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THE IMPACTS OF UNCERTAINTY, INVESTMENT, AND INTEREST RATE ON THE INDUSTRIAL PRODUCT: EMPIRICAL EVIDENCE WITH THE PVAR MODEL

Os Impactos da Incerteza, do Investimento e da Taxa de Juros sobre o Produto Industrial: Evidências Empíricas com o Modelo PVAR

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RESUMO

Objetivo: As taxas de juros e a incerteza devem desempenhar um papel importante nas decisões dos agentes. Este estudo tem dois objetivos principais. Primeiramente, verificamos o impacto dos choques de investimento e das taxas de juros reais sobre a produção industrial dos países do Mercosul utilizando o modelo PVAR por meio do sistema GMM (1997-2016). Os resultados das estimativas mostram, por um lado, que a produção industrial responde de forma positiva e estatisticamente significativa às variações dos investimentos e, por outro, responde negativamente às variações das taxas de juro reais. O teste de causalidade de Granger sugere que os investimentos e as taxas de juros de Granger causam o produto industrial. Em segundo lugar, apresentamos evidências empíricas do papel das incertezas no processo de tomada de decisão de investimento dos agentes, considerando apenas o caso do Brasil (2002-2016). Verificamos que o produto industrial e os investimentos aumentam com a confiança dos agentes no comportamento futuro do governo federal, mas diminuem quando as incertezas aumentam.

PALAVRAS-CHAVE: Incerteza, literatura pós-keynesiana. Taxa de Juros. Investimento. Produção Industrial.

ABSTRACT

Objective: Interest rates and uncertainty are supposed to play an important role in agents' decision. This study has two objectives. First, we examine the impact of investment and real interest rate shocks on industrial product in Mercosur countries using the PVAR model through the GMM system (1997-2016). The results of the estimates show, on the one hand, that industrial product responds positively and statistically significant to changes in investments and, on the other, it responds negatively to changes in real interest rates. Granger's causality test suggests that investments and interest rates Granger cause the industrial product. Second, we present empirical evidence of the role of uncertainties in agents' investment decision-making process, considering only the case of Brazil (2002-2016). We found that the industrial product and investments increase with the agents' confidence in the future behavior of the federal government, but they decrease when uncertainties raise.

KEYWORDS: Uncertainty, post-Keynesian literature. Interest rate. Investment. Industrial production.

1   INTRODUCTION

Although macroeconomic variables, such as the level of output, the exchange rate, and employment, are impacted by the interest rates, investments are fundamentally determined by the behavior of interest over time (KEYNES, 1936; DAVIDON, 2002). The macroeconomic situation can be predicted, taking into account the role of the interest rates that guide agents' decisions regarding how to conserve assets in the alternatives available, such as portfolios net or illiquid investment. Keynes argues that the necessary condition for liquidity preference is uncertainty regarding the future behavior of interest rates. The expectation regarding the future of interest rate does not depend on individual opinion but the psychology of the mass. Hence, if the agent's expectation is such that the expected interest rates will be above what was predicted by the market, there is a good reason for agents to keep their wealth in the liquid form (KEYNES, 1936).

In the last chapter of his General Theory of Employment, Interest, and Money (hereafter referred to as the General Theory), Keynes (1936) argued that the entrepreneurial economy is characterized by two fundamental defects, its inability to generate full employment and income inequalities. The argument that capitalism is incapable of generating aggregate demand sufficiently capable of sustaining full employment justifies the existence of general theory by Keynes (CARDIM, 2008). The deficiency of effective demand would justify the intervention by policymakers aiming at reducing non-probabilistic uncertainty in the decision-making process.

By discussing income inequalities between the rich and poor, particularly in Great Britain, Keynes argues that reducing the propensity to save by taxation can improve product growth. However, the crucial argument in Keynes' discussion of the future of income inequalities is the role of the interest rate. In chapter 13 of the General Theory, he argues that the amount of discretionary savings depends on the volume of investments in each period. Such volume decreases as the interest rate rises. As a result, the interest rate must be reduced to guarantee full employment (KEYNES, 1936, p.343).

Keynes and Post-Keynesians (PK) believe in the potential of an economic policy to generate effective demand. Given the preference for liquidity, changes in the monetary quantity affect the volume of investment and consumption, even in the short term, through its direct impact on current interest rates and asset yields.

Empirically, this finding has been extensively examined in the literature. However, the critical variable that explains employment and output variations in the General Theory mainly depends on the mood of entrepreneurs. They decide to invest based on expectations about profits after selling their products. For key, considerations that inform such expectations are based, in part, on knowledge of existing facts and, in part, by those that can only be predicted with a greater or lesser degree of confidence, among them future changes in capital equipment stock and demand. The "the state of psychological expectation" of which these predictions are part is what Keynes refers to as long-term expectation. Keynes' main argument is that the state of long-term expectation depends not only on the most likely predictions that investors make but also on the confidence to which they make them (KEYNES, 1936; RUNDE, 1997). The state of confidence, in turn, is subject to waves of optimism from agents. In the context of confidence shocks, do interest rates still have a positive impact on Keynesian quantities such as investment and output?

