Revista de Economia Contemporânea
REC
Revista de Economia Contemporânea (2023) 27: p. 1-40
(Journal of Contemporary Economics)
ISSN 1980-5527
http://dx.doi.org/10.1590/198055272714
elocation - e232714
https://revistas.ufrj.br/index.php/rec | www.scielo.br/rec

*Articles*

# A PANEL VAR ANALYSIS OF THE DYNAMIC IMPACT OF UNDERVALUATION ON ECONOMIC GROWTH IN LATIN AMERICAN COUNTRIES

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*Received: 2021/11/07*
*Accepted: 2023/06/13*
*Recebido: 07/11/2021*
*Aceito: 13/06/2023*

**ABSTRACT:** This study analyzes the dynamic effects of undervaluation on the economic growth per capita of Latin American countries from 1980 to 2018. To estimate these effects, a panel vector autoregressive (PVAR) model was used with the System GMM as its estimator. The undervaluation variable is created from different measures of real exchange rates. In addition, various measures of GDP per capita were used to calculate economic growth per capita. Macroeconomic and human capital variables were included to control for the different undervaluation spread channels on economic growth per capita. Results show a positive effect depending on the definition of the real exchange rate used to calculate the undervaluation. Results also include the Granger causality test, a stability test, and impulse response graphs that project the response of per capita economic growth to an undervaluation shock.

**KEYWORDS:** Real exchange rate; undervaluation; panel VAR; developing countries.

**JEL CODES:** F14, F47, C33, C53.

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# COMO É O IMPACTO DINÂMICO DA SUBVALORIZAÇÃO NO CRESCIMENTO ECONÔMICO DOS PAÍSES LATINO-AMERICANOS? UMA ANÁLISE VAR DE PAINEL

**RESUMO:** Neste artigo, analiso os efeitos dinâmicos da subvalorização sobre o crescimento econômico per capita dos países latino-americanos no período 1980-2018. Para estimar esses efeitos, utilizo um Panel Vector Autoregressive (PVAR) cujo estimador é o System GMM. A variável de subvalorização é criada com ajuda de diferentes medidas da taxa de câmbio real, e também utilizo várias medidas do Produto Interno Bruto (PIB) per capita para calcular o crescimento econômico per capita. Incluo como variáveis de controle, variáveis macroeconômicas e de capital humano para controlar os diferentes canais de propagação da subvalorização do crescimento econômico per capita. Os resultados mostram que há um efeito positivo dependendo da definição da taxa de câmbio real utilizada para calcular a subvalorização. Nos resultados incluo o teste de causalidade de Granger, teste de estabilidade e gráficos de resposta ao impulso nos quais projeto a resposta do crescimento econômico per capita a um choque de subvalorização.

**PALAVRAS-CHAVE:** Taxa de câmbio real; subvalorização; painel VAR; países em desenvolvimento.

## 1. INTRODUCTION

Real exchange rate (RER) misalignments and their effects on macroeconomic variables have been extensively evaluated on theoretical and empirical bases but results could be more robust. Starting from different concepts of RER misalignment (which I will explore in section 3) and of equilibrium RER, for which authors use several sets of independent variables and methodologies to estimate it. The two possible types of misalignments refer to currency undervaluation and overvaluation. Currency undervaluation occurs when the current RER remains below the equilibrium RER and overvaluation, when it exceeds it.

The macroeconomic literature has widely discussed the implementation of currency devaluation policies to expand economies. Rapetti, Skott and Razmi (2012) claim the existence of two main channels through which real exchange rates affect economic growth. The first operates by the currency price of a country, influencing its global competitiveness. The second channel facilitates the redirection of resources toward tradable sectors, enabling learning-by-doing externalities and technological spillovers.

We find evidence that these policies were fundamental for the rapid economic growth of Asian countries (COTTANI; CAVALLO; KHAN, 1990). Morrison and Labonte (2013) studied these policies in China. Their theory suggests that a devalued currency may protect newly emerging companies as it provides them greater competitiveness in the world market, but it may negatively affect their GDP (KRUGMAN; TAYLOR, 1978). Hence the interest in studying imbalances in real exchange rates. However, these policies have their detractors, such as Williamson (1990), who points out that they can produce unnecessary inflationary prices, damaging other productive sectors. Balassa (1982) points out that devaluation can be interpreted as imposing tariffs and subsidizing exports. Empirical evidence finds scattered results about these impacts on economic growth (BLEANEY; GREENAWAY, 2001; GALA, 2007; YANG *et al.*, 2013; VAZ; BAER, 2014).

This economic policy has been especially adopted in developing countries (RODRIK, 2008; EICHNGREEN, 2007). Some studies in Latin America have investigated the impact of exchange rate devaluations. For example, Mejía-Reyes, Osborn and Sensier (2010) studied the effects of exchange rate changes on GDP in five Latin American countries, dividing them into two groups, non-oil and oil countries, finding that non-oil nations suffered the negative effects of short-term depreciation. Lanau (2017) assessed the effects of real exchange rate depreciation on growth across Latin American sectors, finding that a shock of 10% depreciation can increase growth in non-traditional sectors from 0.6 to 2%, depending on the transmission channel. Along this same line, Galindo, Izquierdo and Montero (2006) evaluated the effects of real exchange rate depreciation

on industrial sectors in Latin America, finding positive effects except for highly industrialized industries. Cottani *et al.* (1990) and Dollar (1992) found that overvaluation affected economic growth in Latin America and Africa. Rodrik (2008) and Gala and Libânio (2010) mention that a competitive currency aids growth by boosting the industrial sector since undervaluation can encourage technological capabilities and capital accumulation of the firms in the economy.

Abroad, Kappler *et al*. (2011) studied the effects of real exchange rate appreciation in a sample of 128 countries and found no significant effects on economic growth. Habib, Mileva, and Stracca (2017) assessed the effects of real exchange rate depreciation on the growth of 150 countries after the Bretton Woods period, finding that real appreciation significantly reduces real economic growth. Christopoulos (2004) evaluated the effects of currency devaluation on economic growth using a cointegration test, finding insignificant results. Thus, studying the movements of real exchange rates is of key importance. Moreover, the effects various studies found depended on their sample size and methodology.

This study aims to estimate the effects of undervaluation on economic growth per capita in Latin America. It uses several measures of undervaluation and GDP per capita to capture variations in measures and robustness. This research uses Panel VAR — proposed by Love and Zicchino (2006) — as its methodology since it allows us to control for the dynamic effects of undervaluation and the possible endogeneity between these variables. Results show that undervaluation positively affects economic growth. However, their magnitude and duration depend on the used measures.

This study contributes to the literature on the effects of undervaluation on economic growth, especially in developing countries. Its *main contribution* is its use of a Panel VAR model, which, to the best of the author's knowledge, is yet to be used in this kind of study and which was adjusted according to the variables in this kind of analysis. Its *second contribution* is its specific analysis of Latin American countries using updated data.

This study is structured as follows. Section 2 offers a literature review of the studies estimating the effects of undervaluation on economic growth. Section 3 develops the real exchange rate measures with which the undervaluation is estimated, explains ways to calculate GDP per capita to estimate economic growth per capita, and describes the methodology for the estimates. Section 4 shows the results. Section 5 describes our conclusions and limitations. Annexes describe other tests that were developed in our research , our definitions of variables and their sources, and the countries used in this study.

## 2. LITERATURE REVIEW

According to Contractor (2019), undervaluation refers to a situation in which the price of a good in one country is lower (in dollars) than in other countries. Guzmán, Levy-Yeyati, and Sturzenegger (2012) define undervaluation as a deviation from the standard income ratio of real exchange rates based on the typical results of the Balassa-Samuelson effect, which suggests that richer countries tend to have more appreciated real exchange rates. Demir and Razmi (2021) have reviewed the theoretical and empirical analysis of real exchange rates over time.

Given these two definitions, we should understand the implications of undervaluation. By subsidizing exports and tariffing imports, it turns the management of real exchange rates into an alternative trade policy to conventional measures such as direct subsidies or tariffs. A policy of undervaluation shifts relative prices in favor of the whole tradable sector, unlike tariffs or subsidies, which affect specific sectors (DEMIR; RAZMI, 2021).

During the Bretton Woods period, the use of RER focused on the short-term trade channel. However, in recent years, RER has served to incentivize long-term development by various mechanisms. Bresser-Pereira and Rugitsky (2018) provide a literature review of these debates. Frenkel and Ros (2006) coined the term "development channel" to describe the process by which RER can influence long-term development in terms of structural change and economic growth. The interest in this channel was particularly driven by the success of East Asian countries. RER can also help reallocate resources to other sectors with learning spillovers and external economies, ultimately increasing the productivity of the sector which received the resources, as per Rapetti, Skott, and Razmi (2012). This increases welfare, as discussed by Guzman, Ocampo, and Stiglitz (2018).

Rodrik (2008) argues that obtaining a sustained undervalued exchange rate promotes economic growth. However, Woodford (2009) suggests that, although undervaluation positively affects economic growth, the evidence for it is less robust than what Rodrik thinks as he exaggerates the robustness of his findings by suggesting that correlation implies causality between variables. In a study of the determinants of rapid growth in developing countries, Dollar (1992) finds that imbalances in real exchange rates could partially explain the rapid growth of those countries.

According to Sachs *et al.* (1995), the liberalization of exchange rates in developing countries temporarily raised prices and devalued currencies, leading to a period of economic growth. Krugman (1989) asserts that productivity undervaluation enhances economic growth, but the interest in establishing links between undervaluation and economic growth dates back even further. Gylfason and Schmid (1983) developed

a general equilibrium model and found that devaluation positively influences real GDP by supply channels, along the same lines as Taylor and Rosensweig (1984).

Despite the extensive literature on the links between undervaluation and economic growth, results have been mixed. From the perspective of the Washington consensus, Berg and Miao (2010) mention that RER misalignment implies macroeconomic imbalances that harm growth because they inefficiently allocate resources and reduce economic growth. Marconi *et al.* (2021) evaluated the effects of industrial imbalances due to real exchange rates on the income elasticity of export and import demands. Under a structuralist framework, Rapetti, Skott, and Razmi (2012) show that high levels of RER can help accelerate capital accumulation and economic growth.

Various authors have found undervaluation to positively affect economic growth, such as Aguirre and Calderón (2005), Bleaney and Greenaway (2001), Gala (2007), Gala and Libânio (2010), Yang, Zhang, and Tokgoz (2013), Vaz and Baer (2014), Levy-Yeyati and Sturzenegger (2007), Rodrik (2008), Ribeiro, McCombie, and Lima (2019), Chou and Chao (2001), Woodford (2009), Henry (2008), Hausman, Pritchett, and Rodrik (2005), and Frankel and Romer (1999). DA proposed mechanism suggests that undervaluation can lead to economic growth by two widely studied transmission channels. The first refers to capital accumulation (BHALLA, 2007; MONTIEL; SERVÉN, 2009), whereas the second, to productivity, in which undervaluation makes currencies more competitive and helps to boost exports (EICHENGREEN, 2008; MCLEOD; MILEVA, 2011). Despite its clearly positive effects on growth, there remains doubts on which mechanisms are involved. Rapetti (2020) claims the possible involvement of the financial globalization and trade-led growth channels.

