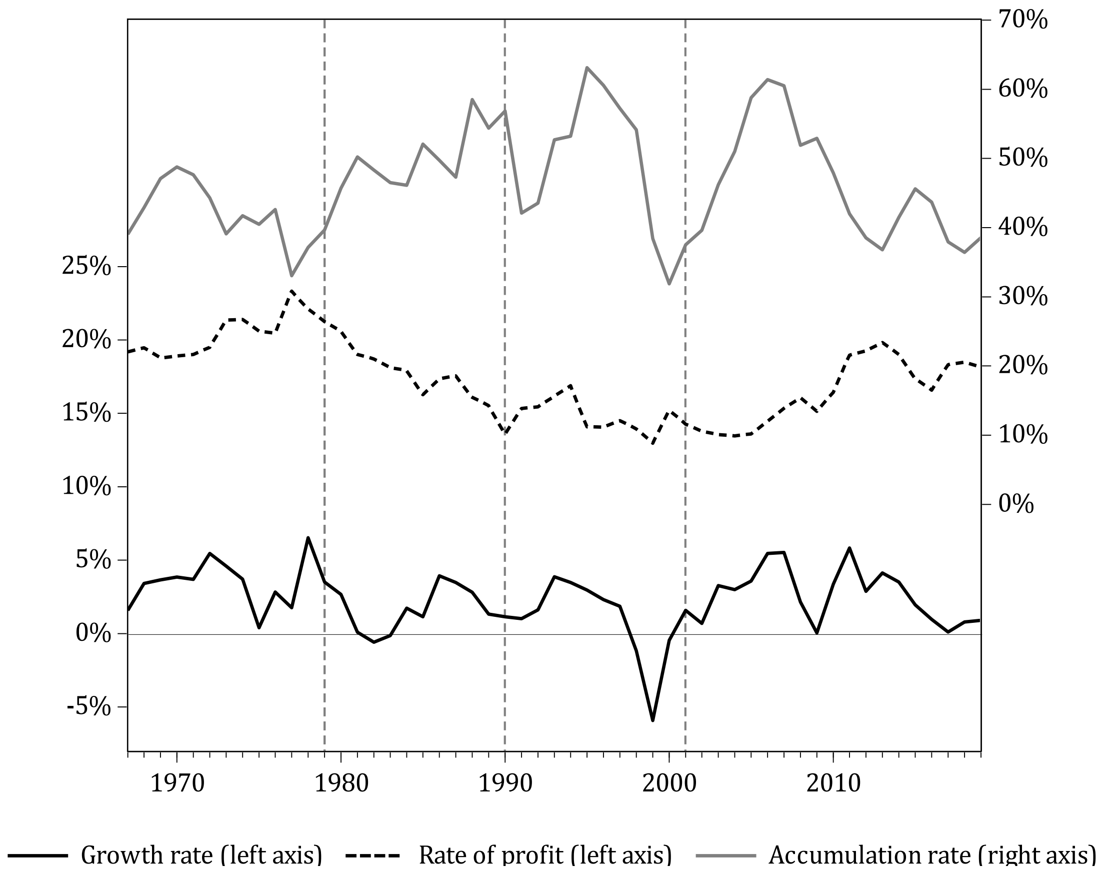
4. Descriptive Statistics and Historical Context (1967-2019)

In this section, we present time series plots of the growth rate and the estimated Marxian ratios. The plots use annual data from 1967 to 2019 (53 observations) for the overall Colombian economy. In general terms, we identify four periods: the import substitution industrialization (ISI) expansion (1967-79), the crisis of the ISI (1980-89), the neoliberal transition (1990-2000), and the neoliberal consolidation (2001-2019).