This paper has twofold objectives. First, we examine the sensitivity of industrial output to changes in investments and interest rates of effective and observer members of Mercosur countries using the PVAR model and the Generalized Method of Moments (GMM System) between 1997 to 2016. Second, we analyze the role of uncertainties in the agents' investment decision-making process, considering only the case of Brazil (2002-2016) because it is the only country in our sample with a confidence index on the government policies.

This study builds on Keynes and Post-Keynesian economic policy studies and their interpretations regarding the concept of uncertainty. Since the classical theory deals with a real exchange economy, that is, without money, Keynes' economy (1936) is a monetary one, that is, an economy of production where money influences the transactions and agents' decisions. Because decisions in the capitalist economy we live in are made based on an uncertain future, money offers psychological security against non-probabilistic uncertainty. Uncertainties deal with the class of events for which the outcome of actions cannot be known, that is, those events for which it would not be possible to make probabilistic calculations of their likely effects but often their frequency. Uncertainties have particular properties: they are neither insurable nor analogous to the risk of a game (DAVIDSON, ibidem). There is no way to know a priori the likely future results of actions in the present. The most we can do is to conjecture about such effects, but all that can be achieved, even if taken under certainties, depends primarily on the state of our expectations (Davidson, 2002).

Keynes' basic proposition is that, due to the uncertainties underlying the property of a non-ergodic world, a capitalist economy can operate below full employment. Therefore, the capitalist economy has as its main characteristic the insufficiency of aggregate demand. In general theory, Keynes qualifies this statement in Chapter 3, which addresses the principle of effective demand. A business-base-economy is organized by entrepreneurs who create productive arrangements called companies with the sole purpose of bringing together the production factors as to obtain the maximum profit; that is, they are machines for the expansion of wealth (CARDIM, 2008, p.12).

Entrepreneurs are responsible for employing productive factors, and all unemployment occurs because workers were laid off; that is, involuntary unemployment is a fundamental characteristic of the business economy. Thus, under certain technical conditions of resources and costs of production factors, whether for industry or the individual firm, the total amount of employment in an economy depends fundamentally on the level of revenue that entrepreneurs expect to receive from the corresponding production (KEYNES, 1936, p.60).

However, as revenues and profits are generated only after sales are made, both employment and output depend on expectations on demand. According to Davidson (2002), in a non-ergodic world of non-probabilistic uncertainty regarding the future behavior of behavioral variables, if expectations are favorable concerning future quasi-rent, entrepreneurs will find sufficient reasons to justify the increase in investments. When pessimism reigns in the business environment, there is an orderly financial asset market where entrepreneurs can convert their illiquid assets to more liquid assets, resulting in the remobilization of resources from the productive side to the financial sector. In such a circumstance, not only will the amount of investment in the economy be reduced, but the level of economic activity will reduce as well, and the economy will be operating below full employment, with a large number of individuals being involuntarily unemployed. Similarly, the demand for liquid assets such as money leads to employment and wealth losses (CARDIM, 2008, p.13). In words by Minsky (1986):

> Instability increases uncertainty. It's harder to make decisions in an economy that changes drastically than in an economy that changes gradually. Increased uncertainty, by itself, is a dampener for economic activity, especially long-term investment. But a more important point, particularly under capitalism, is that instability tends to be amplified. Decision makers start looking for early warning signs and become too sensitive to short-term indicators of change in the economy. One result is that investors are beginning to prefer the large immediate financial gains that can be obtained by being right in the swings about longer-lasting and safer gains,

although smaller ones can be made by investments that facilitate economic growth and long-term development (chapter 02, p.18).

For Keynes, State intervention would be justified, in this context, to minimize uncertainties and to allow resources mobilization for the productive sector. For Post-Keynesians, in the presence of radical uncertainty, the government's responsibility is to influence individual spending decisions to ensure that there is never a persistent lack of effective demand for industry products (CARDIM, 2008). According to Davidson (2002, p.10), government operating budgets must be kept balanced. However, in case of insufficient private expenditure to produce full employment, the government must generate a capital account deficit to employ resources to production with the cooperation of the private sector.

We have two propositions for the Post-Keynesian economic policy: full employment and macroeconomic stability policies (FRITZ et al., 2016). The first proposition is that a capitalist economy with a fragile financial structure supports an interventionist government (MINSKY, 1986; DAVIDSON, 2002; CARDIM, 2008). The government's impact is more substantial than we can imagine; it can stabilize both employment and income, as well as cash flows and, therefore, the industrial product.