Undervaluation can also boost economic growth by improving technological capabilities and capital accumulation for other firms in the economy (GALA; LIBÂNIO, 2010) or by reducing real wages and incentivizing investment via savings, thus boosting profit margins (LEVY-YEYATI; STURZENEGGER, 2007). However, undervaluation can exacerbate inequality (ROSSI; GALBRAITH, 2016). Undervaluation and overvaluation may also varyingly impact economic growth. Razin and Collins (1999) found that a fundamentally based index of RER overvaluation is negatively correlated with economic growth, suggesting the asymmetric effects of undervaluation and overvaluation. This agrees with Aguirre and Calderon (2005) and Nouira and Sekkat (2012), who suggest that the level of RER misalignment matters for effect (COUHARDE; SALLENAVE, 2013). Ribeiro, McCombie, and Lima (2020) found that undervaluation significantly affects economic growth only in the presence of a tolerable degree of income distribution and a level of technological capabilities, otherwise producing non-significant effects and adverse indirect effects.

According to Rapetti (2013), external economies of scale create a trade-off between short-term domestic demand and long-term growth. Berman *et al*. (2012) found that high-productivity exporters with a low demand elasticity respond to RER depreciation by increasing mark-ups more than export volumes, whereas Chatterjee, Dix-Carneiro, and Vichyanond (2013) showed that high-productivity firms increase the prices of their products in the same scenario. Bresser-Pereira *et al*. (2022) found a high negative correlation between exchange rate misalignments and current account deficits. Iasco-Pereira and Missio (2022) found that a competitive RER favors the manufacturing industry and is associated with a more complex and competitive structure. Using dynamic panel models, Gabriel *et al*. (2022) estimated the effects of RER imbalances on the manufacturing industry and per capita growth, finding that this sector is the most important tradeable sector for increasing per capita income.

Razmi (2021) wonders why exchange rate policies have more successfully provided relative prices that enabled industrialization in some countries than others. He distinguishes between the political cycle of East Asian and Latin American countries. The latter have experienced real exchange rate cycles, first undergoing depreciation after an election, followed by consistent overvaluation and current account deficits in an attempt to keep real wages high leading up to the next elections. East Asian countries have a different pattern, involving undervaluation, high investment, and current account surpluses over the course of their political business cycles, followed by appreciations around elections.

Finally, as Guzman, Ocampo, and Stiglitz (2018) pointed out, rather than working in a vacuum, undervaluation policies must be complemented with other monetary, fiscal, and trade policies for certain objectives. Regarding the methodologies in this type of research, most studies have used OLS and fixed effects. However, the recent literature has begun to use GMM and cointegration models. In the next section, we will describe our methodology and data.

## 3. DATA AND METHODOLOGY

This section is divided into two subsections: (i) first, the different undervaluation estimates is presented according to several measures of GDP per capita and then (ii) the methodology used to obtain different undervaluation measures and to estimate the dynamic impact of this variable on economic growth is detailed. Table 18 describes the used database, ranging from 1980 to 2018.

### 3.1. FIRST STAGE: CALCULATING REAL EXCHANGE RATES AND UNDERVALUATION MEASURES

As mentioned at the beginning, different real exchange rate variables will be used to estimate undervaluation. This will enable us to obtain consistent and robust estimates. The first definition of real exchange rates I will use consists of two variables, as per Equation (1) below:

$$RER_{1i,t} = \frac{XRAT_{i,t}}{PPP_{i,t}} \tag{1}$$

In (1), i refers to the country at the time and t, to the estimated real exchange rate, i.e., the nominal exchange rate of a local currency compared to the US dollar divided by purchasing power parity. This first real exchange rate variable is also called an enhanced purchasing power parity measure. It has been used to estimate determinants from the fundamental equilibrium exchange rate and behavioral equilibrium exchange rate approaches — Clark and MacDonald (1998) reviewed these two approaches. Froot and Rogoff (1995) have used this construction to estimate and predict the behavior of real exchange rates and to estimate their convergence to the equilibrium of real exchange rates, whereas Frankel (2006) employed the method to examine the trends of the Chinese local currency, among others. This useful transformation can adjust real exchange rates by the Balassa-Samuelson effect (MACDONALD; RICCI, 2001). However, it has also received criticism because, as Nouira and Sekkat (2012) and Ghura and Grennes (1993) pointed out, it may differ from the definition used to find macroeconomic equilibria.

The second definition of real exchange rates I use consists of three variables, as per equation (2):

$$RER_{2i,t} = \frac{XRAT_{i,t} * PPI_{US}}{WPI_{i,t}} \tag{2}$$

As mentioned, $RER_{i,t}$ is the real exchange rate of country i at time t and $XRAT_{i,t}$ is the nominal exchange rate of a local currency compared to the US dollar. $PPI_{us}$ is the producer price index for the United States and $WPI_{i,t}$ is the sales price index of country i at time t. Due to the low availability of data on this variable, I can replace it with $CPI_{i,t}$, i.e., the consumer price index. Among others, Rodrik (2008) used this methodology to estimate the effects of undervaluation on growth using a data panel. Rodrik (2008) advocates this use to correct for the Balassa-Samuelson effect. However, Woodford (2009) mentions that, as the type of regression includes country-fixed effects, neither average differences in real exchange rates nor the Balassa-Samuelson effect would affect this coefficient.

The third definition I use is the inverse of the price level of a country compared to the price level of the United States, as per equation (3):

$$RER_{3i,t} = \left( \frac{p_{i,t}}{P_{USA}} \right)^{-1} \quad (3)$$

In (3), $p_{i,t}$ is the price level of a local economy expressed in dollars and $P_{USA}$ is the price of the US dollar. The advantage of this estimate is that it is expressed in dollars. Once all real exchange rate variables are described, the following variable will be added: GDP per capita, using it as a proxy for the initial period of an economy to estimate undervaluation and its effects on economic growth. The first GDP per capita will be estimated from two variables, as per equation (4):

$$GDP_{percap1i,t} = \frac{GDP\ real_{i,t}}{Population_{i,t}} \quad (4)$$

In (4), $Real\ GDP_{i,t}$ is the PPP adjusted real output of country i at time t and $Population_{i,t}$ is the population level of country i at time t. The following definition of GDP per capita was collected from the World Bank. It is the same as the variable in equation (4) but adjusted to constant dollars based on 2010 rates. The last definition of GDP per capita is the same as the previous ones but adjusted to current dollars. These variables per capita will be used to calculate economic growth. As I have shown all the definitions in our modeling, I propose to estimate undervaluation following equation (5):

$$\text{In } RER_{i,t} = a + \beta\, InGDPpercap_{i,t} + f_i + \delta_t + v_t \quad (5)$$

Equation (5)[1] is estimated with the fixed effects estimator to control for any effect from unobservable time-invariant, country-specific ($f_i$) time-variant, and country-invariant ($\delta_t$) characteristics. Table 1 describes our results.

Results show that the first definition of real exchange rates finds positive coefficients for all definitions of GDP per capita. The second definition of real exchange rates is poorly adjusted and positive in two of the three regressions for different GDP per capita. The third definition of real exchange rates is positive only in the first definition of economic growth but shows the best adjustment. Then, after estimating these regressions, I calculate undervaluation from the difference of current real exchange rates with the real exchange rate predicted by our model, as per equation (6).

[1] All variables have been transformed in terms of natural logarithm.

**Table 1 – First stage: estimating undervaluation**

| | Real Exchange Rate: First GDP measure | | |
|---|---|---|---|
| | **(1)** | **(2)** | **(3)** |
| *GDP per capita*$_1$ | −0.61*** | 0.87*** | 0.23** |
| | (−9.31) | (4.51) | (3.03) |
| N | 418 | 418 | 418 |
| Adj. Rsquared | 0.204 | −0.004 | 0.703 |
| | **Real Exchange Rate: Second GDP measure** | | |
| | **(1)** | **(2)** | **(3)** |
| *GDP per capita*$_2$ | −0.78*** | 0.23 | −0.32*** |
| | (−8.24) | (2.48) | (−4.04) |
| N | 418 | 418 | 418 |
| Adj. Rsquared | 0.161 | −0.012 | 0.709 |
| | **Real Exchange Rate: Third GDP measure** | | |
| *GDP per capita*$_3$ | −0.65*** | −0.50*** | −0.50*** |
| | (−5.70) | (−4.33) | (−12.88) |
| N | 418 | 418 | 418 |
| adj. R-sq | 0.332 | −0.008 | 0.790 |

Notes: t statistics in parentheses. * p<0.05, ** p<0.01, *** p<0.001. All estimates used robust standard errors. Each column represents an estimate for each real exchange rate and each row shows us the results for each measure of GDP per capita.

Source: Own elaboration.

$$\text{In } Underval_{i,t} = \text{In } RER_{i,t} - \text{In } \overline{RER}_{i,t} \qquad (6)$$

In (6), In $\overline{RER}_{i,t}$ is the predicted value of equation (5). The interpretation of these undervaluation variables occurs as follows: If $Underval_{i,t}$ exceeds unity, it indicates that the exchange rate of country i is cheaper (in dollars) than that of other countries. Then, the local currency rate is undervalued. Otherwise, i.e., if $Underval_{i,t}$ remains below unity, the currency is overvalued. If it is equal to a unit, it is in equilibrium. I now describe the methodology for estimating the effects of undervaluation on economic growth.

