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**Working Paper**

## Sustained exchange rate misalignment and economic development

Working Paper, No. 2022-05

**Provided in Cooperation with:**

Department of Economics, University of Massachusetts

*Suggested Citation:* Martins, Guilherme Klein; Razmi, Arslan (2022) : Sustained exchange rate misalignment and economic development, Working Paper, No. 2022-05, University of Massachusetts, Department of Economics, Amherst, MA, <https://hdl.handle.net/doi:10.7275/qn6k-km70>

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## **Sustained Exchange Rate Misalignment and Economic Development**

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# Sustained Exchange Rate Misalignment and Economic Development\*

Guilherme Klein Martins<sup>†</sup> Arslan Razmi<sup>‡</sup>

February 5, 2022

## Abstract

Employing propensity score reweighting and event-based strategies, we provide evidence that *sustained* real exchange rate (RER) misalignments have significant effects on economic development: positive on GDP *per capita* and capital stock in the case of undervaluation, and negative on the capital stock in the case of overvaluation. Moreover, a large set of structural parameters are tested, and the results point to some structural changes during and after these episodes: real undervaluations increase investment and the share of intermediate and capital goods imported, and decrease the shares of consumption, wages, the services sector, and consumption goods imported. Overvaluations cause a reduction in investment, and an increase in the share of the services sector, and of commodities and natural-resources in exports. We also find evidence that these effects are heterogeneous by income level. Our approaches to analyzing sustained misalignments help us address endogeneity and heterogeneity concerns, mismeasurement issues, identify causal channels, and incorporate issues relating to expectations and other mechanisms that play an important role in structural transformation.

JEL codes: F43, F31, O47

Key words: real exchange rates, sustained misalignments, growth, investment, structural change, structural heterogeneity.

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\*We would like to thank Daniele Girardi and Peter Skott for comments, as well as the participants of the 25th FMM Conference and Analytical Political Economy (UMASS) workshop. We also like to thank Mateo Hoyos Lopez for comments and for sharing data on economic complexity and exports diversification.

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# 1 Introduction, Background, and Brief Overview

The effect of real exchange rate (RER) misalignments on economic growth and capital accumulation have been the subject of several research efforts in recent years.<sup>1</sup> While the literature has generally found a positive effect of real exchange rate undervaluation on growth, and the inverse for overvaluations, there are exceptions and relevant methodological criticism.

We explore the question from a different and, to the best of our knowledge, novel angle. Employing panel data covering 124 countries from 1950 to 2019, we apply a formal set of criteria to identify episodes of sustained RER misalignments (both undervaluations and overvaluations). We then investigate the subsequent consequences for output, capital stock, and other important macroeconomic variables over extended periods. As discussed later, there are several advantages to this approach.

We find that persistent RER misalignments can have significant longer-term consequences. Our baseline estimation implies that, on average, a country that experiences an undervaluation episode achieves, after 14 years of the beginning of the episode, a GDP *per capita* and a capital stock about 6 percent higher than would be the case otherwise. Conversely, an overvaluation episode is associated with a 5 percent smaller capital stock 14 years after the beginning of the episode. The effects are heterogeneous among income levels: the positive effects on GDP occur only in low and high-income countries, with the final effect after 14 years surpassing 10 percent in both cases; positive effects on the capital stock, however, are only seen in low-income countries. We also find that this heterogeneity is influenced by the degree of volatility within the misalignment episodes and by the composition of exports. Low income countries that are less specialized in primary commodities appear to benefit the most from undervaluation episodes while those specialized in primary commodity exports suffer the highest loss in terms of GDP and the capital stock.