Figure 2 shows the trend of the Colombian growth rate, rate of profit, and accumulation rate from 1967 to 2019. During the whole period, the average rate of growth was 2.3 percent a year. The ISI expansion presented the highest average rate of growth (3.5 %), without an economic recession, while the industrial share in GDP increased from 21.1% in 1967 to 23% in 1979 (CEPAL 2020). In the 1980s, in the context of the debt crisis, the Colombian ISI model went into crisis: the average annual rate of growth was only 1.6%; an economic recession hit the country from 1982 to 1983, and the industrial share in GDP decreased to 21.4% in 1989 (CEPAL 2020). Thus, the Colombian economy followed a similar pattern to other Latin American countries like Brazil, México, and Argentina (Bulmer-Thomas 2003). During the ISI expansion, the rate of profit presented the highest average annual value (20.4%). Later, from 1977 to 1985, the rate of profit fell 7.1 percentage points marking the beginning of the ISI crisis. In fact, in figure 2 we can see that during the overall ISI crisis period, the rate of profit tended to decrease reaching 15.5% in 1989. This profitability crisis at the end of the 70s and during the 80s, also identified in other Latin American countries (Marquetti, Maldonado Filho, and Lautert 2010; Maito 2015), negatively impacted the economic growth and possibly boosted the neoliberal transition in the 1990s. Meanwhile, the accumulation rate during the ISI expansion was 41,8% on average and increased to 49,9% during the ISI crisis.

From 1990 to 2000 Colombian economy went through a series of neoliberal reforms in the context of an increasing confrontation between the Colombian state and left-wing guerrillas and other political turmoil (Álvarez 2006; Thomson 2011). The average rate of growth during the neoliberal transition was only 1% a year, the economy registered its worst recession in 1998-2000, and the industrial share in GDP fell to 14.5%. In this period, the rate of profit reaches its lowest levels (14.7% on average) although its decreasing pattern, from the 1980s, tends to stop. On the contrary, the accumulation rate increases vigorously during 1991-95, reaching 63,1% in 1995, to later collapse during 1996-1999 preceding and accompanying the end-of-the-century crisis.

FIGURE 2 Time series plots of the growth rate, the profit rate and the accumulation rate, Colombia 1967-2019



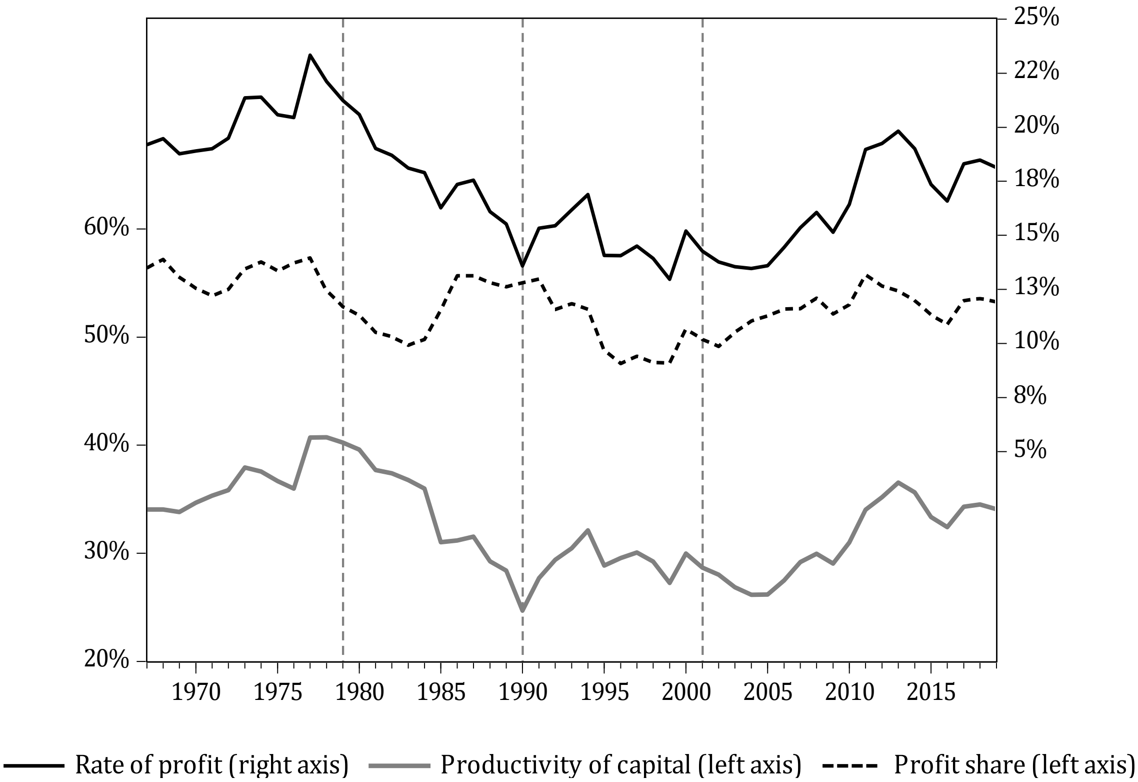
Source: Author´s estimations on the basis of annual data obtained from Colombian official statistics (DANE 2020).
Notes: The vertical dotted lines point out the four historical periods suggested: ISI expansion (1967-79), ISI's crisis (1980-89), neoliberal transition (1990-2000), and neoliberal consolidation (2001-2019).