In his analysis of the impact of "Big Government", Minsky (1986) divides the effects of government deficits into three categories: the income and employment effect, which, according to him, operates through the government demand for goods, services, and labor; the budgetary effect works through industrial product and public deficits; and the portfolio effect, which, for him, exist because the financial instruments destined to fund a deficit must appear in the portfolio of the firm. The first effect is the same as in conventional product determination models. The government can impact employment and income through current spending with employed, health care, transfers, or lowering taxes. These expenditures may increase disposable income, impacting demand for goods and affecting the level of economic activity and industrial product. The second effect derives from the accounting identity. Each time some unit (family, company, or government) uses the money to purchase the product, some other unit receives the same money. Thus, the sum of the excess financial resources and deficits in all departments must equalize. During the economic crisis, household and business deficits can only be offset through a government budget deficit responsible for increasing business cash flows. That said, the indebtedness capacity of companies and the safety margins in the lending system can only be sustained by a fiscal

deficit, hence the third effect of the government deficit on industrial product, according to Minsky (1986).

We build on and advance to this literature in several directions. First, to our knowledge, few studies, from a post-Keynesian perspective, assess the effects of the interest rate (and with expectations) and investments on industrial production using models that incorporate the state of confidence, a fundamental component for Keynes's considerations about the investment decisions by entrepreneurs. An induced downward movement of interest rates may not have the expected positive effects of increasing investments if the confidence state is sufficiently low to the point of compromising earnings expectations. Thus, our consideration of the term interest rate policy, rather than monetary policy, shares the same spirit as Sawyer (2014): the interest rate is a policy instrument configured by the central bank to affect other macro variables, but we do not consider its effect on the monetary stock, thus avoiding variations, for example, in the amount of investments that are due to changes in this stock. What is implicit is that if the mood of entrepreneurs is such that there is no reason to make new investments, the economic policy authority can respond to this by promoting reductions in interest rates without the monetary base suffering significant variations. So, changes in Keynesian quantities can only be explained by interest rates movements, considering the role of the state of confidence in a PK model.

Second, we adopt a time-series autoregressive vector panel model, whose specification takes economic units into account; because PK literature has analyzed the dynamics of the economic system through units, which can be firms, sectors, states, regions, or countries (MINSKY, 1986). Panel VAR models are particularly suitable for analyzing the transmission of idiosyncratic shocks in units and time (CANOVA & CICCARELLI, 2013). A commonly applied standard structural vector autoregressive (VAR) model may not consider these unique features and may have little economic justification for the objectives proposed here. Additionally, we use the GMM as our best-fits estimator. The application of GMM instead of other estimators is justified because we deal with large N and fixed T. Furthermore, the GMM has two advantages: (i) it solves the endogeneity problem, and (ii) it allows variables not correlated with the error term to be used as instruments.

Finally, we focus on the sectoral level since the transmission channel of government incentives on employment occurs via industrial production. An analysis of the implications of investment and interest rates on the industrial product may allow understanding the effectiveness of the Keynes and Post-Keynesian prepositions on productive dynamics,

facilitating the design of future strategies to boost this vital sector and growth even in the long term.

The remainder of the study is structured as follows. Section 2 presents the model to be estimated. Section 3 discusses the results. Section 4 concludes.

2 THE MODEL

This section discusses the PVAR methodology and recent studies related to the topic addressed in this study (subsection 2.1). The data and sources are equally presented (subsection 2.2).

A general VAR(1) model in which variables are treated as endogenous and interdependent can be represented by the following notation:

$$Y_t = A_o(t) + A(l)Y_{t-1} + u_t \tag{1}$$

where Y_t is a vector $N \times 1$ of endogenous variables. Their corresponding lagged values are Y_{t-1}. $A(l)$ is a polynomial in the lag operator. The vector of all deterministic components of the data is represented by $A_0(t)$. u_t is an independent and identically distributed error term with mean and variance given as $(0, \sum_u)$. To delimit the variance of Y_t and to certify that there are $A(l)^{-1}$, the matrix of coefficient A_j is constrained in the usual way (See, CANOVA & CICCARELLI, 2013).

In many relevant empirical applications, however, specifying the VAR as in Equation (1) can be very restrictive and incomplete (JUODIS, 2018). In such a situation, it is necessary to allow Y_t to be a linear function of a set of exogenous or commonly predetermined variables Z_{it}. By doing so, we have the following I unit structural VAR(1):

$$Y_{it} = A_i(t) + A(l)Y_{it-1} + B(l)Z_{it} + u_{it} \tag{2}$$

The variable Z_{it} in the Equantion (2) is used since dynamic responses to policy shocks are different from one economy to another. Cushman and Zha (1997) estimated a model as in (2) explicitly for the characteristics of the small economy, Canada. They found evidence of consistent dynamic responses to the monetary policy shock.

The structure of a panel VAR, henceforth PVAR, is the same as traditional VAR models. In a PVAR all variables are also taken as being endogenous and independently represented by adding a cross-section dimension. Therefore, we can rewrite Equation (1) as:

$$y_{it} = A_{0i}(t) + A_i(l)Y_{it-1} + u_{it} \qquad i = 1,\ldots,N \qquad t = 1,\ldots,T \tag{3}$$

where y_{it} is the vector of N variables for each $i = 1, \ldots, N$; i is an index indicating country; Y_{it-1} is a $N \times T$ matrix of lag $j = 1$; $A_{0i}(t)$ and A_i depend on units, and u_{it} is an $N \times 1$ vector of random disturbances, with the moments $u_{it} = [u_{1t}, u_{2t}, \ldots, u_{Nt}]' \approx (0, \Omega)$.