We further investigate the channels through which misalignment could influence development. In general, undervaluation episodes raise investment, particularly in machinery, and the export share of GDP; such episodes are also associated with decreases in the share of consumption, the wage share, and the relative size of the services sector. Broadly, there is a shift of imports away from consumption goods and towards intermediate and capital goods. Overvaluation episodes are associated with increases in the consumption share, the share of commodities

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<sup>1</sup>See, for example, Rodrik (2008), Rajan and Subramanian (2011), Razmi et al. (2012), Schröder (2013), Demir and Razmi (2021).

and natural-resources in exports, and the service sector employment; they have a negative effect on investment (particularly in physical structures) and the share of low-tech manufactures. Imports shift towards capital and consumption goods and away from intermediate ones.

Causal estimations, as the ones intended in the paper, face well-known challenges which tend to be even more severe in macroeconomic settings where the degree of endogeneity of the independent variable is either hard to define or arguably high. One important challenge when estimating the causal effects of real exchange rate misalignments is that economies that go through such episodes might differ from others in unobserved characteristics that also affect the variables of interest. Consequently, cross-country regressions tend to be biased. A tentative solution for this problem is the use of country fixed effects in difference-in-difference or panel estimates. However, a second important challenge is that misalignment episodes might be preceded by movements in macro variables that we are interested in, such as GDP and the trade balance. In a difference-in-differences or panel data setting this implies a violation of the parallel-trends assumption, which, if ignored, also generates biased estimates.

Existing studies of the effects of RER misalignment on growth and development have typically addressed the endogeneity issue by employing the GMM approach, which uses lagged values of the dependent and independent variables as instruments [e.g., Rodrik (2008)].<sup>2</sup> As is well-recognized in macroeconometric literature, it is typically quite hard to find satisfactory instrumental variables. Moreover, difference and system GMM estimates are subject to the criticism that the number of instruments tends to explode with an increasing time dimension.

Given the gaps in the literature and the nonexistence of an ideal method to address these problems simultaneously, our empirical strategy is to use multiple approaches, each with its advantages and limitations, to estimate the causal effects of RER misalignment on economic development. Our baseline approach is a semiparametric treatment effects estimation (Inverse Probability Weighted Regression Adjustment, or IPWRA) in which the ‘treatment’ is the occurrence of a RER misalignment episode. It is a semiparametric method since, while it requires a model for the selection into episodes of misalignment, it does not impose a parametric model for the dynamics of the dependent variable.

Our second approach is based on event-specific estimations: each episode is analyzed indi-

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<sup>2</sup>Habib et al. (2017) is an exception that uses external instrumental variables (global capital flows interacted with individual country financial openness and the growth rate of official reserves). Bussière et al. (2015) employ a propensity matching approach, and unlike the present paper, use business cycle frequency (annual) data and look only at appreciations. The paper controls for whether real appreciations are accompanied by a productivity boom or a rise in capital inflows.

vidually and with ‘clean’ controls. This method allows us to observe the total distribution of effects instead of their average. It also allows us to take into account heterogeneity among panel units, and thus address the concern raised by Schröder (2013) (see below). Moreover, stacked event-by-event regressions can be used to estimate the average effect to compare - qualitatively, given the different selection of controls - with the baseline approach.

Thirdly, we also perform a dynamic linear estimation with time and country fixed effects and autoregressive dynamics. For a number of reasons, among them the lack of confidence that the effects are linear, we perform this estimation only for GDP and do not attribute much weight to it for our conclusions, although the effects are close to the ones achieved with the non-linear methods. This method, however, is relevant to our choice of four lags of the variable of interest to control for pre-treatment effects, a choice that we then use in the other approaches. We believe, thus, that the effort to address issues that bias causal estimates for the effect of RER misalignment is an important contribution of the paper to this much debated topic.

As mentioned earlier, we use formal criteria to distinguish sustained misalignments, which then constitute our treatment. This approach we believe is superior in several respects to earlier work. First, on a practical note, the concept of an equilibrium real exchange rate level is not well-defined in the literature [Hinkle and Monteil (1999), Demir and Razmi (2021)], so that focusing on significant and sustained deviations rather than annual or higher frequency movements helps minimize mismeasurement issues. Second, our approach helps mitigate the confounding effect of changes in macroeconomic variables that are purely due to recovery from a one-time large RER change, such as one following a currency crisis. Third, as pointed out by Schröder (2013), most empirical studies of the relationship between RER levels and economic growth treat under- and overvaluations symmetrically and, therefore, are unable to address potential differences. By explicitly making this distinction, we are able to address this critique.