Finally, from 2001 onwards the neoliberal order was consolidated in Colombia. Despite the continuous relative deindustrialization (the industrial share in GDP was only 10.9% in 2019), economic growth recovered. From 2001 to 2019 the annual average rate of growth was 2.6% due mainly to the growth in construction, with an average annual growth of 8.7%, utilities, with an average annual growth of 8.7%, and mining, with an average annual growth of 7% during the 2005-2014 "commodities boom" (DANE, 2020). During the neoliberal consolidation, the profit rate also recovered reaching 19.8% in 2013 and an average of 16.4% in those years. Nevertheless, neither the growth and the profit rates reached the average levels achieved during the ISI expansion. On the other hand, the accumulation rate presented an average of 45.7% with strong growth from 2001-2006 and a significant reduction from 2007 to 2013 in the context of the world economic recession.

We can look closer at the rate of profit dynamics analyzing its internal components: the productivity of capital, which reflects the effects of technology, and the profit share, which reflects the effects of distribution (see equation 6 and figure 3). The overall dynamic in the productivity of capital was quite similar to those observed for the profit rate. In the course of the ISI expansion, the productivity of capital tended to increase reaching a maximum peak of 58.1% in 1977, while its average in this phase was 36.7%. Meanwhile, the profit share was relatively stable around an average of 55.6% in this phase (in the context of the authoritarian Colombian "national front"). As a consequence, the rate of profit tended to grow thru the ISI expansion.

On the contrary, during the ISI crisis, the productivity of capital declined from 39.6% in 1980 to only 24.7% in 1990. The diminishing productivity of capital during the ISI crisis was accompanied by a significant reduction of the profit share at the end of the 1970s and the beginning of the 1980s. All in the context of a boom in workers' struggle during the 1970s and the general strike of 1977 (Archila 2002). In fact, between 1980 and 1984 real wages increased: 21.7% for industrial workers, 44.9% for construction workers, and 22.8% for services workers (Urrutia and Ruiz 2010). Thus, the profit share in the capitalist new value decreased from 57.3% in 1977 to 49.8% in 1984. The combined effect was a profitability crisis during the 1980 decade.

FIGURE 3 Time series plots of the rate of profit, the productivity of capital, and the profit share, Colombia 1967-2019



Source: Author´s estimations on the basis of annual data obtained from Colombian official statistics (DANE 2020).
Notes: The vertical dotted lines point out the four historical periods suggested: ISI expansion (1967-79), ISI's crisis (1980-89), neoliberal transition (1990-2000), and neoliberal consolidation (2001-2019).

With the neoliberal transition, the productivity of capital recovered moderately (especially during 1990-94) reaching an average of 29% in this period and, with the neoliberal consolidation, the productivity of capital presented an increasing tendency. However, as in the profit rate case, it did not recover the average levels of the first period: during the neoliberal consolidation, the average productivity of capital was 31.2% (compared with the 36.7% average in the course of the ISI expansion). Onward out the Turbay government (1978-82), the political repression against the Colombian working-class and left-wing organizations was intensified (Archila 2002). Thus, throughout the ISI crisis and the neoliberal transition, far-right-wing violence lead to a progressive weakening of workers' movement and a tendential recovery of the profit share finally achieved in the neoliberal consolidation. Therefore, the recovery in both the productivity of capital and profit share, throughout this final stage, explains the growing pattern in the Colombian rate of profit in the last decades.