Considering the VARX recursive block structure as in (2), a PVAR model has the following functional form

$$y_{it} = A_{0i}(t) + A_i(l)Y_{it-1} + B_i(l)Z_{it} + u_{it} \qquad (4)$$

Canova and Ciccarelli (2013) show that a PVAR used in macroeconomic studies has three distinctive features. First, there is a dynamic interdependence in its structure because it allows entering the lags of all endogenous variables of all units. Second, there are static interdependencies, as the recursive structure of a PVAR suggests that are generally correlated across units. Furthermore, there are restrictions on the covariance matrix of u_{it}, as the same variables appear in each unit. Finally, there is cross-section heterogeneity, allowing the intercept, slope, and variation of shocks u_{it} to be specific to unit i.

We present a PVAR model $Y_{it} = [Inv_{it}, rat_{it}, Stat_{it}]'$ as a vector of k endogenous variables of country i at time t. We assume Y_{it} to have a PVAR(p) functional form such as:

$$\Phi(L)(Y_{it} - \lambda_i) = u_{it} \quad i = 1, \ldots, 10 \qquad t = 1997, 1998, \ldots, 2016 \qquad (5)$$

$$\Phi(L) = I_m - \sum_{j=}^{p} \Phi_j L^j \qquad (6)$$

Inv_{it}, rat_{it} and $Stat_{it}$ are the investment, interest rate, and state of confidence of the country i at time t., respectively; L is lag operator , such as $LY_{it} = Y_{i,t-1}$; I_m is a identity matrix $m \times m$; $\Phi(L), j = 1, 2, \ldots, p$ of slope coefficients. Our panel has a finite time dimension T, being $T > p$ for the available observations $Y_{i0}, Y_{i1}, \ldots, Y_{iT}$; u_{it} is a $m \times 1$ vector of random shocks, with the moments: $(u_{it}) = 0$ and $E(u_{it}u'_{it}) = \Omega_u$, where Ω_u is a non-singular matrix. Furthermore, u_{it} and u_{is} are orthogonal to all $t \neq s$, that is, $E(u_{it}u'_{is}) = 0$.

Assuming that the data generating process has dynamic homogeneity, the Ordinary Least Squares Estimator (OLS) could be applied. However, since the country-specific coefficients in Equation (6) are correlated with the error term, OLS reports estimates of the biased coefficients. Bias can also occur when T is fixed. In such a case, a common strategy is to resort to the GMM, which is applied when there is a large N and fixed T. Therefore, we use PVAR instead of other models such as structural VAR or VECM because it allows us to estimate a time series panel model, which increases the degree of freedom. It is worth anticipating that although there are several other methods, such as the VEC Panel, PVAR is the best-fit tool in this study.

Canova and Ciccarelli (2013) show that a PVAR used in macroeconomic studies has three distinctive features. First, there is a dynamic interdependence in its structure because it allows entering the lags of all endogenous variables of all units. Second, there are static interdependencies, as the recursive structure of a PVAR suggests that are generally correlated across units. However, as in the GMM method, the number of parameters grows with N, leading to inconsistency since GMM requires the cross-sections in time to be differentiated, excluding the information from the sample and making the inference less accurate when the data being ignored are important for the structural parameters of interest (CANOVA & CICCARELLI, 2013, p.14).

Previous works by Alonso-Borrego and Arellano (1996) and Blundell and Bond (1998) show that, in dynamic models of panel data where the autoregressive parameter is moderately large and the number of time series observations is moderately small, the estimator of the linear GMM has a large bias in finite samples and low precision in simulation studies. In such a case, the lagged dependent variable is a weak instrument for the transformed variables. Arellano and Bover (1995) presented an approach in which, to increase the estimator efficiency, it is necessary to assume the condition of moment $E(\Delta I_{ijt}\lambda_i) = 0$ for all i and t, being ΔI_{ijt} the lagged instruments.

Thus, even the GMM estimator being biased in finite samples, compared to the OLS estimator, it is asymptotically more efficient. The OLS bias operates in the opposite direction; that is, it is increasing (ARELLANO-BOND, 1991). GMM estimator system is used when N >T. As mentioned before, in our model, using a 10-country panel increased the degree of freedom, allowing us to apply this method. A dynamic GMM has two potential benefits: (i) it solves the endogeneity problem and allows the use of internally generated instruments (BOND, 2002; OSENI, 2016); (ii) all variables not correlated with the error term can be used as valid instruments (WOOLDRIDGE, 2002; BALTAGI, 2005; GREENE, 1993 and 2012).