### 3.2 SECOND STAGE: ESTIMATING DYNAMICS EFFECTS

Love and Zicchino's (2006) empirical methodology will be used to estimate the dynamic effects of investments on financial development. The authors have used a panel vector autoregressive (PVAR) model as in equation (7):

$$Y_{i,t} = A \sum_{P=1}^{2} Y_{t-P} + u_{i,t} + e_{,i,t} \qquad (7)$$

In (7), $Y_{i,t}$ is a $vector_{1xk}$ of dependent variables, such as [$Economic\ Growth_{i,t}$, $GDP\ per\ capita_{i,t}$, $Underval_{i,t}$],[2] $u_{i,t}$ is the $vector_{1xk}$ that contains the fixed and specific invariant effects over time of the dependent variable, $e_{i,t}$ is the term error or idiosyncratic error, and **A** is the coefficient matrix of the impacts of the lagged values of endogenous variables. Idiosyncratic errors are assumed as follows in this estimation: $E[e_{i,t}] = 0$, $E[e'_{i,t}e_{i,t}] = \Sigma$ y $E[e'_{i,t}e_{i,s}] = 0$ for all t > s. The estimator of this Panel VAR is the system GMM, proposed by Blundell and Bond (1998). A transformation is achieved by our model by adding exogenous variables, as per equation (8):

$$Y_{i,t} = A \sum_{P=1}^{2} Y_{t-P} + B\, X_{i,t} + u_i + e_{,i,t} \qquad (8)$$

In (8), $X_{i,t}$ is the vector of exogenous variables included in the model and B, its matrix of coefficients. The model presented in these equations has a that may be correlated with regressors due to lags in our variables. Thus, variables must be transformed with a technique known as forward orthogonal deviations or Helmert procedure (ARELLANO; BOVER, 1995), consisting of subtracting the average of all future observations of our dependent variables. This technique is shown in equation (9):

$$y_{i,y+1} = c_{i,t}\left(y_{i,t} - \frac{1}{T_{i,t}} \sum_{S>t}^{N} y_{i,s}\right) \qquad (9)$$

In (9), the sum is taken from all available observations and $T_{i,t}$ is the number of observations and $c_{i,t}$ is a scale factor that takes the following form $\sqrt{\frac{T_{i,t}}{T_{i,t}+1}}$ This transformation enables us to get independent and identically distributed variables. So, since $\nabla$ means that the variable has been transformed with forward orthogonal deviations, our model takes the form of equation (10):

$$\nabla Y_{i,t} = A \sum_{P=1}^{2} \nabla Y_{t-P} + B\, \nabla X_{i,t} + e_{,i,t} \qquad (10)$$

After describing the methodology, the next section details our results.

## 4. RESULTS

The section will be divided into four subsections, the first subsection shows our results considering only endogenous variables such as economic growth, GDP per capita, and undervaluation. The second one adds macroeconomic variables

[2] Only the economic growth variable is not in terms of natural logarithm.

such as government spending, terms of trade, and monetary aggregates. The third subsection adds human capital variables, such as average labor hours, human capital index, and productivity. The final subsection considers both macroeconomic and human capital variables. I also added three rows to the end of a table, the antepenultimate of which shows the p-values of the overidentification test (J-statistics). Its null hypothesis proposes that if the used instruments are exogenous, the penultimate row will show the number of used instruments and the last row, whether our model meets our stability condition.

### 4.1 RESULTS WITHOUT COVARIATES

Table 2 shows our results considering the first measure of GDP per capita:

**Table 2 – Second Stage: estimating impacts without covariates**

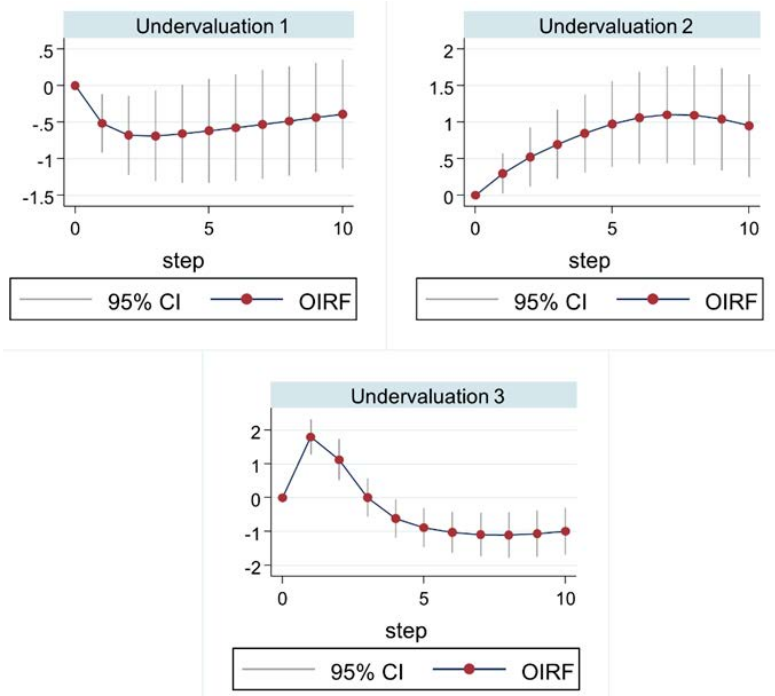
| Variables | First GDP per capita measure | | |
|---|---|---|---|
| | (1) | (2) | (3) |
| Economic Growth$_{i,t-1}$ | 0.13*** | 0.07 | 0.38*** |
| | (2.33) | (1.63) | (6.829 |
| Economic Growth$_{i,t-2}$ | −0.06 | −0.09*** | −0.08 |
| | (−1.51) | (−2.95) | (−1.73) |
| GDP per capita$_{i,t-1}$ | 0.37*** | 0.50*** | 0.25*** |
| | (11.21) | (19.34) | (7.7) |
| GDP per capita$_{i,t-2}$ | −0.37 | −0.50 | −0.25 |
| | (11.17) | (19.52) | (7.78) |
| *Undervaluation*$_{i,t-1}$ | −0.01*** | 0.02*** | 0.18*** |
| | (−2.17) | (3.42) | (7.54) |
| *Undervaluation*$_{i,t-2}$ | −0.00 | −0.02 | −0.19 |
| | (−0.05) | (−3.70) | (−7.62) |
| Observations | 385 | 385 | 385 |
| Overidentification Test (p-value) | 0.223 | 0.067 | 0.12 |
| Number of instruments | 72 | 72 | 72 |
| Stability Condition | Yes | Yes | Yes |

Notes: t statistics in parentheses. * p<0.05, ** p<0.01, *** p<0.001. This table shows the results for the first GDP per capita measure (ignoring macroeconomic variables). Each column represents an estimate for each real undervaluation measure. All estimates used robust standard errors. All variables have been transformed in terms of natural logarithm.

Source: Own elaboration.

Table 2 shows that, by using definition (2) and (3), undervaluation positively affects economic growth. Figure 1 shows the response of economic growth to a shock of each undervaluation.

**Figure 1 – Undervaluation shocks to economic growth without covariates according to the first GDP per capita measure**




Source: Own elaboration.

Figure 1 shows that an undervaluation shock 1 causes a negative response from economic growth. An undervaluation 2 shock causes a persistent positive response from economic growth and, finally, an undervaluation 3 shock increases economic growth in the first period, which then begins to decline. Table 3 shows the results of the second measure of GDP per capita.

**Table 3 – Second Stage: estimating impacts without covariates**

| Variables | Second GDP per capita measure | | |
|---|---|---|---|
| | (1) | (2) | (3) |
| Economic Growth$_{i,t-1}$ | −1.12 | −3.14*** | −3.95*** |
| | (−1.15) | (−4.96) | (−2.74) |
| Economic Growth$_{i,t-2}$ | 0.02 | −0.11*** | −0.090 |
| | (0.64) | (−4.35) | (−1.55) |
| GDP per capita$_{i,t-1}$ | 0.02 | 0.04*** | 0.05** |
| | (1.73) | (5.74) | (3.18) |
| GDP per capita$_{i,t-2}$ | −0.02 | −0.04*** | −0.05** |
| | (−1.74) | (−5.72) | (−3.18) |

***(Cont.)***

**Table 3 – Second Stage: estimating impacts without covariates - (CONTINUATION)**

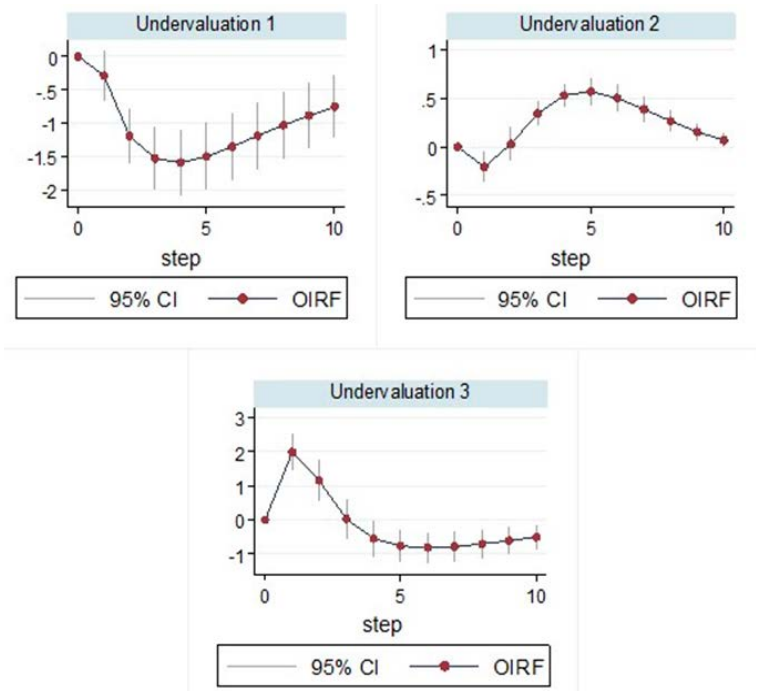
| Variables | Second GDP per capita measure | | |
|---|---|---|---|
| | (1) | (2) | (3) |
| $Undervaluation_{i,t-1}$ | −0.01 | −0.02** | 0.21*** |
| | (−1.54) | (−3.00) | (7.66) |
| $Undervaluation_{i,t-2}$ | −0.01*** | 0.04*** | −0.23*** |
| | (−5.06) | (6.20) | (−8.13) |
| Observations | 385 | 385 | 385 |
| Overidentification Test (p-value) | 0.183 | 0.022 | 0.897 |
| Number of instruments | 72 | 72 | 72 |
| Stability Condition | Yes | No | Yes |

Notes: t statistics in parentheses. * p<0.05, ** p<0.01, *** p<0.001. This table shows the results for the second GDP per capita measure (ignoring macroeconomic variables). Each column represents an estimate for each real undervaluation measure. All estimates used robust standard errors. All variables have been transformed in terms of natural logarithm.

Source: Own elaboration.

Results show that the first two undervaluation variables negatively impact economic growth, whereas the last positively affects it. Figure 2 shows the related impulse response graphs.

**Figure 2 – Undervaluation shocks to economic growth without covariates according to the second GDP per capita measure**




Source: Own elaboration.

Figure 2 shows that a shock of undervaluation 1 causes a negative response from economic growth without recovery, undervaluation 2 causes a period of fall of economic growth, which then begins to increase. Finally, an undervaluation shock 3 increases economic growth for two periods, which then begins to fall. Table 4 shows the results for the third measure of GDP per capita.