5. VAR time-series analysis

A VAR model provides a powerful framework to capture and analyze the dynamics of multiple time-series. According to Stock and Watson (2001): "A VAR is an *n*-equation, *n*-variable linear model in which each variable is in turn explained by its own lagged values, plus current and past values of the remaining *n*-1 variables". This methodology allows us to estimate short-run impacts of the Marxian ratios over the growth rate as well as dynamic interactions among the Marxian ratios (see figure 1). This section estimates a VAR model using least-squares algorithms, based on equation (1) (see also figure 1). Due to VAR models require stationary variables to avoid spurious regressions, the first step is to identify the order of integration of the variables using unit root and stationary tests.

5.1. Integration Analysis

Due to every unit root and stationary test has statistical advantages and disadvantages, three different standard tests were used: the Augmented Dickey-Fuller (ADF) test (Dickey and Fuller 1979), the Phillips-Perron (PP) test (Phillips and Perron 1988), and the Kwiatkowski, Phillips, Schmidt, and Shin (KPSS) test (Kwiatkowski et al. 1992). The results of those tests are presented in table 1. While the growth rate is clearly stationary, i.e., I (0), the other variables can reasonably be treated as integrated variables of order 1 in levels, and stationary in terms of first differences.

TABLE 1 Unit Root and Stationarity Test, Colombia 1967-2019

Variable	Specification of the test equation	Unit Root tests [a]		Stationarity test [b]	Order of integration
		ADF[c]	PP[d]	KPSS[e]	
g_t	None	-2.45**	-2.23**	N.D.	
	Only intercept	-3.84***	-3.88***	0.12	I(0)
	Trend and intercept	-3.89**	-3.94**	0.08	
a_t	None	-0.43	-0.45	N.D.	
	Only intercept	-3.20**	-2.68*	0.14	I(1)
	Trend and intercept	-3.14	-2.62	0.14*	
Δa_t	None	-6.35***	-6.31***	N.D.	
	Only intercept	-6.29***	-6.24***	0.08	I(0)
	Trend and intercept	-6.25***	-6.19***	0.03	
r_t	None	-0.37	-0.36	N.D.	
	Only intercept	-1.64	-1.64	0.41*	I(1)
	Trend and intercept	-1.53	-1.53	0.18**	
Δr_t	None	-7.30***	-7.33***	N.D.	
	Only intercept	-7.23***	-7.26***	0.15	I(0)
	Trend and intercept	-7.22***	-7.28***	0.09	

Notes: Author´s estimations on the basis of annual data obtained from Colombian official statistics (DANE 2020). N.D. = not defined. Δ = first differences. *, **, *** denotes rejection of the null hypothesis at the 10%, 5%, and 1% significance levels, respectively. [a] Null hypothesis: unit root, [b] Null hypothesis: stationarity, [c] Augmented Dickey-Fuller test, [d] Phillips-Perron test, [e] Kwiatkowski–Phillips–Schmidt–Shin test. In the ADF tests, the Schwarz Information Criterion was used to determine the lag length of each test equation. In the PP and KPSS tests we control the bandwidth using the Newey-West bandwidth selection method and the Bartlett kernel.

The second diagnostic test related to the integration analysis is a test of parameter stability. We applied the Bai and Perron (2003) methodology to identify multiple structural breakpoints in the stationary variables ($g_t, \Delta a_t, \Delta r_t$) used in the VAR analysis. The results, presented in the appendix, suggests that there is no significant structural change.

5.2. VAR Model

The general specification of our VAR model with stationary variables, based on equation (1), can be represented in the following form:

$$\boldsymbol{Y_t} = \boldsymbol{B_0} + \boldsymbol{B_1}\boldsymbol{Y_{t-1}} + \cdots + \boldsymbol{B_p}\boldsymbol{Y_{t-p}} + \boldsymbol{\varepsilon_t} \qquad (8)$$

Where:

$\boldsymbol{Y_t} = \begin{bmatrix} g_t \\ \Delta a_t \\ \Delta r_t \end{bmatrix}$ is a 3x1 vector of variables of the VAR model.