The Levin-Lin-Chiu (2002) and Harris-Tzavalis (1999) unit root tests will be applied. The null hypothesis of these tests is that the series contains a unit root, against the alternative hypothesis that it is stationary. We use the model and moment selection criteria proposed by Andrews and Lu (2001) to choose the lag order of the PVAR model. Furthermore, the confidence intervals of the error variance decomposition are calculated using Monte Carlo simulations based on the previously estimated PVAR(1) model.

2.1 Related literature

PVAR models have been increasingly used for a variety of studies of economic issues. For instance, Canova et al. (2007) investigated the properties of G-7 country cycles using cross-country PVAR with time variations, unit-specific dynamics, and interdependencies between countries. In turn, Canova and Ciccarelli (2012) examined macroeconomic fluctuations in the Mediterranean and their similarities and convergence through a PVA. He shows that idiosyncratic shocks still dominate cyclical changes in many countries.

Canova et al. (2004) use annual panel data from the 48 continental US states to study the relationship between fiscal constraints and macroeconomic behavior. The main objective was to examine whether government expenditures are more countercyclical, on average, in countries or states with fiscal restrictions established by the constitution.

Our model shares the same spirit as Love and Zicchino (2006). But while they apply a 36-country firm-level PVAR to study the dynamic relationship between firms' financial conditions and investment, we use similar modeling to explore the dynamic relationship between uncertainty in the investment decisions and interest rates.

A plethora of studies has examined implications of Keynesian and Post-Keynesian policy prepositions. For instance, Li and Khurshid (2015) use a vector error correction model (VECM) to evaluate the effect of the interest rate on investments in Jiangsu Province, China, and found evidence that there is a long-term relationship between these two variables.

In turn, Ingersoll and Ross (1992), using a simple investment model, substituted the stochastic interest rate in place of the discount rate and observed the effects of uncertainty on the interest rate on investments dynamic: an annual standard deviation of the yearly change in interest is about 0.025.

Dupor (2001) analyzed the effects of interest rates on investments using an imperfect competition model with price rigidity. The main finding is that a temporary exogenous increase in the nominal interest rate causes a temporary increase in investment and output, which does not corroborate the post-Keynesian literature. It is argued that such positive relationships are likely to occur in models of generalized preference and different interest policy alternatives, as was the case with the model applied by this author, which is perfectly adjustable for the analysis of the equilibrium uniqueness.

Kapoor and Ravi (2009), through a natural experiment in India, found that an increase in the interest rate on deposits by 50 points leads to an immediate decline in consumption expenses by 12%. Wilcox (1990) found that interest impacts household

consumption, but the transmission channel occurs through the nominal interest rate and not the real one, as is usually assumed.

2.2 Data

All data, except where noted, are in US dollars and are from the World Bank's world development indicators. The last access for this work was made on January, 2021. Mercosur here includes both effect members and associate members of the bloc. The countries in the sample are: Argentina, Bolivia, Brazil, Chile, Colombia, Ecuador, Paraguay, Peru, Uruguay and Venezuela. Due to lack of data, two associate members were excluded: Guyana and Suriname. The model variables are:

$Y_{it} \equiv$ Industrial product of country i at time t (2010=100).

$Inv_{it} \equiv$ country i's gross domestic investment at time t (2010=100): The World Bank's methodology defines gross investments quite broadly, but we refer this variable as fixed assets plus net changes in the level of inventories.

$Ir_{it} \equiv$ Real interest rate in country i at time t (%): The real interest rate is the inflation-adjusted loan interest rate measured by the GDP deflator.

$Stat_{it} = (Conf_{it}$ or $SConf_{it}) \equiv$ Confidence $Conf_{it}$ or no confidence $SConf_{it)}$ index in the government of country i at time t (indexes from 1 to 100) – (Source: IPEA)[1]. According to IPEADATA, the confidence index is an opinion survey on the federal government and its policies. It is carried out through 2,002 household interviews applied to a stratified sample of voters aged 16 or over, covering the national territory. The estimated confidence interval is 95%, and the maximum estimated margin of error is two percentage points on the results found in the total sample.

Descriptive statistics for variables in level are shown in Table 1. In a pooled and balanced PVAR, we would have 200 observations for each variable. However, in the first three years, there is no investment data for Colombia, reducing the number of observations to 197. All observations have positive values, except for the interest rate whose minimum was -18.91%. Furthermore, while the data for Argentina, Uruguay, and Brazil are updated, we cannot get current statistics for the other countries. Up to 2016 allowed us to obtain richer information to build a balanced panel. It should also be emphasized that the use of

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[1] http://www.ipeadata.gov.br/Default.aspx

aggregate investment, rather than industrial investment, is due to the lack of sector-level investment data for each country in the sample.

Table 1 - Descriptive statistics

Variables	Observations Mercosur	Mean	Standard deviation	Minimum	Maximum
Y_{it}	197	3.35e+11	5.61e+11	1.25e+10	2.42e+12
Inv_{it}	194	6.29e+10	1.08e+11	1.68e+09	5.17e+11
Ir_{it}	188	15.97465	16.85864	-18.9085	93.9150
Conf	15	235.2667	77.90605	62	340
Sconf	15	144.7333	87.71176	46	327

Source: Prepared by the authors.