Fourth, an important reason to isolate and focus on sustained misalignments is the issue of the permanence of price signals. Bénassy-Quéré et al. (2021) find that, in contrast to the symmetry assumption typically made in macroeconomics, tariffs have a significantly stronger impact on exports than real exchange rate changes.<sup>3</sup> Based on product level data for 110 countries over 1989-2013, a one percent depreciation reduces imports by around 0.5 percent in current dollars, whereas an increase in import tariffs by 1 percentage point reduces imports

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<sup>3</sup>See also see e.g., Fitzgerald and Haller (2018) and Fontagné et al. (2018) for country level firm studies. The macroeconomic assumption mentioned in the main text is related to the well-known Lerner symmetry: a currency devaluation is equivalent to an export subsidy combined with an import tariff.

by around 1.4 percent. As the literature recognizes, this may partly be because tariff changes are seen as more permanent than real exchange rate changes. In the presence of fixed costs, imperfect information, and time inconsistency issues, exporters and importers are more likely to change suppliers and pass-through levels in response to changes that are perceived as longer-lasting. By focusing on sustained signals, we hope to address headlong the complications posed by the presence of beachhead effects [Baldwin and Krugman (1989)], fixed costs of exporting [Dutt et al. (2013)], J-curve related delays, and the trade-induced entry and exit caused by the presence of heterogeneous firms in international trade [Melitz (2003)].

Focusing on long-lasting RER movements is likely to give us a better idea of the effects of relative price movements on various slow-moving macro aggregates such as the level of the capital stock, the composition of GDP, and the sectoral structure of the economy. This is especially true for processes which have a significant forward-looking component; expectations about the stability of the future path of exchange rate and monetary policy, for example, would influence investment and saving decisions. In addition to a forward-looking component, moreover, the process of expectation formation itself is also likely to have a backward-looking component. Therefore, one would expect a few years of consistent misalignment in one direction or the other to influence expectations about the future. This again is likely to influence macroeconomic behavior in a manner more significant than that induced by brief misalignments.

At a broader level, the focus on sustained price signals can be motivated by the debate in development economics about the relative roles of history and expectations. In a world where differential returns between sectors – say due to learning externalities - generate multiple equilibria, the equilibrium that an economy settles at is likely to be a function of history. On the other hand, as emphasized by a body of literature, self-fulfilling expectations could become a key determinant once one considers forward-looking behavior [Krugman (1991), Matsuyama (1991), Murphy et al. (1989), Kaneda (2003)]. This is because resource movements are costly, and hence gradual and forward-looking expectations would incorporate the discounted trade-off between current and future costs and benefits. Expectations, thus, are central in determining whether or not resources move between sectors. Combining the presence of externalities with this role of expectations makes it easy to see that any relative price change that subsidizes resource movements would have to be perceived as durable enough to make the shift worthwhile for a critical mass of economic actors. As Kaneda (*ibid.*) demonstrates in a dynamic model of infant industry protection, policy duration is a crucial component of policy design aimed at achieving

a “good” equilibrium. In our case, the relevant relative price signal is the one coming from the real exchange rate, the resource movement can be seen as occurring between tradable and non-tradable sectors, and consistent with large parts of the literature, the manufacturing sector, which is largely tradable, can be seen as the sector with greater learning and other Marshallian externalities.