**Table 4 – Second Stage: estimating impacts without covariates**

| Variables | Third GDP per capita measure | | |
|---|---|---|---|
| | (1) | (2) | (3) |
| Economic Growth$_{i,t-1}$ | 0.123** | 0.35*** | 0.43*** |
| | (3.23) | (9.73) | (9.17) |
| Economic Growth$_{i,t-2}$ | −0.04 | −0.09** | −0.13*** |
| | (−1.18) | (−3.18) | (−3.98) |
| GDP per capita$_{i,t-1}$ | 0.10*** | 0.14*** | 0.05*** |
| | (11.40) | (11.99) | (4.43) |
| GDP per capita$_{i,t-2}$ | −0.09*** | −0.13*** | −0.05*** |
| | (−11.15) | (−11.80) | (−4.40) |
| *Undervaluation*$_{i,t-1}$ | 0.04*** | 0.10*** | 0.05** |
| | (18.41) | (10.19) | (3.15) |
| *Undervaluation*$_{i,t-2}$ | −0.04* | −0.10*** | −0.08*** |
| | (−2.38) | (−10.14) | (−5.08) |
| Observations | 385 | 385 | 385 |
| Overidentification Test (p-value) | 0.276 | 0.006 | 0.185 |
| Number of instruments | 72 | 72 | 72 |
| Stability Condition | Yes | Yes | Yes |

Notes: t statistics in parentheses. * p<0.05, ** p<0.01, *** p<0.001. This table shows the results for the third GDP per capita measure (ignoring macroeconomic variables). Each column represents an estimate for each real undervaluation measure. All estimates used robust standard errors. All variables have been transformed in terms of natural logarithm.

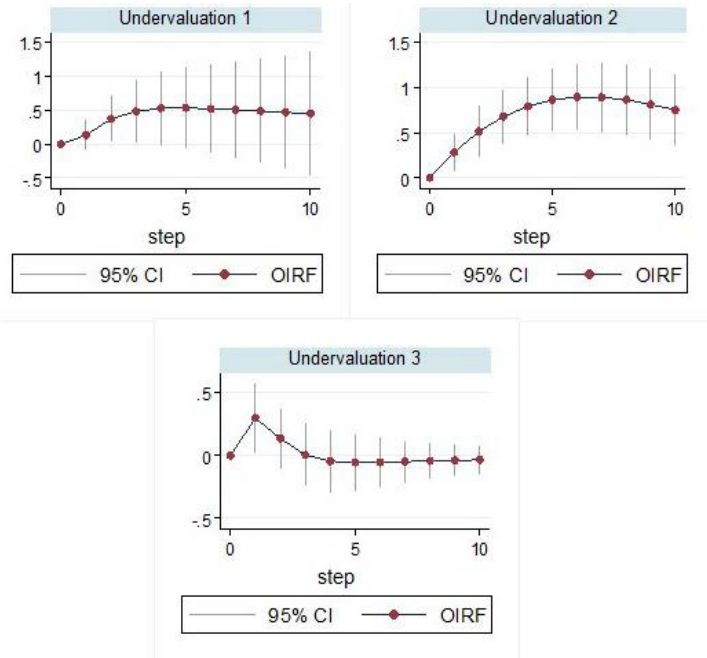
Source: Own elaboration.

Table 4 shows that the coefficients of all undervaluation measures are positive in the first lag and that those in the second lag period are negative. Figure 3 shows the related impulse response graphs using this measure of GDP per capita.

All impulse response graphs show that economic growth positively responds to the shocks of undervaluation measures. The first two are persistent, whereas the third one returns to zero in the third period. To conclude this subsection, I found that the third measure of GDP per capita produces positive undervaluation shocks. The first two measures of GDP per capita varyingly affect economic growth. From another point of view, the third measure of undervaluation positively impacts it in the first

periods and then falls. The other two undervaluation measures have different effects. Having shown the results without covariates, I move on to the following subsection, in which I add macroeconomic variables such as government spending, terms of trade, and monetary aggregates.

**Figure 3 – Undervaluation shocks to economic growth without covariates according to the third GDP per capita measure**




Source: Own elaboration.

## 4.2 RESULTS WITH MACROECONOMICS COVARIATES

Table 5 shows our results after adding macroeconomic variables to our model and using the same GDP per capita measure as that in Table 2.

**Table 5 – Second Stage: Estimating impacts with macroeconomics covariates**

| Variables | First GDP per capita measure | | |
|---|---|---|---|
| | (1) | (2) | (3) |
| $\text{Economic Growth}_{i,t-1}$ | 0.50*** | 0.15** | 0.28*** |
| | (3.35) | (3.13) | (4.84) |

***(Cont.)***

**Table 5 – Second Stage: Estimating impacts with macroeconomics covariates - (CONTINUATION)**

| Variables | First GDP per capita measure | | |
|---|---|---|---|
| | (1) | (2) | (3) |
| Economic Growth$_{i,t-2}$ | −0.10 | −0.05 | −0.08* |
| | (−0.97) | (−1.21) | (−2.04) |
| GDP per capita$_{i,t-1}$ | −0.16 | 0.24*** | 0.14*** |
| | (−1.28) | (9.11) | (4.98) |
| GDP per capita$_{i,t-2}$ | 0.18 | −0.19*** | −0.10*** |
| | (1.40) | (−7.18) | (−3.66) |
| *Undervaluation*$_{i,t-1}$ | 0.01 | 0.03** | 0..09*** |
| | (1.07) | (3.04) | (4.35) |
| *Undervaluation*$_{i,t-2}$ | 0.01 | −0.02* | −0.06** |
| | (0.79) | (−2.22) | (−3.23) |
| *Government Spending*$_{i,t}$ | −0.03 | −0.07*** | −0.06*** |
| | (−1.27) | (−8.87) | (−6.36) |
| *Terms of trade*$_{i,t}$ | 0.02 | 0.06*** | 0.06*** |
| | (0.51) | (9.08) | (7.81) |
| *Monetary Aggregates*$_{i,t}$ | 0.00 | −0.04*** | −0.02** |
| | (0.09) | (−4.23) | (−2.62) |
| Observations | 385 | 385 | 385 |
| Overidentification Test (p-value) | 0.649 | 0.083 | 0.696 |
| Number of instruments | 75 | 75 | 75 |
| Stability Condition | Yes | Yes | No |

Notes: t statistics in parentheses. * p<0.05, ** p<0.01, *** p<0.001. This table shows the results for the first GDP per capita measure considering macroeconomic variables. Each column represents an estimate for each real undervaluation measure. All estimates used robust standard errors. All variables have been transformed in terms of natural logarithm.

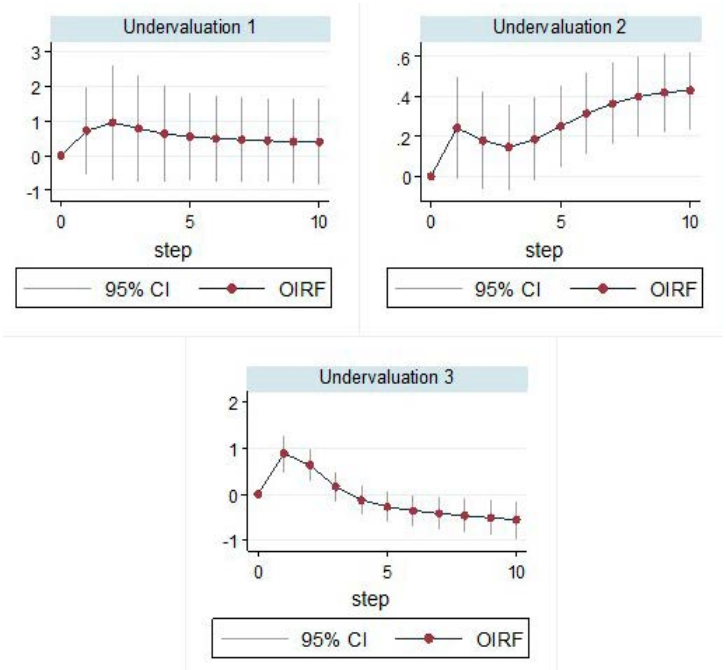
Source: Own elaboration.

Table 5 shows a first positive undervaluation measure with an insignificant impact on the first lag. The other two variables show significant effects on coefficients for both first and second lags. Figure 4 shows the impulse response graphs of these estimates.

Figure 4 shows positive economic growth responses to undervaluation shocks in all its measures. The first and third measures cause an increase in the first periods and then a decline, whereas the second measure shows a persistent increase over time. Table 6 shows our results according to the second measure of GPD per capita.

Results varied. The second and third undervaluation measures positively affected economic growth (the latter significantly so), whereas the first one showed negative and insignificant effects. Figure 5 shows the impulse response graphs of these undervaluation measures on economic growth.

**Figure 4 – Undervaluation shocks to economic growth considering macroeconomics variables according to the first GDP per capita measure**




Source: Own elaboration.

**Table 6 – Second Stage: Estimating impacts with macroeconomics covariates**

| Variables | Second GDP per capita measure | | |
|---|---|---|---|
| | (1) | (2) | (3) |
| Economic Growth$_{i,t-1}$ | −5.19*** | −4.48*** | −5.41*** |
| | (−3.78) | (−5.14) | (−4.38) |
| Economic Growth$_{i,t-2}$ | −0.04 | −0.08* | −0.05 |
| | (−0.94) | (−2.38) | (−1.08) |
| GDP per capita$_{i,t-1}$ | 5.49*** | 4.83*** | 5.83*** |
| | (3.96) | (5.55) | (4.69) |
| GDP per capita$_{i,t-2}$ | −5.45*** | −4.77*** | −5.78*** |
| | (−3.94) | (−5.49) | (−4.65) |
| *Undervaluation*$_{i,t-1}$ | −0.02 | 0.00 | 0.13*** |
| | (−0.46) | (0.12) | (6.47) |
| *Undervaluation*$_{i,t-2}$ | −0.00 | 0.01 | −0.09*** |
| | (−0.70) | (0.84) | (−5.20) |