3 RESULTS

This section presents the estimates and discusses the results of the PVAR model. The initial unit root and model selection tests were performed in subsection 3.1. The next subsection reports the estimates of the PVAR model using the GMM method. We start with parsimonious regressions without including indices that reflect agents' expectations, which will be covered later.

3.1 Diagnostic tests

An initial diagnosis in a PVAR is to verify that the time series are stationary. Table 2 shows the critical statistics and p-value of the Levin-Lin-Chiu (2002), hereinafter LLC unit root test. The adjusted t-statistic of the LLC test for industrial product (Y_{it}) is 2.40, and is not significant for the usual significance levels. Therefore, the null hypothesis that (Y_{it}) contains a unit root is not rejected. The same interpretation applies to the investment variable (Inv_{it}), which is also non-stationary in level. On the other hand, the real interest rate (Ir_{it}) has a t-adjusted statistic of -4.43 which is statistically significant at the usual significance levels, leading to the rejection of the unit root null hypothesis.

Estimation through GMM requires the model time series to be stationary. A common strategy is to turn stationary those time values that contain the unit root. The variables (Y_{it}) and (Inv_{it}) are differentiated. The LLC test reveals that they are first order integrated, that is, they are I(1), as the calculated statistics are both significant at the 1%.

Table 2: LLC unit root test

Variable	Variable at level		Variable at first lag	
	calculated statistics	P-value	calculated statistics	P-value
(2) Y_{it}	2.3779	0.9913	-3.5769	0.0002***
(3) Inv_{it}	0.1649	0.5655	-4.2471	0,0000***
(4) Ir_{it}	-4.4250	0.0000***		

Source: Search results. Prepared by the authors. Annual observations are from 1997 to 2016. *** p < 0:01. Decision rule: Assuming the common autoregressive parameters for all data panels, the null hypothesis of the Levin-Lin-Chu test is that the time variables contains a unit root versus the alternative that the time series is stationary.

However, the LLC test is limited due to its asymptotic properties. The test assumption is that if we divide the number of panels by each other the result of this division between the number of panels tends to be asymptotically zero, which limits the test performance for large data sets with many panels and few periods of time (see ABRIGO &LOVE, 2015). Thus, we applied also Harris-Tzavalis (1999) HT unit root, which assumes the number of panels to be infinite, while the number of time periods is fixed (Table 3).

The HT test reveals that Y_{it} is not stationary in level, that is, it is not I(0), but Inv_{it} and Ir_{it} are both stationaries. In fact, Ir_{it} has a t-adjusted calculated statistic of 0.57, which is statistically significant at 1%, while the t-adjusted calculated statistic of Inv_{it} is 0.80, statistically significant at 10%, indicating that Ir_{it} and Inv_{it} are both stationary in level. However, as before, the first differences of Y_{it} reveal that it is first-order integrated, the first difference of Y_{it} being statistically significant even at 1%.

Table 3: Unit Root HT Test

Variable	Variable at level		Variable at first lag	
	calculated statistics	P-value	calculated statistics	P-value
Y_{it}	0.9365	0.9550	0.0574	0.0000***
Inv_{it}	0.7868	0.0663*		
Ir_{it}	0.5655	0.0000***		

Source: Prepared by the authors. Annual observations are from 1997 to 2016. * p < 0:10, and *** p < 0:01. Decision rule: The null hypothesis of the Harris-Tzavalis test is that the series contains a unit root, versus the alternative that the series is stationary.

We use Schwarz's Bayesian Criteria (MBIC), Akaike's Criteria (MAIC) and Hannan-Quinn's Criteria (MQIC) model and moment selection criteria as proposed by Andrews and Lu (2001). They are used here to select the order of the model (for more details, see

Andrews and LI, p.124, 2001). The first-order PVAR model, that is, PVAR (1), is a preferred model, as it has lower MBIC, MAIC and MQIC values (Table 4).

Table 4: The Model Selection Criteria

Lag	P-value	MBIC	MAIC	MQIC
1	0.3396	-158.3806	-43.5759	-89.7536
2	0.5599	-112.0051	-33.8402	-65.2803
3	0. 50140	-55.7634	-16.6809	-32.40103

Source: Elaborated by authors.

We must emphasize that a crucial methodological discussion of macroeconometrics models in general concerns what is called series mixing. For example, we do not find a strong justification for estimating a model with series in level when two variables are not stationary at level. As the HT test did not reveal the stability of the series that would justify the level estimate, the model was estimated with first-difference variables, with stationary series, that is, first-order integrated.

3.2 Estimation of the PVAR model (1)

A first-order panel PVAR model, PVAR(1), is estimated using the GMM system à la Holtz-Eakin et al. (1988) - Table 5. We present in Columns the impulse variables and the rows the response variables. Values outside and in parentheses are estimates of the coefficients and standard errors, respectively. Row (2) represents the industrial level product equation; Row (3) the investment equation; and Row (4) are the estimated values for the interest rate equation of the PVAR(1) system.