Our paper can be related to several strands of existing literature. Most directly, it contributes to the body of work that analyzes the relationship between RER misalignment and growth. Employing an AK-type endogenous growth framework, Rodrik (2008) argues that market failures characterize the tradable sector in developing economies to a greater degree than the rest of the economy, and that this creates room for real undervaluation to counter the distortion. Razmi et al. (2012) emphasize productivity increases based on shifting of resources (including Lewisian surplus labor; Lewis (1954)) from traditional to modern/industrial sectors. If the tradable sector is the relatively modern part of the economy, and represents the locus of productivity growth, raising the profit rate through undervaluation boosts aggregate employment and productivity. Other contributions, such as Rapetti (2013) and Ros (2015), credit the tradable sector with providing opportunities for learning-by-doing and other Marshallian externalities. Korinek and Serven (2016) consider a set-up in which the externality originates, in an AK-type model, from learning by investing in the tradable sector. The first-order short-run outcome of real undervaluation is to generate static welfare losses. Over time, however, the second-best subsidy provided to the tradable sector moves private returns on capital closer to the social returns and results in dynamic gains. Under certain conditions, the inter-temporal trade-off between static losses and dynamic gains results in a net welfare gain from undervaluation. Levy-Yeyati et al. (2013) emphasize the distributional effects of real undervaluations. The shift in income away from wages, they argue, could boost saving and enable financially constrained tradable goods firms to invest more through larger supply of internal funds and/or through lower cost of capital and greater credit availability.

While earlier empirical studies mainly explored the relationship between real overvaluation and output growth, and generally found a negative relationship, a series of more recent contributions have looked at the flip side and found a positive relationship between real undervaluation and growth. Examples include Hausmann et al. (2005), Gala (2007), Prasad et al. (2007), Rodrik (2008), Miao and M. A. Berg (2010), Di Nino et al. (2011), A. Berg et al. (2012), Rapetti et al. (2012), Levy-Yeyati et al. (2013), and Habib et al. (2017). There are exceptions, however,

such as Schröder (2013), who finds that the relationship disappears once one controls for heterogeneity across countries and distinguishes between under- and overvaluations, and Goncalves and Rodrigues (2017) that argue the positive relationship also vanishes once one controls for countries' savings rate.<sup>4</sup>

None of the empirical literature cited above looks at the effect of sustained real misalignments. For the reasons discussed earlier, this is a significant gap. There are, however, other recent studies that deploy formal criteria to identify episodes of sustained changes in other macroeconomic variables and attempt to understand the causal factors preceding them. For example, Hausmann et al. (2005) explore the preceding correlates of episodes of economic growth, Freund and Pierola (2012) explore surges of manufactured exports, while Cerra and Woldemichael (2017) study correlates of export accelerations in general, Libman et al. (2019) investigate investment episodes, Benigno et al. (2015) consider periods of sustained large capital inflows, and Bista and Sheridan (2021) take an econometric look at trade variables preceding episodes of growth takeoffs. In terms of the conceptual approach, our paper is related to this strand of literature.

Our findings about the effect of sustained RER misalignments shed light on the relationship between trade aggregates and relative price changes. There is, of course, a vast literature that addresses this question.<sup>5</sup> As discussed earlier, recent papers have found that trade responses to tariffs are more elastic than those to exchange rate changes. To the best of our knowledge, ours is the first paper that employs formal criteria to identify sustained and stable misalignments episodes to study trade responses.

This paper also contributes to a large literature on the correlates of structural change. One thread of this strand of work, starting with Corden and Neary (1982), analyzes the “Dutch disease” aspect of RER misalignments. A natural resource discovery or terms of trade shock that leads to increased spending on non-tradables and subsequently to real overvaluation, could crowd out other tradable sectors such as manufacturing, leading to de-industrialization. A more recent strand of literature in this spirit finds some evidence for premature de-industrialization in developing countries with the services sector expanding at the expense of industries (Rodrik (2016)). Conversely, some studies have found real undervaluations to lead to diversification

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<sup>4</sup>As we discuss later, our approaches address both the issue of heterogeneity and that of asymmetry between under- and overvaluations. Martin (2020) and Demir and Razmi (2021) provide exhaustive surveys of the relevant literature.