***(Cont.)***

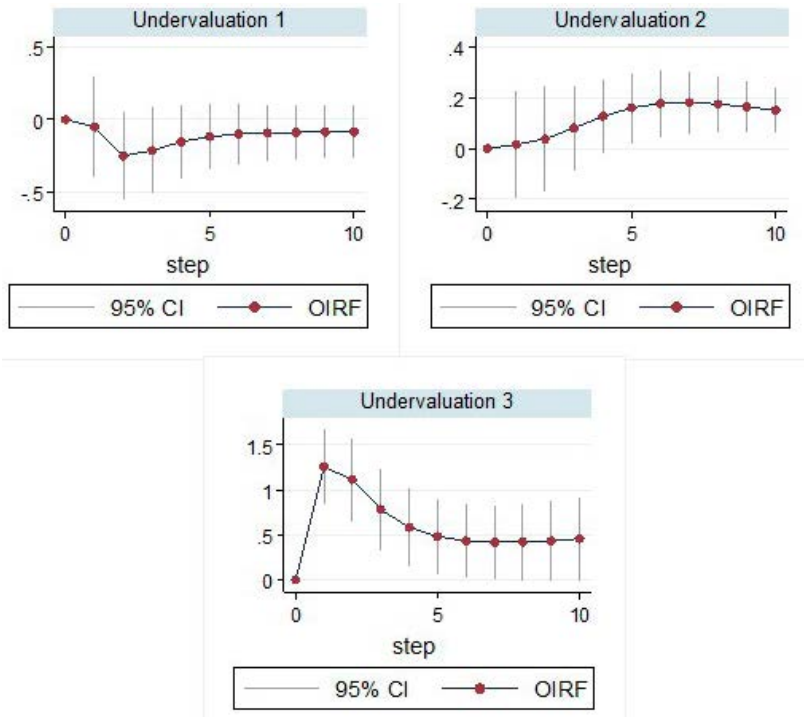
**Table 6 – Second Stage: Estimating impacts with macroeconomics covariates - (CONTINUATION)**

| Variables | Second GDP per capita measure | | |
|---|---|---|---|
| | (1) | (2) | (3) |
| *Government Spending*$_{i,t}$ | −0.08*** | −0.08*** | −0.08*** |
| | (−7.10) | (−14.10) | (−8.01) |
| *Terms of trade*$_{i,t}$ | 0.04*** | 0.06*** | 0.05*** |
| | (5.28) | (9.17) | (6.71) |
| *Monetary Aggregates*$_{i,t}$ | 0.00 | −0.02** | −0.00 |
| | (0.58) | (−3.04) | (−1.06) |
| Observations | 385 | 385 | 385 |
| Overidentification Test (p-value) | 0.724 | 0.229 | 0.811 |
| Number of instruments | 75 | 75 | 75 |
| Stability Condition | Yes | Yes | Yes |

Note: t statistics in parentheses. * p<0.05, ** p<0.01, *** p<0.001. This table shows the results for the second GDP per capita measure considering macroeconomic variables. Each column represents an estimate for each real undervaluation measure. All estimates used robust standard errors. All variables have been transformed in terms of natural logarithm.

Source: Own elaboration.

**Figure 5 – Undervaluation Shocks on economic growth with macroeconomic covariates using the second GDP per capita measure**




Source: Own elaboration.

Figure 5 shows scattered results, a shock from the first undervaluation measure caused a drop in economic growth and a subsequent recovery without compensating for this effect. A shock from the second undervaluation measure caused persistently positive effects on economic growth, whereas the last undervaluation measure first increased economic growth and then a gradual decrease without compensating for its impact. Table 7 shows the results for the third measure of GDP per capita.

**Table 7 – Second Stage: Estimating impacts with macroeconomics covariates**

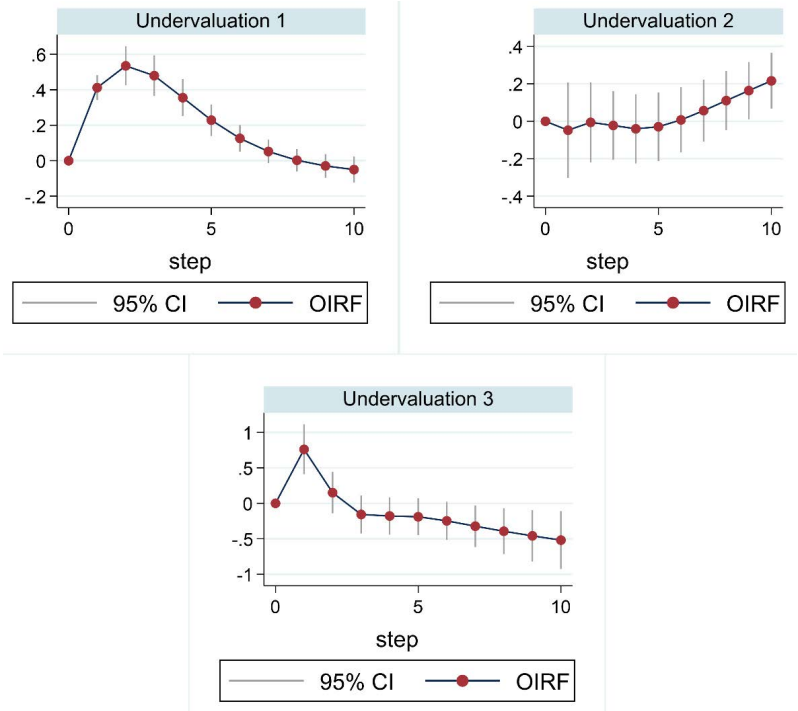
| Variables | Third GDP per capita measure | | |
|---|---|---|---|
| Economic Growth$_{i,t-1}$ | 0.26*** | 0.54*** | 0.46*** |
| | (7.51) | (11.54) | (6.86) |
| Economic Growth$_{i,t-2}$ | 0.03 | −0.15*** | −0.14** |
| | (1.43) | (−3.53) | (−2.92) |
| GDP per capita$_{i,t-1}$ | 0.02* | −0.12*** | −0.03* |
| | (2.23) | (−8.07) | (−2.03) |
| GDP per capita$_{i,t-2}$ | −0.01 | 0.15*** | 0.05*** |
| | (−1.62) | (9.80) | (3.34) |
| *Undervaluation*$_{i,t-1}$ | 0.03*** | −0.09*** | 0.10*** |
| | (17.08) | (−6.40) | (4.08) |
| *Undervaluation*$_{i,t-2}$ | 0.01*** | 0.11*** | −0.11*** |
| | (4.47) | (8.52) | (−4.93) |
| *Government Spending*$_{i,t}$ | −0.09*** | −0.13*** | −0.09*** |
| | (−20.06) | (−15.25) | (−6.21) |
| *Terms of trade*$_{i,t}$ | 0.01*** | 0.07*** | 0.07*** |
| | (3.76) | (10.31) | (7.89) |
| *Monetary Aggregates*$_{i,t}$ | 0.03*** | −0.02** | −0.01 |
| | (8.10) | (−3.21) | (−1.53) |
| Observations | 385 | 385 | 385 |
| Overidentification Test (p-value) | 0.294 | 0.227 | 0.305 |
| Number of instruments | 75 | 75 | 75 |
| Stability Condition | No | Yes | No |

Note: t statistics in parentheses. * p<0.05, ** p<0.01, *** p<0.001. This table shows the results of the third GDP per capita measure considering macroeconomic variables. Each column represents an estimate for each real undervaluation measure. All estimates used robust standard errors. All variables have been transformed in terms of natural logarithm.

Source: Own elaboration.

Results show that the first and third undervaluation measures positively impacted economic growth, whereas the second measure negatively affected it. Figure 6 shows the impulse response graphs for all undervaluation measures:

**Figure 6 – Undervaluation shocks on economic growth with macroeconomic covariates using the third GDP per capita measure**




Source: Own elaboration.

Figure 6 shows impulse response graphs in which a shock of the first and second measures elicited a positive response from economic growth, whereas the second one had no impact until the fifth period, in which it began to increase growth. Having shown the results of this subsection, we conclude that the third undervaluation measure positively impacted economic growth, whereas the others show scattered results. I now move on to the third subsection, in which I include human capital variables such as average labor hours, human capital index, and productivity.

### 4.3 RESULTS WITH HUMAN CAPITAL COVARIATES

Table 8 shows the results for the first GDP per capita measure:

**Table 8 – Second Stage: Estimating impacts with human capital covariates**

| Variables | First GDP per capita measure | | |
|---|---|---|---|
| | (1) | (2) | (3) |
| Economic Growth$_{i,t-1}$ | 0.12* | 0.25*** | 0.05 |
| | (2.21) | (5.25) | (0.75) |
| Economic Growth$_{i,t-2}$ | −0.14*** | −0.04 | −0.03 |
| | (−4.03) | (−0.97) | (−0.64) |
| GDP per capita$_{i,t-1}$ | 0.24*** | 0.12** | 0.04 |
| | (5.73) | (3.17) | (0.85) |
| GDP per capita$_{i,t-2}$ | −0.27*** | −0.25*** | −0.21*** |
| | (−7.76) | (−8.09) | (−5.26) |
| *Undervaluation*$_{i,t-1}$ | 0.00 | 0.10*** | 0.10*** |
| | (1.41) | (8.91) | (4.99) |
| *Undervaluation*$_{i,t-2}$ | −0.00 | −0.10*** | 0.02 |
| | (−0.44) | (−8.11) | (0.99) |
| *Average Labor Hours*$_{i,t}$ | 0.02*** | 0.01*** | 0.01** |
| | (4.48) | (3.29) | (2.81) |
| *Human Capital index*$_{i,t}$ | 0.09 | 0.44*** | 0.62** |
| | (1.67) | (7.61) | (9.24) |
| *Productivity*$_{i,t}$ | 0.04 | 0.17*** | 0.18*** |
| | (1.51) | (6.62) | (6.07) |
| Observations | 385 | 385 | 385 |
| Overidentification Test (p-value) | 0.307 | 0.155 | 0.414 |
| Number of instruments | 75 | 75 | 75 |
| Stability Condition | Yes | Yes | Yes |

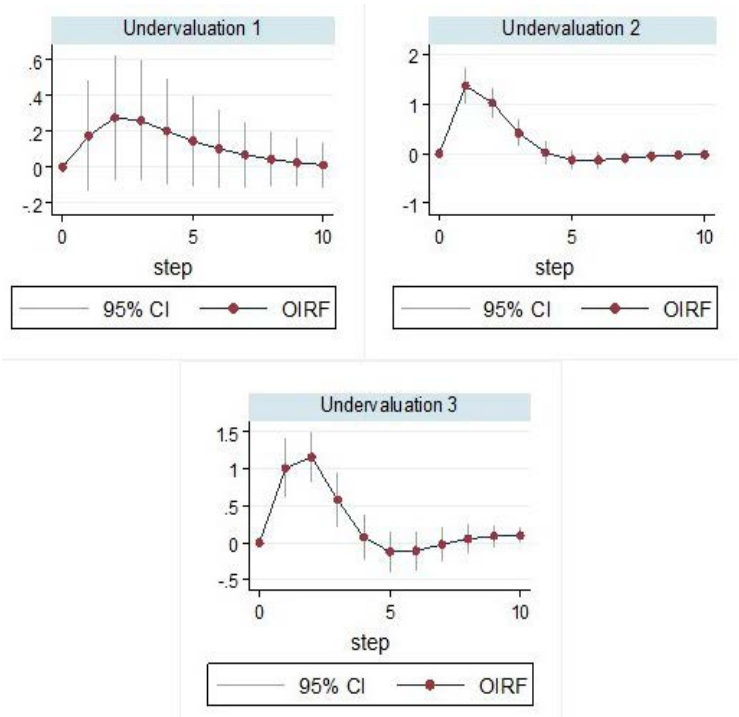
Notes: t statistics in parentheses. * p<0.05, ** p<0.01, *** p<0.001. This table shows the results for the first GDP per capita measure considering human capital covariates. Each column represents an estimate for each real undervaluation measure. All estimates used robust standard errors. All variables have been transformed in terms of natural logarithm.