The response of the industrial product to its past values, although statistically significant at the 5% level, is negative. A 1% variation of the product causes a reduction of -1.34 percentage points in the current product. The estimated investment coefficient is statistically significant at 1%, and the product increases by 0.23 percentage points as investments vary by 1%. Meanwhile, the impact of the interest rate on output is statistically significant at the 5% level. A variation of 1% in the real interest rate causes a reduction of -0.013 percentage points in the industrial product. On the one hand, investments are negatively related to interest rates, and, on the other one, product responds positively to variations in contemporary investments (Row 4). The product impacts the real interest rate positively and statistically significant at the usual significance levels, while the effect of investment on interest rate is negative.

Table 5 - GMM estimates of the PVAR(1) model

Variables	$Y^{\diamond}_{i,t-1}$	$Inv^{\diamond}_{i,t-1}$	$Ir^{\diamond}_{i,t-1}$
(2)$Y^{\tau}_{i,t-1}$	-1.3395	0.2341	-0.01332
	(0.1642)**	(0.0364)***	(0.00530)**
(3)$Inv^{\tau}_{i,t-1}$	-3.4598	0.3434	-0.0705
	(0.5057)***	(0.1200)***	(0.0156)***
(4)$Ir^{\tau}_{i,t-1}$	15.8750	-0.9705	0.9224
	(1.9668)***	(0.5243)*	(0.0628)***

Source: Prepared by the authors. * p < 0:10, ** p < 0:05, and *** p < 0:01. $\diamond$ indicates impulse variables, τ indicates response variables, and $t-1$ the order of the model, PVAR (1).

The results of the Granger causality test of the first-order PVAR are reported in Table 6 below. The values outside and in parentheses are the test statistics and the p-Values, respectively. The test results show that all explanatory variables Granger-cause all dependent variables. From the standpoint of the individual equations, we observe that interest rates and investments Granger-cause output; the interest rate and the product Granger-cause investments; and the product Granger-causes interest rates, but investments not Granger-cause interest rates at conventional significance levels.

Table 6 - Granger Causality Test for the first-order PVAR model

Variáveis	$Y^{\diamond}_{i,t-1}$	$Inv^{\diamond}_{i,t-1}$	$Ir^{\diamond}_{i,t-1}$	All
(2)$Y^{\tau}_{i,t-1}$		41.333	6.311	6.311
		(0.000)***	(0.012)**	(0.000)***
(3)$Inv^{\tau}_{i,t-1}$	46.801		20.380	95.385
	(0.000)***		(0.000)***	
				(0.000)***
(4)$Ir^{\tau}_{i,t-1}$	65.148	3.426		87.047
	(0.000)***			
		(0.064)		(0.000)***

Source: Prepared by the authors. ** p < 0:05, and *** p < 0:01. Number of panels is equal to 10, with 170 observations. Values outside parentheses are the calculated statistics of the test and within parentheses are their respective p-value. $\diamond$ indicates impulse variables and τ indicates response variables.

The stability of these results is analyzed. It is verified that, since all eigenvalues are located within the unit circle, the stability condition for the first-order PVAR is satisfied (Figure 1). Taking the industrial product determination equation in Table 6 above, for example, the stability of the estimated PVAR (1) means that investment and interest rate shocks have direct impacts on output.

Figure 1 - Stability condition of the first order PVAR model
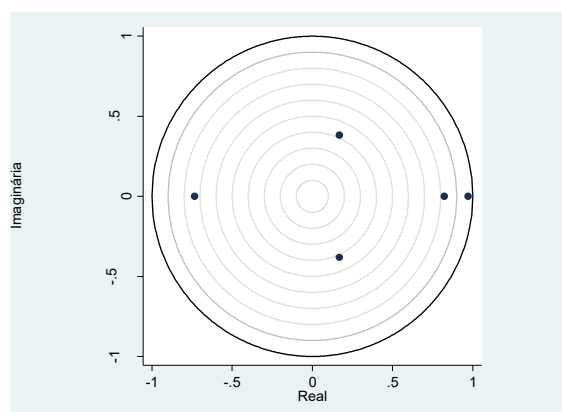
Source: Prepared by the authors. Dots indicate the region where the eigenvalues are located.

Like Abrigo and Love (2015), the confidence intervals of industrial predicted output error variance decomposition are calculated using 200 Monte Carlo designs based on the previously estimated PVAR(1) model. Estimates from the variance decomposition of the output forecast error show that more than 68% variation in the product is due to the investments accomplished, and 22 due to variation in real interest rates in the economies (Table 7).

Table 7 - Historical decomposition of product forecast error variance

Year	$Y_{i,t-1}$	$Inv_{i,t-1}$	$Ir_{i,t-1}$
0		0	0
2	0.7371	0.0680	0.0227
4	0.6270	0.0695	0.0389
6	0.5944	0.0698	0.0375
8	0.5685	0.0672	0.0357
10	0.5486	0.0647	0.0345

Source: Prepared by the authors.