<sup>5</sup>See Hillberry and Hummels (2013) for an overview.

of economic structures, export diversification along intensive and extensive margins, greater tradable sector employment, and spurts of manufacturing export growth.<sup>6</sup>

To sum up, we contribute to the current literature on four relevant fronts by: i) evaluating the consequences of sustained RER misalignments (in both directions); ii) addressing endogeneity concerns; iii) dealing explicitly with heterogeneity issues by looking at the distribution of effects and by defining episodes so that we are essentially looking at *within* effects; and iv) analyzing a wide set of macroeconomic variables to evaluate structural changes in the economy.

Besides this introduction, the paper has 7 more sections. The next one discusses the identification of the episodes and some basic statistics. Section 3 presents linear estimates of the effects of RER misalignments on GDP. Section 4 presents the baseline results of the paper using the IPWRA method. Section 5 contains the results of the analysis of the episodes case-by-case. Section 7 contains a number of robustness checks and extensions. The main text ends with Section 8 in which results are summarized and some possible interpretations are discussed.

## 2 Identification of Episodes

The episodes are found using RER data from the Penn World Table 10.0. The first step is to calculate a measure of real exchange rate misalignment. Following the standard procedure in the literature, we begin by computing the equilibrium real exchange rate, which takes into account that the law of one price is not expected to hold for non-tradables. In practical terms, this is done by adjusting the real exchange rate (*RER*) for the Balassa-Samuelson effect,<sup>7</sup> regressing *RER* on real GDP *per capita* at national prices (*RGDPCH*):

$$\ln RER_{it} = \alpha + \beta \ln RGDPCH_{it} + f_t + \epsilon_{it} \quad (1)$$

where  $i$  and  $t$  are country and time indexes, respectively,  $f_t$  accounts for time fixed effects, and  $\epsilon_{it}$  is the error term. We obtain an estimate of  $\hat{\beta} = -0.19$ , with a t-statistic of 51.3. The sign of the coefficient is in line with the Balassa-Samuelson (BS) prediction. Finally, we define the undervaluation index (*UNDERVAL*) as the ratio of actual to BS-adjusted real exchange rates:  $UNDERVAL_{it} = RER_{it}/\hat{RER}_{it}$ . Defined in index form, *UNDERVAL* is comparable across

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<sup>6</sup>See Krugman (1987) who develops a Ricardian framework with a continuum of goods and shows how, in the presence of learning externalities and international spillovers, a temporary real devaluation can help achieve permanent diversification. For empirical treatments, see Freund and Pierola (2012), McMillan and Rodrik (2011), and Goya (2020). Guzman et al. (2018) survey these issues in comprehensive detail.

<sup>7</sup>Constructed from PWT10 data as the reciprocal of the variable  $pl_{con}$ .

countries and over time: an increase in the index signals a real exchange rate depreciation and a decrease, an appreciation.

As our baseline window is 7 years, we compute the rolling geometric mean of this misalignment index. We then use 3 criteria to define sustained undervaluation (overvaluation) episodes:

1. *Size*: a devaluation (overvaluation) of at least 10% compared to the juxtaposed window.<sup>8</sup>
2. *Volatility*: the window must have a standard deviation within 10% of the average for the episodes that comply with criteria (1). This translates into values of 0.17 for the undervaluation episodes and 0.12 for the overvaluation ones.
3. *Identifying the start*: If multiple episodes are found within the same 7-year window, a criterion to choose the more accurate beginning is added: the year with the highest misalignment change (compared to the previous year) is considered the beginning of an episode.

Criteria (1) ensures that the misalignment is a sustained change compared to the baseline trend for the country. This is somewhat similar to including a fixed effects term in the sense that it is a *within* comparison. Criteria (2) ensures that we leave out highly volatile periods that experience large swings due to uncertainty or crisis. Criteria (3) helps set the clock to zero at the point where the largest change in the RER occurs within a window.