B_0 is a 3x1 vector of intercept terms, and $\{B_i,\ i = 1, 2, \dots p\}$ are 3x3 coefficient matrices of the VAR model. On the other hand, ε_t is a 3x1 vector of shocks. It behaves according to the following assumptions: $E(\varepsilon_t) = 0,\ E(\varepsilon_t, \varepsilon_t{}') = \Lambda$, for every *t,* where $\Lambda = \{\sigma_{ij},\ i,j = 1, \dots, 3\}$ is a normal diagonal positive definite matrix, while $E(\varepsilon_t, \varepsilon_s{}') = 0$ for every *t* and *s*, $t \neq s$, in the set 1,…, T. Due to the covariance matrix of innovations (Λ) is a non-diagonal, the elements of ε_t are contemporaneously correlated. A Cholesky decomposition of matrix Λ was used by Sims (1980) in order to orthogonalize the VAR residuals. However, the resulting variance decompositions, Granger causality tests, and impulse-response functions are sensitive to the ordering of the equations in the VAR model. Thus, in *recursive* VAR models "the results depend on the order of the variables: changing the order changes the VAR equations, coefficients, and residuals, and there are *n!* recursive VARs representing all possible orderings" (Stock and Watson 2001).

5.3. Generalized Impulse-Response Functions

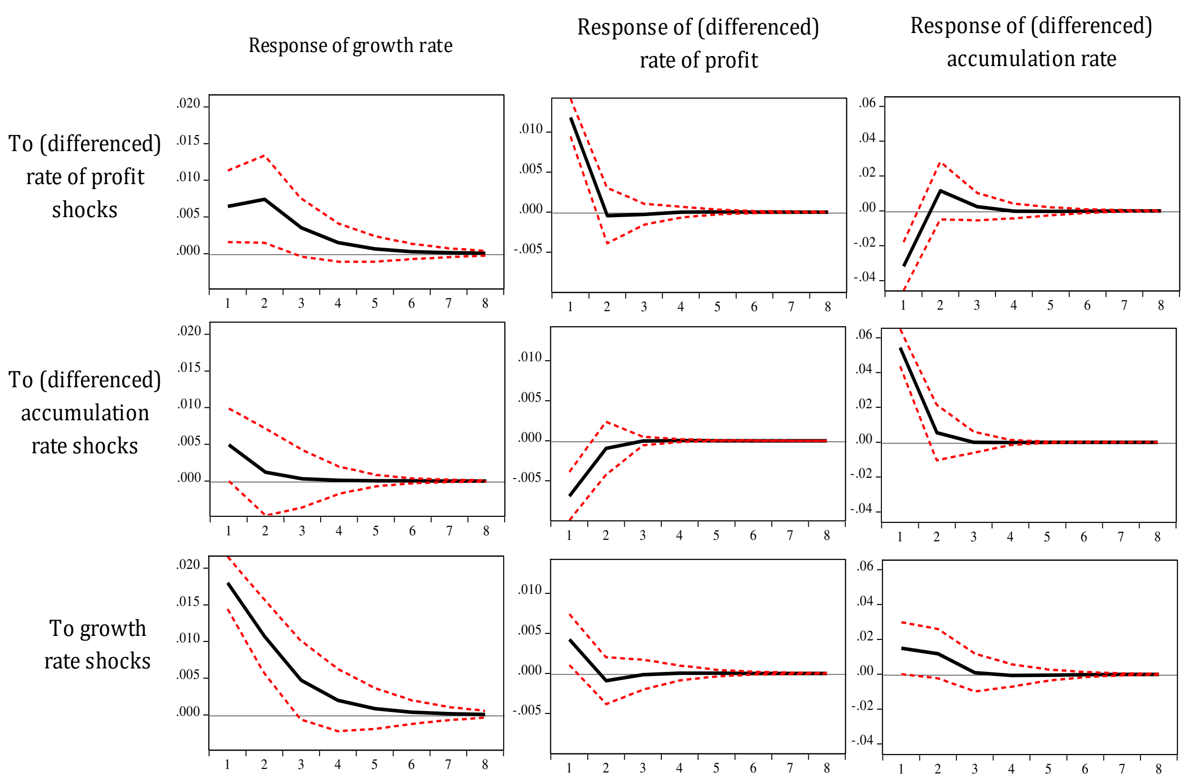
To avoid the ordering limitations of recursive VAR models, we use the generalized impulse-response approach suggested by Pesaran and Shin (1998). In this approach, the impulse-response analysis is invariant to the ordering of the variables in the VAR. The basic results for eight-year impulse-response functions with 95% confidence intervals (for establishing statistical significance) are reported in figure 4[2].