In addition to these results, we analyze the effect of agents' pessimism or optimism, regarding the business environment and future product sales, on investments and industrial products in Brazil between 2002 to 2016. We include, therefore, the confidence and low confidence indexes on the Brazilian federal government policies. In this case, we used the Feasible Generalized Least Squares Method (GLS), which allowed us to deal with the heterogeneity problem. More importantly, the GLS was applied because the number of observations from the confidence indexes was insufficient to estimate a PVAR since we only have data for Brazil. On the one hand, we find that the greater the confidence, the greater

the amount invested and the product generated and, on the other hand, the investments and the product are negatively related to the agents' mistrust or little confidence in the federal government's policies [Equations (7) and (8)]. The estimated coefficients of these indexes are both statistically significant at the 1% level.

In Equation (7), we find that a positive change in the confidence index by 1% leads to an increase in investments by 0.24 percentage points, while distrust of government actions increases by 1%, the investments decrease by -0.12 percentage points.

$$Inv_t = 0.2420 \ln Conf_t + u_t, \; dp = 0.1406 \, ; \; Inv_t = \text{-}0.1220 \ln Sconf_t + u_t, \; dp = 0.0301 \qquad (7)$$

The product sensitivity to changes in confidence and distrust indices is less than the investment sensitivity to changes in these indices. A 1% positive change in agents' confidence, that is, little uncertainty about the government's future behavior, increases industrial product by 0.07 percentage points. In contrast, an increase in uncertainty, that is, a positive change in agents' distrust of federal government actions, decreases the product by 0.04 percentage points [Equation (8) and (9)].

$$ln \, Y_t = 0.0719 \ln Conf_t + u_t, \; dp = 0.0281 \qquad (8)$$

$$ln \, Y_t = \text{-}0.0379 \ln Sconf_t + u_t, \; dp = 0.0119 \qquad (9)$$

Thus, the positive and significant statistical effect of investments on output can be an important result that reinforces the Keynesian argument that this variable is essential to determine the level of economic activity. In fact, without considering the past effect of the product itself, the estimate of the investment coefficient is higher among the coefficients estimated in the product equation. That is consistent with the Keynes and Post-Keynesian theory that investment is primarily responsible for the output fluctuation over time.

Also, the negative response of output to interest rate variations is consistent with the Keynesian and Post-Keynesian literature. According to this literature, interest rate, far from serving as a mechanism that balances the supply and demand for loanable funds, it influences the investment decisions of entrepreneurs, and so the PK literature defends that interest rates should always be kept at such a low level. This pattern was evident when we analyzed the investment determinants equation, which shows that an increase in real interest rate implies a non-proportional reduction in the amount of investment.

In terms of the results of the product equation in Table 5, it can be said that, excluding the rapid influence of other factors, future product values can be better predictable based on investment values and interest rates, which corroborates the study by Bader and Malawi (2010). The authors found evidence that interest rate increase leads to a reduction in

investment. Especially, a 1% increase in interest rates leads to a 44% reduction in the volume of investment.

4 CONCLUSIONS

Uncertainties influence both the allocation and mobilization of resources in business economies. In a non-ergodic world, maximizing utility agents look for simplifying mechanisms that help them in the decision-making process and tend to be more conservative during low optimism, preferring liquidity than other ways of wealth accumulation. The interest rate in this context plays a vital role in the consumer's and entrepreneurs' decisions. For Keynes and Post-Keynesians, consumption is a function of disposable income, but the discount rate of consumption between two periods increases with the interest rate. The interest rate is the liquid premium. The investment depends on both the marginal efficiency of capital and the interest rate. Given the uncertainty, the investment must increase until there is no investment capital good among all equally possible investment goods whose efficiency is greater than the current interest rate. Investments and interest rates are central to Keynes and Post-Keynesian discussions about the determinants of aggregate demand in a capitalist economy where entrepreneurs constantly seek to maximize their expected profits.

The first objective of this work was to estimate the Keynesian equation for determining the product, focusing on the industrial product, instead of the usual accounting identity, for the effective and observer members of Mercosur countries. The analysis was based on recent time-series panel models estimated using the GMM. We found, on the one hand, that the industrial product responds positively and statistically significantly to variations in investments and, on the other, responds negatively to variations in interest rates. Granger's causality test suggests that investments and interest rates Granger-cause the product. We show that this result of the estimated PVAR(1) model is relatively stable. Furthermore, using Monte Carlo designs as the basis of the PVAR(1) model, estimates of the variance decomposition of the output forecast error show that more than 68% of output variation in our data sample is explained by investment variation.

The second objective was to present empirical evidence of the role played by uncertainties in the decision-making process of agents, considering only the case of Brazil. The evidence was that output and investments increase with agents' confidence in the future behavior of the federal government but decrease if uncertainty rises.

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