Countries are grouped into three sets (low, middle, and high income) based on their classification by the World Bank and their GDP *per capita*.<sup>9</sup> For each year, the bottom half of countries by income *per capita* in the low-middle income group (as defined by the World Bank) is categorized as low income, and the upper half as middle-income.<sup>10</sup>

We find 189 undervaluation and 238 overvaluation episodes and are able to capture many well-documented historical cases, such as the large undervaluations in Korea beginning in 1961, India in 1991, and Brazil in 1999, and large overvaluations in Ghana beginning in 1965, Kenya in 1970, and Brazil in 2005.<sup>11</sup> A list of episodes is provided in appendix A. Table 1 presents a

<sup>8</sup>For instance, in the case of undervaluation: if the average misalignment is 10% higher (i.e., undervalued) in the period 2000-2006 than it was in the period 1993-1999.

<sup>9</sup>For reference, the upper threshold at 2000 yearly real GDP *per capita* at constant 2017 national prices is of 8,007 for low income and 18,350 for middle income countries.

<sup>10</sup>Very small countries, with less than 1 million in population in any year, were excluded from the sample. Five countries with extreme RER misalignment were also excluded – the average misalignment index value for the entire sample is 1.1 without much variation over time, while the values for Turkmenistan, Kyrgyzstan, Azerbaijan, Iraq, and Vietnam range from 4.4 in Kyrgyzstan in 1991 to 7.3 in Viet Nam in 1981.

<sup>11</sup>For a discussion of some of these overvaluation episodes, see Shatz and Tarr (2000).

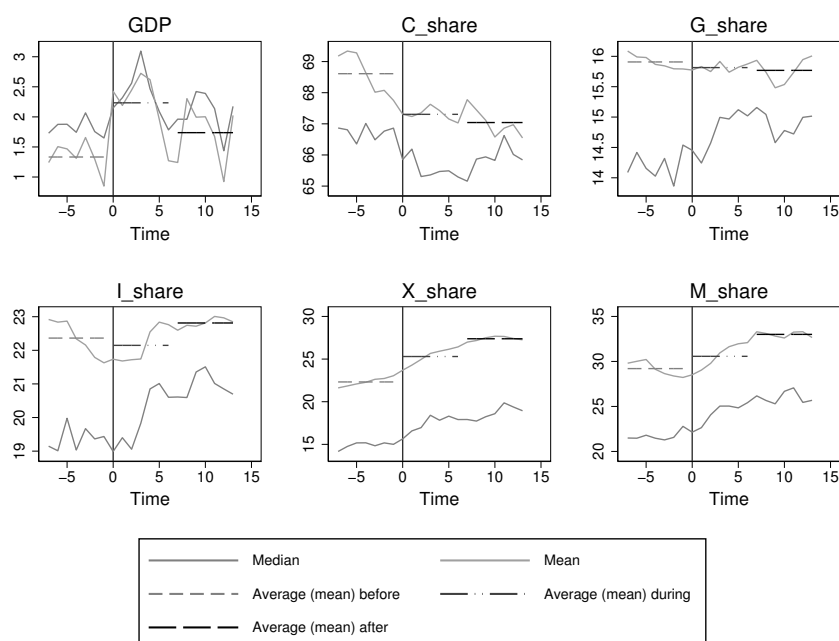
profile of the episodes categorized by regions, income levels, and decades. Episodes were most frequent in low-income countries and in the 1990s. Figures 1 and 2 show simple patterns of GDP and its components around episodes.

Table 1: Profile of episodes

|             | <i>Region</i> |      | <i>Income</i> |      | <i>Time</i> |                  |    |    |
|-------------|---------------|------|---------------|------|-------------|------------------|----|----|
|             | Under         | Over | Under         | Over | Under       | Over             |    |    |
| <i>EAP</i>  | 33            | 27   | <i>Low</i>    | 91   | 92          | <i>1950-1959</i> | 5  | 11 |
| <i>ECA</i>  | 32            | 74   | <i>Middle</i> | 61   | 83          | <i>1960-1969</i> | 20 | 24 |
| <i>LAC</i>  | 37            | 38   | <i>High</i>   | 37   | 55          | <i>1970-1979</i> | 37 | 48 |
| <i>MENA</i> | 23            | 13   |               |      |             | <i>1980-1989</i> | 43 | 44 |
| <i>NA</i>   | 4             | 5    |               |      |             | <i>1990-1999</i> | 49 | 57 |
| <i>SA</i>   | 11            | 5    |               |      |             | <i>2000-2009</i> | 35 | 47 |
| <i>SSA</i>  | 49            | 69   |               |      |             |                  |    |    |