[2] Overall results should be treat with caution since the size sample (53 observations) lies in the boundaries of an adequate sample size to make any inference using these procedures.

We estimated the VAR model with one lag, following the Hannan-Quinn (HQ) and the Akaike information criterion (AIC).

The first column in figure 4 shows the dynamic responses of growth rate, g_t, to shocks in the same variable as well as in Δa_t and Δr_t. Each shock corresponds to a one-standard-deviation increase in the variable, which is unexpected and transitory as it lasts for one period (one year) only. We can see that positive shocks in both Δa and Δr_t raise the growth rate in the short-run. However, the effect of Δr_t is stronger and more durable (two years) on the growth rate. These results are consistent with the theoretical predictions of the Marxian models and the *Cambridge equation*: growth rate will increase with the profit rate and the accumulation rate.

FIGURE 4 Generalized Impulse Responses in VAR (1) model, Colombia 1967-2019



Notes: Author´s estimations on the basis of annual data obtained from Colombian official statistics (DANE 2020). Shocks of one standard deviation. Dot lines correspond to 95% confidence intervals.

VAR analysis also allows us to explore the dynamic interactions between the rate of profit and the accumulation rate. Thus, the third column in figure 4 reports that, in the short-run, a positive shock in the rate of profit, Δr_t, has a negative (and statistically significant) effect over the rate of accumulation, Δa_t. Similarly, in the second column, we can see that a positive shock in the rate of accumulation has a negative effect over the rate of profit. This negative simultaneous relationship between Δr_t and Δa could be tentatively explained by the "compulsive" necessity of capital expansion. According to Marx "competition subordinates every individual capitalist to the immanent laws of capitalist production, as external and coercive laws. It compels him to keep extending his capital, so as to preserve it, and he can only extend it by means of progressive accumulation" (Marx 1990, 739). As the magnitude of capital accumulated is a share of the profits, a reduction in the profit rate will reduce the *magnitude* of profits and, therefore, the amount of capital accumulated. Thus, in the short-run, to expand the capital in the required magnitude, the capitalist must increase their rate of accumulation when the profit rate decreases.

On the other hand, as we have seen in figure 1 and the literature review, the accumulation of capital and the output growth also can affect the profit rate and the rate of accumulation. This *feedback effect* is clearly visible in the VAR analysis: in the bottom row of figure 4, we can see that positive shocks in the growth rate do not only affect the economic growth but also Δr_t and Δa_t. Therefore, a positive economic growth can increase both the capacity utilization and profit share stimulating the profit rate as well as the rate of accumulation. The econometrical diagnostics for the VAR (1) model is reported in the appendix.

6. Conclusions

This paper provides an econometric analysis of the impact of the rate of profit and the rate of accumulation over the growth rate in Colombia. Using data from Colombian official statistics (DANE, 2020), we estimate the rate of profit, the rate of accumulation, the profit share and the productivity of capital for Colombia from 1967 to 2019. The general pattern in the variables allows us to identify four phases in the postwar Colombian economy: the ISI expansion (1967-79), with relatively high profitability and growth; the ISI crisis (1980-89), with low profits and growth; the neoliberal transition (1990-2000), with moderate profitability and low growth; and the neoliberal consolidation (2001-2019), with high profitability and moderate growth (see figure 2).