Source: Own elaboration.

Table 8 shows that all undervaluation measures positively impacted economic growth. Figure 7 shows the impulse response graphs for all undervaluation measures on economic growth.

Impulse response graphs show the positive impact of undervaluation measures on economic growth up to the third period, in which it starts to decline. Second and third measure compensations reached zero in the fourth and fifth period, respectively, whereas those of the first measure occurred in the tenth period. Table 9 shows the results for the second measure of GDP per capita.

**Figure 7 – Undervaluation shocks on economic growth with human capital covariates using the first GDP per capita measure**




Source: Own elaboration.

**Table 9 – Second Stage: Estimating impacts with human capital variables**

| Variables | Second GDP per capita measure | | |
|---|---|---|---|
| | (1) | (2) | (3) |
| Economic Growth$_{i,t-1}$ | 3.88*** | 5.05*** | 2.29 |
| | (3.37) | (3.70) | (1.31) |
| Economic Growth$_{i,t-2}$ | −0.06 | −0.12** | −0.08 |
| | (−1.70) | (−3.06) | (−1.74) |
| GDP per capita$_{i,t-1}$ | −3.42** | −4.80*** | −2.02 |
| | (−2.97) | (−3.47) | (−1.14) |
| GDP per capita$_{i,t-2}$ | 3.41** | 4.65*** | 1.89 |
| | (2.96) | (3.36) | (1.07) |
| *Undervaluation*$_{i,t-1}$ | 0.02** | 0.03*** | 0.09*** |
| | (2.87) | (4.33) | (4.55) |
| *Undervaluation*$_{i,t-2}$ | −0.02** | −0.02** | −0.03 |
| | (−3.00) | (−2.70) | (−1.59) |

***(Cont.)***

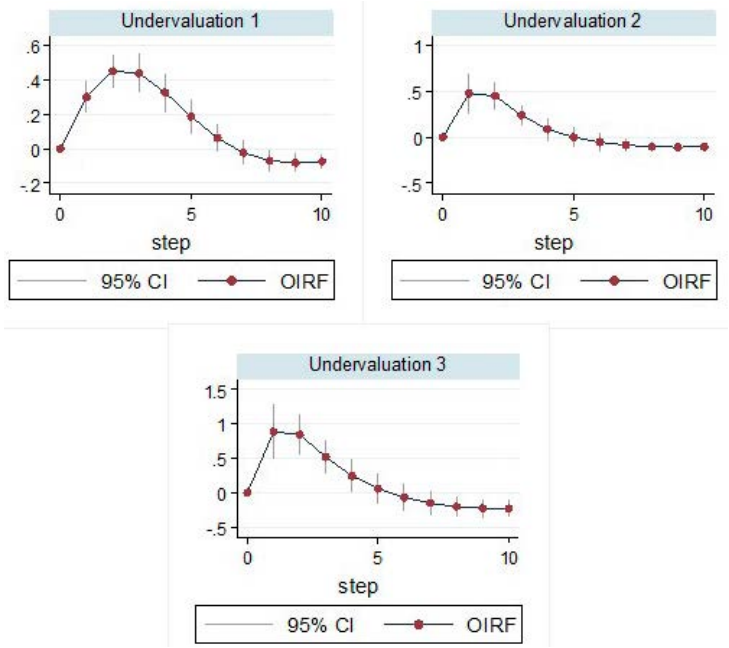
**Table 9 – Second Stage: Estimating impacts with human capital variables - (CONTINUATION)**

| Variables | Second GDP per capita measure | | |
|---|---|---|---|
| | (1) | (2) | (3) |
| *Average Labor Hours*$_{i,t}$ | 0.01** | 0.01** | −0.00 |
| | (3.25) | (2.70) | (−0.63) |
| *Human Capital index*$_{i,t}$ | 0.01 | 0.35*** | 0.31*** |
| | (0.47) | (13.19) | (8.76) |
| *Productivity*$_{i,t}$ | −0.01 | 0.08*** | 0.04** |
| | (−1.24) | (6.01) | (2.98) |
| Observations | 385 | 385 | 385 |
| Overidentification Test (p-value) | 0.354 | 0.120 | 0.747 |
| Number of instruments | 75 | 75 | 75 |
| Stability Condition | Yes | Yes | Yes |

Notes: t statistics in parentheses. * p<0.05, ** p<0.01, *** p<0.001. This table shows the results for the second GDP per capita measure considering human capital covariates. Each column represents an estimate for each real undervaluation measure. All estimates used robust standard errors. All variables have been transformed in terms of natural logarithm.
Source: Own elaboration.

Results show that undervaluation measures positively impact economic growth. Figure 8 shows the associated impulse response graphs.

**Figure 8 – Undervaluation shocks on economic growth with human capital covariates using the second GDP per capita measure**




Source: Own elaboration.

Figure 8 shows that the three undervaluation measures provoke a positive response in economic growth up to the third period, which then begins to decrease below zero. Table 10 shows the results for the third measure of GDP per capita.

**Table 10 – Second Stage: Estimating impacts with human capital variables**

| Variables | Third GDP per capita measure | | |
|---|---|---|---|
| | (1) | (2) | (3) |
| Economic Growth$_{i,t-1}$ | 0.36*** | 0.28*** | 0.30*** |
| | (7.27) | (9.62) | (6.16) |
| Economic Growth$_{i,t-2}$ | 0.00 | −0.13*** | −0.05 |
| | (0.10) | (−6.42) | (−1.51) |
| GDP per capita$_{i,t-1}$ | 0.04*** | −0.13*** | 0.00 |
| | (4.16) | (−13.44) | (0.99) |
| GDP per capita$_{i,t-2}$ | −0.05*** | 0.13*** | −0.03*** |
| | (−5.16) | (13.83) | (−3.33) |
| *Undervaluation*$_{i,t-1}$ | 0.02*** | −0.20*** | 0.09*** |
| | (9.52) | (−21.12) | (5.18) |
| *Undervaluation*$_{i,t-2}$ | −0.00 | 0.26*** | −0.06*** |
| | (−1.20) | (25.29) | (−3.65) |
| *Average Labor Hours*$_{i,t}$ | −0.01 | 0.26*** | −0.01 |
| | (−0.17) | (6.11) | (−0.10) |
| *Human Capital index*$_{i,t}$ | 0.05** | 0.14*** | 0.12*** |
| | (3.13) | (9.80) | (6.54) |
| *Productivity*$_{i,t}$ | 0.01 | −0.00 | −0.02 |
| | (1.68) | (−0.26) | (−1.84) |
| Observations | 385 | 385 | 385 |
| Overidentification Test (p-value) | 0.328 | 0.330 | 0.263 |
| Number of instruments | 75 | 75 | 75 |
| Stability Condition | Yes | Yes | Yes |

Notes: t statistics in parentheses. * p<0.05, ** p<0.01, *** p<0.001. This table shows the results for the third GDP per capita measure considering human capital covariates. Each column represents an estimate for each real undervaluation measure. All estimates used robust standard errors. All variables have been transformed in terms of natural logarithm.

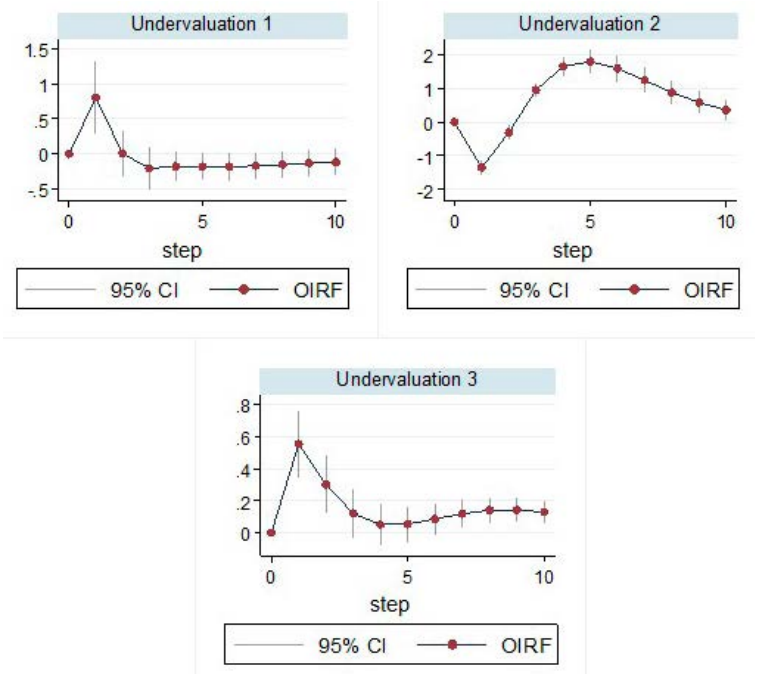
Source: Own elaboration.

Table 10 shows that the first and third measures positively impacted economic growth, whereas the second measure negatively impacted it. Figure 9 shows the related impulse response graphs.

Figure 9 shows that a shock of the first and second undervaluation measures elicited a positive response from economic growth. However, the first measure falls

below zero, whereas the third one remains positive for the remaining periods. The second measure has a negative impact below zero but increases until it exceeds zero for the remaining period. Thus, I found that the first and third measures positively impacted economic growth considering all GDP per capita measures. While the second undervaluation measure positively impacted the first and second measures of GDP per capita, the third measure showed a negative impact in the first period, whose increase remained above zero. The following subsection shows results for all variables, i.e., including government spending, terms of trade, monetary aggregates, average labor hours, human capital index, and productivity.

**Figure 9 – Undervaluation shocks on economic growth with human capital covariates using the third GDP per capita measure**




Source: Own elaboration.