Performing a Vector Autoregressive (VAR) estimation with generalized impulse-response functions, we find that positive shocks in the rate of accumulation and the rate of profit raise the growth rate in the short-run. A feedback effect from the growth rate to the Marxian variables was also founded. All those results are consistent with and provide empirical support for the Marxian macroeconomic models reviewed in this paper. In those models, the growth rate is a process driven by the behavior of the rate of accumulation and rate of profit. The VAR models also allow us to explore the dynamic interactions between the Marxian ratios. We find an inverse simultaneous relationship between the rate of accumulation and the rate of profit. This finding could be explained by the compulsion to capital expansion in a context of decreasing profits.

The results presented in this paper expand the body of Marxian empirical research on the rate of profit. Our econometrical analyses provide empirical support for the Marxian claim about the fundamental role of the rate of profit, and its constituent elements, in the accumulation of capital and, consequently, in the economic growth.

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7. Appendix

TABLE 2. Estimates for fixed capital stock (*K*), GDP (*Y*), profits (*P*), rate of profit (*r*), growth rate (*g*) and rate of accumulation (*a*), Colombia 1967-2019. Values in billions of Colombian current prices.

Year	K	Y	P	r	g	a
1967	227.9	112.6	43.7	19.2%	1.6%	39.1%
1968	262.1	129.5	51.0	19.5%	3.4%	42.9%
1969	303.6	149.0	57.0	18.8%	3.7%	47.1%
1970	352.6	177.1	66.6	18.9%	3.8%	48.8%
1971	406.4	207.6	77.3	19.0%	3.7%	47.6%
1972	487.9	252.5	95.1	19.5%	5.5%	44.3%
1973	594.3	323.9	126.9	21.4%	4.6%	39.1%
1974	795.3	429.6	170.1	21.4%	3.7%	41.7%
1975	1,021.4	540.0	210.2	20.6%	0.4%	40.5%
1976	1,341.5	697.1	274.4	20.5%	2.8%	42.6%
1977	1,581.5	919.4	369.0	23.3%	1.8%	33.1%
1978	2,036.4	1,184.9	450.3	22.1%	6.5%	37.1%
1979	2,705.1	1,556.8	574.7	21.2%	3.5%	39.7%
1980	3,653.3	2,072.3	752.0	20.6%	2.7%	45.7%
1981	4,796.4	2,601.3	911.9	19.0%	0.1%	50.2%
1982	6,112.4	3,289.2	1,143.3	18.7%	-0.6%	48.3%
1983	7,612.6	4,032.2	1,378.3	18.1%	-0.1%	46.5%
1984	9,779.1	5,074.9	1,750.9	17.9%	1.7%	46.1%
1985	14,399.4	6,528.8	2,343.0	16.3%	1.1%	52.1%
1986	19,438.2	8,846.9	3,373.9	17.4%	3.9%	49.7%
1987	24,932.7	11,466.9	4,376.1	17.6%	3.5%	47.3%
1988	35,768.4	15,391.8	5,757.3	16.1%	2.8%	58.5%
1989	47,397.0	19,876.2	7,357.1	15.5%	1.3%	54.4%
1990	71,080.4	26,371.0	9,655.4	13.6%	1.1%	56.9%
1991	83,297.2	34,169.8	12,771.1	15.3%	1.0%	42.1%
1992	102,216.7	44,199.9	15,786.1	15.4%	1.6%	43.5%
1993	131,899.9	58,931.9	21,337.4	16.2%	3.9%	52.7%
1994	164,637.0	77,147.1	27,796.0	16.9%	3.5%	53.2%
1995	210,851.0	96,403.4	29,680.9	14.1%	3.0%	63.1%