## 4.4 RESULTS WITH ALL COVARIATES

Table 11 shows our results considering all variables and using the first measure of GDP per capita:

**Table 11 – Second Stage: estimating impacts with all covariates**

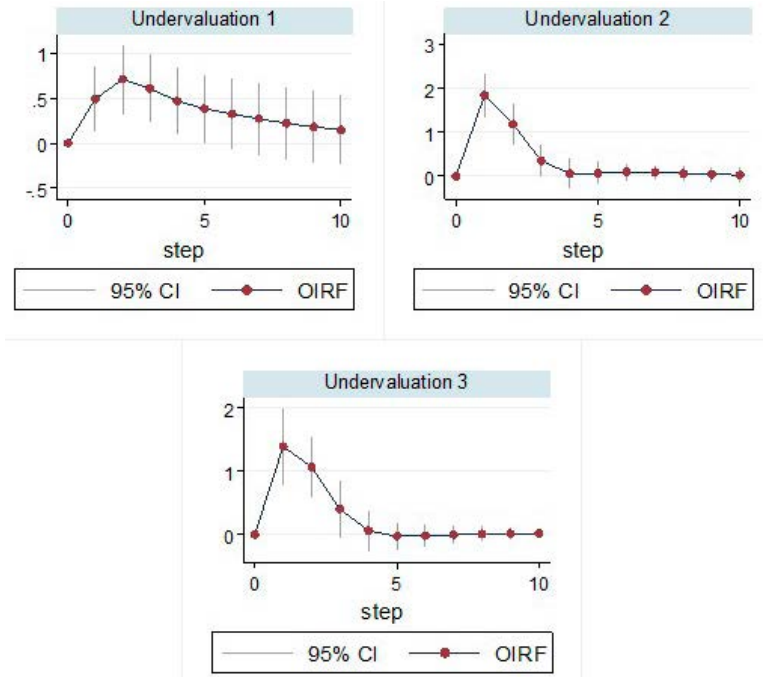
| Variables | First GDP per capita measure | | |
|---|---|---|---|
| | (1) | (2) | (3) |
| Economic Growth$_{i,t-1}$ | 0.09 | 0.32*** | 0.17 |
| | (1.35) | (4.59) | (1.58) |
| Economic Growth$_{i,t-2}$ | −0.21*** | −0.07 | −0.05 |
| | (−5.04) | (−1.28) | (−0.77) |
| GDP per capita$_{i,t-1}$ | 0.27*** | 0.10* | 0.04 |
| | (6.09) | (2.05) | (0.61) |
| GDP per capita$_{i,t-2}$ | −0.17*** | −0.16*** | −0.13* |
| | (−5.01) | (−3.85) | (−2.10) |
| *Undervaluation*$_{i,t-1}$ | 0.01** | 0.15*** | 0.14*** |
| | (3.25) | (7.58) | (4.75) |
| *Undervaluation*$_{i,t-2}$ | −0.00 | −0.14*** | −0.01 |
| | (−0.20) | (−6.59) | (−0.36) |
| *Average Labor Hours*$_{i,t}$ | 0.00 | 0.01** | 0.01 |
| | (0.28) | (2.96) | (1.73) |
| *Human Capital index*$_{i,t}$ | −0.13* | 0.23*** | 0.32*** |
| | (−2.54) | (4.55) | (4.65) |
| *Productivity*$_{i,t}$ | −0.05 | 0.086** | 0.06 |
| | (−1.92) | (3.17) | (1.56) |
| *Government Spending*$_{i,t}$ | −0.09*** | −0.02 | −0.01 |
| | (−6.86) | (−1.76) | (−0.58) |
| *Terms of trade*$_{i,t}$ | 0.05*** | 0.01 | −0.00 |
| | (5.12) | (0.89) | (−0.18) |
| *Monetary Aggregates*$_{i,t}$ | −0.04*** | 0.00 | 0.01 |
| | (−4.40) | (0.23) | (0.89) |
| Observations | 385 | 385 | 385 |
| Overidentification Test (p-value) | 0.476 | 0.151 | 0.870 |
| Number of instruments | 78 | 78 | 54 |
| Stability Condition | Yes | Yes | Yes |

Notes: t statistics in parentheses. * p<0.05, ** p<0.01, *** p<0.001. This table shows the results of the first GDP per capita measure considering all covariates. Each column represents an estimate for each real undervaluation measure. All estimates used robust standard errors. All variables have been transformed in terms of natural logarithm.

Source: Own elaboration.

Table 11 shows that undervaluation positively impacted economic growth under the first measure of GDP per capita. Figure 10 shows the impulse response graphs of undervaluation measures on economic growth.

**Figure 10 – Undervaluation on economic growth with all covariates using the second GDP per capita measure**




Source: Own elaboration.

Figure 10 shows that a positive undervaluation shock positively impacts economic growth, compensating for the second and third measures up to the fourth period, whereas the first measure remains uncompensated for the first 10 periods. Table 12 shows the results using the second measure of GDP per capita.

**Table 12 – Second Stage: Estimating impacts with all covariates**

| Variables | Second GDP per capita measure | | |
|---|---|---|---|
| | (1) | (2) | (3) |
| Economic Growth$_{i,t-1}$ | −7.85*** | −6.84*** | −5.42*** |
| | (−4.86) | (−6.36) | (−3.88) |
| Economic Growth$_{i,t-2}$ | −0.11** | −0.09* | −0.06 |
| | (−2.61) | (−1.97) | (−1.42) |
| GDP per capita$_{i,t-1}$ | 8.12*** | 7.00*** | 5.69*** |
| | (5.01) | (6.56) | (4.06) |

***(Cont.)***

**Table 12 – Second Stage: Estimating impacts with all covariates - (CONTINUATION)**

| Variables | Second GDP per capita measure | | |
|---|---|---|---|
| | (1) | (2) | (3) |
| GDP per capita$_{i,t-2}$ | −8.08*** | −7.07*** | −5.70*** |
| | (−4.97) | (−6.60) | (−4.06) |
| *Undervaluation*$_{i,t-1}$ | 0.01 | 0.05*** | 0.11*** |
| | (1.54) | (6.28) | (5.94) |
| *Undervaluation*$_{i,t-2}$ | −0.00 | −0.03*** | −0.04* |
| | (−0.53) | (−4.38) | (−2.40) |
| *Average Labor Hours*$_{i,t}$ | 0.01 | 0.01*** | 0.00 |
| | (1.24) | (4.00) | (0.07) |
| *Human Capital index*$_{i,t}$ | −0.04 | 0.21*** | 0.16*** |
| | (−1.16) | (6.58) | (6.20) |
| *Productivity*$_{i,t}$ | 0.06** | 0.16*** | 0.06*** |
| | (3.24) | (9.51) | (3.67) |
| *Government Spending*$_{i,t}$ | −0.05*** | −0.01 | −0.05*** |
| | (−4.16) | (−1.75) | (−4.58) |
| *Terms of trade*$_{i,t}$ | 0.05*** | 0.08*** | 0.06*** |
| | (6.57) | (10.27) | (6.07) |
| *Monetary Aggregates*$_{i,t}$ | −0.01 | −0.02* | −0.03*** |
| | (−0.86) | (−2.43) | (−3.85) |
| Observations | 385 | 385 | 385 |
| Overidentification Test (p-value) | 0.840 | 0.177 | 0.702 |
| Number of instruments | 77 | 77 | 77 |
| Stability Condition | Yes | Yes | Yes |

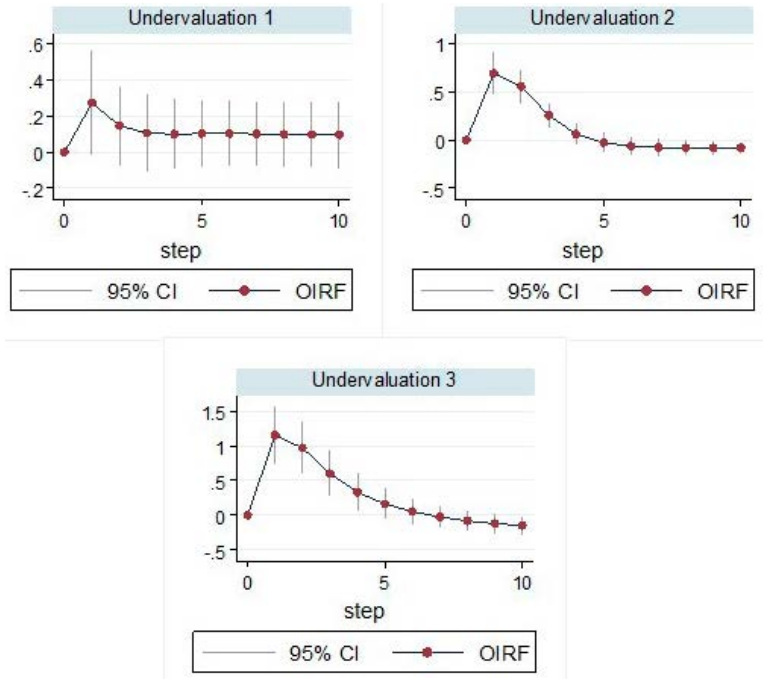
Notes: t statistics in parentheses. * p<0.05, ** p<0.01, *** p<0.001. This table shows the results of the second GDP per capita measure considering all covariates. Each column represents an estimate for each real undervaluation measure. All estimates used robust standard errors. All variables have been transformed in terms of natural logarithm.

Source: Own elaboration.

Table 12 describes estimates using the second measure of GDP per capita, showing positive results for all of them (although significant only in the second and third undervaluation measures). Figure 11 shows the related impulse response graphs.

Figure 11 shows that the shock of all undervaluation measures increases economic growth, but only the second and third measures are offset by reaching zero, whereas the first measure remains constant in all periods. Finally, Table 13 shows estimates considering the third measure of GDP per capita.

**Figure 11 – Undervaluation shocks on economic growth with all covariates using the third GDP per capita measure**




Source: Own elaboration.

**Table 13 – Second Stage: Estimating impacts with all covariates**

| Variables | Third GDP per capita measure | | |
|---|---|---|---|
| | (1) | (2) | (3) |
| Economic Growth$_{i,t-1}$ | 0.30*** | 0.22*** | 0.13** |
| | (5.70) | (6.52) | (2.62) |
| Economic Growth$_{i,t-2}$ | 0.03 | −0.16*** | −0.06 |
| | (0.83) | (−6.45) | (−1.48) |
| GDP per capita$_{i,t-1}$ | −0.06*** | −0.17*** | −0.02 |
| | (−6.45) | (−15.31) | (−1.56) |
| GDP per capita$_{i,t-2}$ | 0.05*** | 0.19*** | 0.01 |
| | (6.17) | (15.76) | (0.88) |
| *Undervaluation*$_{i,t-1}$ | −0.02** | −0.21*** | 0.09*** |
| | (−3.28) | (−17.39) | (6.48) |

***(Cont.)***

**Table 13 – Second Stage: Estimating impacts with all covariates - (CONTINUATION)**

| Variables | Third GDP per capita measure | | |
|---|---|---|---|
| | (1) | (2) | (3) |
| $Undervaluation_{i,t-2}$ | 0.02** | 0.26*** | −0.04*** |
| | (2.93) | (24.52) | (−3.97) |
| $Average\ Labor\ Hours_{i,t}$ | −0.03 | 0.18*** | 0.06 |
| | (−0.57) | (4.48) | (0.78) |
| $Human\ Capital\ index_{i,t}$ | −0.03 | 0.01 | −0.07*** |
| | (−1.47) | (0.66) | (−3.32) |
| $Productivity_{i,t}$ | 0.10*** | 0.11*** | 0.13*** |
| | (8.10) | (11.43) | (11.36) |
| $Government\ Spending_{i,t}$ | −0.11*** | −0.05*** | −0.01 |
| | (−10.97) | (−7.71) | (−0.94) |
| $Terms\ of\ trade_{i,t}$ | 0.08*** | 0.12*** | 0.15*** |
| | (11.14) | (18.57) | (17.41) |
| $Monetary\ Aggregates_{i,t}$ | 0.02*** | 0.00 | 0.02*** |
| | (6.24) | (0.69) | (4.69) |
| Observations | 385 | 385 | 385 |
| Overidentification Test (p-value) | 0.253 | 0.408 | 0.636 |
| Number of instruments | 77 | 77 | 77 |
| Stability Condition | Yes | Yes | Yes |

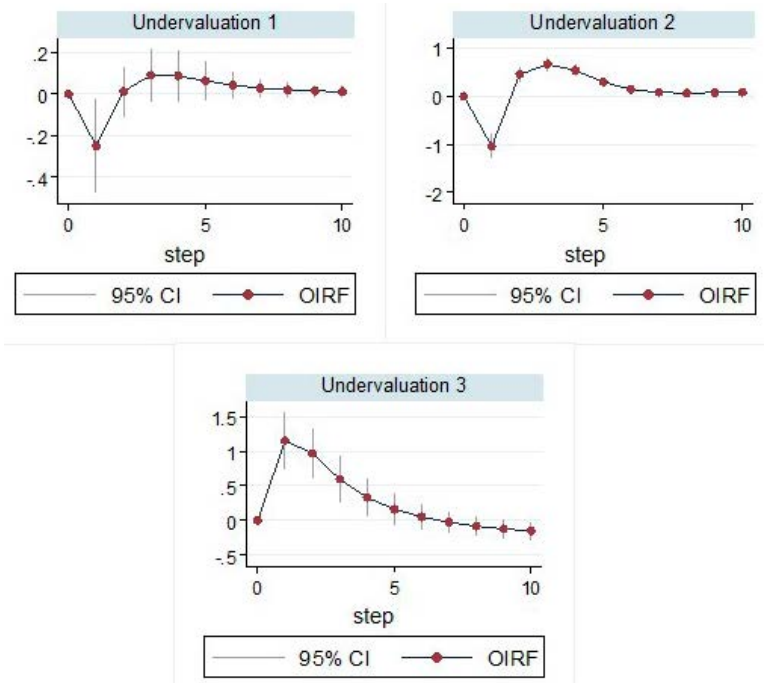
Note: t statistics in parentheses. * p<0.05, ** p<0.01, *** p<0.001. This table shows the results of the third GDP per capita measure considering all covariates. Each column represents an estimate for each real undervaluation measure. All estimates used robust standard errors. All variables have been transformed in terms of natural logarithm.

Source: Own elaboration.

Figure 12 shows that the shock of all undervaluation measures increases economic growth, but that only the second and third measures are offset by reaching zero, whereas the first measure remains constant in all periods.

Figure 12 shows that the first and second undervaluation measures negatively impact economic growth, whereas the third measure has positive impacts, increasing in the first period and then falling below zero. Thus, results show that only the third measure of undervaluation shows positive effects for all measures of GDP per capita, whereas the other two, scattered results. I conclude this study in the next section. The subsequent annex describes the Granger causality tests for all estimates in this investigation.

**Figure 12 – Undervaluation shocks on economic growth with all covariates using the third GDP per capita measure**




Source: Own elaboration.

## 5. CONCLUSION

*Undervaluation* is an economic policy tool governments use to promote economic growth. While the literature finds mixed results, most studies find positive effects under certain circumstances. This study will answer whether undervaluation episodes in Latin America use a Panel VAR from 1980 to 2018.

Results show that undervaluation positively affects economic growth, considering the third measure of undervaluation for all definitions of GDP per capita (which also serves to construct economic growth per capita). These significant effects show that changing undervaluation by 1% can positively impact economic growth from 5 to 19%, whereas the other two undervaluation measures show dispersed effects depending on the measures of GDP per capita and included variables.

Suppose I look at the first undervaluation measure without considering macroeconomic and human capital variables, i.e., the results of Tables 2-4. In that case, I would observe a positive effect in one of the three measures of GDP per capita, only finding significance

in the first measure of GDP per capita. If I were to include macroeconomic variables (i.e., the results of Tables 5-7), I would find positive effects in the first and third measure of GDP per capita but significance only in the last measure. Considering human capital variables (i.e., the results of Tables 8-10), I would find positive effects on all GDP per capita but only significant ones in the second and third measures. Lastly, considering all macroeconomic and human capital variables (i.e., the results in Tables 11-13), I would find positive effects in the first and second measures of GDP per capita but only significant ones in the first measure.

Turning to the second measure of undervaluation, without including variables (i.e., the results of Table 2-4), I found positive and significant effects in the first and third measures of GDP per capita. Considering macroeconomic variables (i.e., the results in Table 5-7), I found positive effects in the first and second measures of GDP per capita, only significant in the first one. Considering human capital variables (i.e., the results in Table 8-10), I found positive and significant effects in the first and second measures of GDP per capita. Finally, considering all variables (i.e., Tables 11-13), I found positive effects and significance in the first and second measures of GDP per capita.

This study contributes to the literature primarily in two ways. First, we focused on emerging economies, such as developing countries, over 30 years and considered various measures of undervaluation and GDP per capita. Our second contribution refers to our analysis using a relatively new methodology (Panel VAR), which, to the best of the author's knowledge, enabled us to control for possible endogeneity between undervaluation and economic growth, despite its rare use in this kind of study.

The main limitation of this study is that we ignored the transmission mechanisms by which undervaluation affects economic growth. However, our literature review suggested plural transmission mechanisms.

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# APPENDIX 1

**Table 14 – Panel VAR-Granger causality Wald test (without covariates)**

| | First GDP per capita measure | Second GDP per capita measure | Third GDP per capita measure |
|---|---|---|---|
| First undervaluation measure | 0.011 | 0.000 | 0.000 |
| Second undervaluation measure | 0.001 | 0.000 | 0.000 |
| Third undervaluation measure | 0.000 | 0.000 | 0.000 |

Ho: Excluded variable fails to Granger-cause Equation another variable
Ha: Excluded variable Granger-causes Equation another variable
Source: Own elaboration

**Table 15 – Panel VAR-Granger causality Wald test (Macroeconomic variables)**

| | First GDP per capita measure | Second GDP per capita measure | Third GDP per capita measure |
|---|---|---|---|
| First undervaluation measure | 0.500 | 0.247 | 0.000 |
| Second undervaluation measure | 0.000 | 0.005 | 0.000 |
| Third undervaluation measure | 0.000 | 0.000 | 0.000 |

Ho: Excluded variable fails to Granger-cause Equation another variable
Ha: Excluded variable Granger-causes Equation another variable
Source: Own elaboration

**Table 16 – Panel VAR-Granger causality Wald test (Human capital covariates)**

| | First GDP per capita measure | Second GDP per capita measure | Third GDP per capita measure |
|---|---|---|---|
| First undervaluation measure | 0.275 | 0.110 | 0.000 |
| Second undervaluation measure | 0.000 | 0.000 | 0.000 |
| Third undervaluation measure | 0.000 | 0.000 | 0.000 |

Ho: Excluded variable fails to Granger-cause Equation another variable
Ha: Excluded variable Granger-causes Equation another variable
Source: Own elaboration

**Table 17 – List of countries**

| | | |
|---|---|---|
| Bolivia | Brazil | Chile |
| Colombia | Costa Rica | Dominican Republic |
| Guatemala | Mexico | Paraguay |
| Perú | Uruguay | |

Source: Own elaboration elaboration.

**Table 18 – List of Variables**

| Variable | Definition | Source |
|---|---|---|
| First Economic Growth per capita | Expenditure-side real GDP at chained PPPs to compare relative living standards across countries and over time divided by population | Penn World Table v9.1 |
| Second Economic Growth per capita | GDP per capita is gross domestic product divided by the mid-year population. GDP is the sum of gross value added by all resident producers in the economy plus any product taxes and minus any subsidies not included in the value of the products. It is calculated without making deductions for the depreciation of fabricated assets or for the depletion and degradation of natural resources divided by population. Data are in constant 2010 U.S. dollars. | World Bank |
| Third Economic Growth per capita | GDP per capita is the gross domestic product divided by the mid-year population. GDP is the sum of gross value added by all resident producers in the economy plus any product taxes and minus any subsidies not included in the value of the products. It is calculated without making deductions for the depreciation of fabricated assets or for the depletion and degradation of natural resources divided by population. Data are in current U.S. dollars. | World Bank |
| Nominal Exchange Rate | The official exchange rate refers to the exchange rate determined by national authorities or to the rate determined in the legally sanctioned exchange market. It is calculated as an annual average based on monthly averages (local currency units relative to the U.S. dollar). | World Bank |
| Producer Price Index (U.S) | Average change over time in the selling prices received by domestic producer for their output. | IMF |
| Consumer Price Index | The consumer price index reflects changes in the cost to the average consumer of acquiring a basket of goods and services that may be fixed or changed at specified intervals, such as yearly ones. The Laspeyres formula is generally used. Data are period averages. | World Bank |
| PPP | The purchasing power parity conversion factor is the number of units of the currency of a country required to buy the same amounts of goods and services in the domestic market as U.S. dollar would buy in the United States. This conversion factor is for GDP. For most economies, PPP figures are extrapolated from the 2011 International Comparison Program (ICP) benchmark estimates or imputed using a statistical model based on the 2011 ICP. For 47 high- and upper middle-income economies, conversion factors are provided by Eurostat and the Organisation for Economic Co-operation and Development (OECD). | World Bank |
| First Real Exchange Rate | The first RER is the Nominal Exchange Rate divided by PPP | Own Estimation |
| Second Real Exchange Rate | This RER is the multiplication of the Nominal Exchange Rate and the Producer Price Index divided by Consumerr Price Index | Own Estimation |
| Third Real Exchange Rate | Inverse of Price level of the CGDPo, price level of USA GDPo in 2011=1 | Penn World Table v9.1 |
| Government Spend | The general government final consumption expenditure (formerly general government consumption) includes all government current expenditures for purchases of goods and services (including compensation of employees). It also includes most expenditures on national defense and security but excludes government military expenditures that are part of government capital formation. | World Bank |
| Terms of Trade | The terms of trade effect equals capacity to import less exports of goods and services in constant prices. Data are in constant local currency. | World Bank |

***(Cont.)***

**Table 18 – List of Variables - (CONTINUATION)**

| Variable | Definition | Source |
|---|---|---|
| Monetary Aggregates | Broad money (IFS line 35L..ZK) is the sum of currency outside banks; demand deposits other than those of the central government; the time, savings, and foreign currency deposits of resident sectors other than those of the central government; bank and traveler's checks; and other securities such as deposit certificates and commercial paper. | World Bank |
| Average Labor Hours | Average annual hours worked by engaged persons | Penn World Table v9.1 |
| Human Capital Index | Human Capital Index | Penn World Table v9.1 |
| Productivity | Welfare-relevant Total Factor Productivity at constant prices (2011 =1) | Penn World Table v9.1 |

Source: Own elaboration.