1996	258,907.1	117,183.9	36,396.5	14.1%	2.3%	60.6%
1997	311,932.9	141,383.1	45,240.3	14.5%	1.9%	57.2%
1998	365,860.5	163,598.5	50,965.4	13.9%	-1.2%	54.1%
1999	426,509.2	177,038.3	55,317.6	13.0%	-5.9%	38.4%
2000	445,774.5	200,762.3	67,762.3	15.2%	-0.5%	31.9%
2001	507,065.3	219,063.4	72,355.8	14.3%	1.6%	37.5%
2002	562,072.2	237,505.6	77,396.4	13.8%	0.7%	39.6%
2003	666,275.2	268,144.1	90,257.5	13.5%	3.3%	46.2%
2004	771,065.8	302,514.7	103,863.7	13.5%	3.0%	51.0%
2005	862,485.6	337,958.3	117,274.1	13.6%	3.6%	58.8%
2006	934,820.4	381,604.1	135,077.9	14.4%	5.5%	61.4%
2007	992,259.4	428,505.9	152,343.6	15.4%	5.5%	60.5%
2008	1,085,454.2	476,554.2	174,339.9	16.1%	2.1%	51.9%
2009	1,183,993.1	501,574.1	179,243.7	15.1%	0.0%	52.9%
2010	1,220,926.2	544,060.1	200,618.7	16.4%	3.4%	47.9%
2011	1,289,022.5	619,023.4	244,503.4	19.0%	5.8%	42.0%
2012	1,347,807.4	666,507.3	259,468.2	19.3%	2.9%	38.5%
2013	1,397,963.5	714,092.9	277,093.9	19.8%	4.1%	36.8%
2014	1,520,666.5	762,903.0	289,099.2	19.0%	3.5%	41.5%
2015	1,684,436.1	804,692.0	292,338.5	17.4%	2.0%	45.6%
2016	1,832,936.1	863,782.0	303,953.2	16.6%	1.0%	43.7%
2017	1,951,895.3	920,471.0	357,390.6	18.3%	0.1%	38.0%
2018	2,096,617.0	987,791.0	387,578.4	18.5%	0.8%	36.4%
2019	2,286,382.1	1,061,119.0	414,667.4	18.1%	0.9%	38.6%

Source: Author´s estimations on the basis of annual data obtained from Colombian official statistics (DANE 2020).

VAR (1) diagnostics

Table 3 reports the results of the multivariate serial correlation LM tests for the VAR (1) model. The LM statistics and their corresponding *p*-values suggest the absence of serial correlation up to a lag order of five. On the other hand, to show that the model satisfies the stability condition, the inverse roots of the characteristic autoregressive polynomial were also calculated. As the table 4 shows, all roots have an absolute value (modulus) of less than 1 and lie within the unit circle. This implies that the overall models are stable and stationary. In addition, table 5 reports the results of the White heteroscedasticity test indicating there is no evidence of heteroscedasticity. Finally, in table 6 are reported the results of the normality tests for the VAR (1) model. We find that two of three variables in the model follow a normal distribution.

TABLE 3 Multivariate serial correlation LM test, 1967-2019

	VAR 1	
Lag order (p)	**LM-Statistics**	**Probability**
1	6.177372	0.7220
2	5.896473	0.7502
3	5.871133	0.7527
4	2.042616	0.9908
5	9.968907	0.3530

Notes: Author´s estimations on the basis of annual data obtain from Colombian official statistics (DANE 2020). Null hypothesis: there is no serial correlation at lag order (p).

TABLE 4 Stability condition test, 1967-2019

VAR (1) Root	Modulus
0.434317	0.434317
0.117350 - 0.099685i	0.153975
0.117350 + 0.099685i	0.153975

Notes: Author´s estimations on the basis of annual data obtain from Colombian official statistics (DANE 2020). All inverse roots have an absolute value (modulus) < 1, so the stability condition is fulfilled.

TABLE 5 White heteroscedasticity tests for VAR residuals, 1967-2019

Joint test	**VAR (1)**
Degrees of freedom	36
Chi-Squared statistic ($\chi 2$)	35.28261
Probability	0.5025

Notes: Author´s estimations on the basis of annual data obtain from Colombian official statistics (DANE 2020). White test does not include cross terms.

TABLE 6 Normality tests for VAR residuals, 1967-2019

Component	Jarque-Bera	Prob.
1	1.17	0.5569
2	0.98	0.6125
3	10.65	0.0049
Joint	12.81	0.0462

Notes: Author´s estimations on the basis of annual data obtain from Colombian official statistics (DANE 2020). Null hypothesis: residuals follow a multivariate normal distribution. Orthogonalization: Cholesky (Lutkepohl)