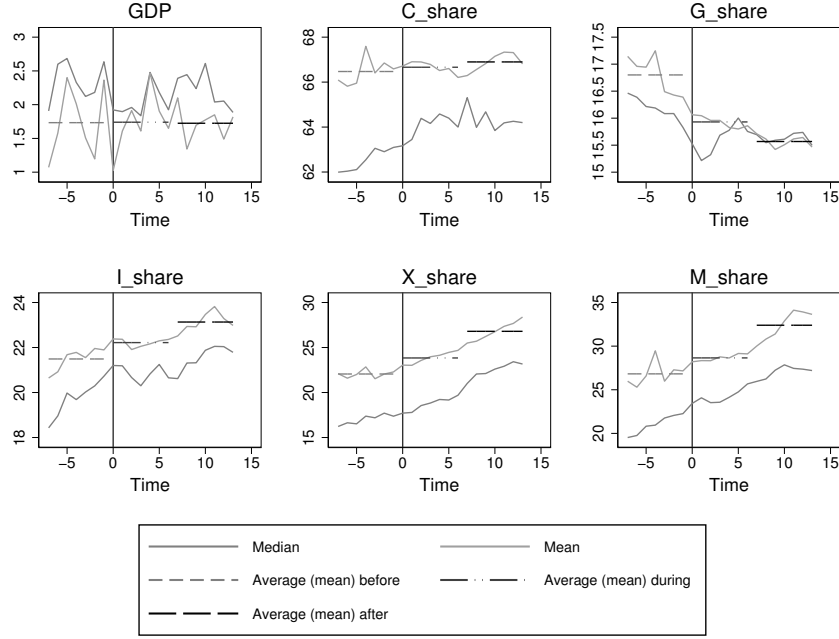
EAP = East Asia and Pacific; ECA = Europe and Central Asia; LAC = Latin America and Caribbean; MENA = Middle East and North Africa; NA = North America; SA = South Asia; SSA = Sub-Saharan Africa.

Figure 1: Averages of selected variables around undervaluation episodes - GDP in growth rates, others in %



*Note:* The results presented are simple averages for each year around the episode for all undervaluation cases.

Figure 2: Averages of selected variables around overvaluation episodes - GDP in growth rates, others in %



*Note:* The results presented are simple averages for each year around the episode for all overvaluation cases.

In the next section we present linear estimations of the effects of under and overvaluation episodes on GDP.

### 3 Linear Estimations

A common way to estimate the effects of such episodes is the use of a dynamic model.<sup>12</sup> Formally, we have:

$$y_{ct} = \beta E_{ct} + \sum_{j=1}^d \gamma y_{ct-j} + \alpha_c + \theta_t + \epsilon_{ct} \quad (2)$$

where  $y$  is the variable of interest,  $E$  the episode dummy, and  $\alpha$  and  $\theta$  the country and year fixed effects. Adding  $d$  lags of the variable of interest can help eliminate residual serial correlation in the error term and remove potential pre-treatment trends in the dependent variable.<sup>13</sup>

The long-run effect of the episode is determined by its contemporaneous effect and the serial

<sup>12</sup>See Acemoglu et al. (2019) for democratization episodes, for instance.

<sup>13</sup>This is related to the usual assumption made with linear dynamic panel models:  $[\epsilon_{ct}|y_{ct-1}, \dots, y_{ct_0}, E_{ct}, \dots, E_{ct_0}, \theta_t, \text{ and } \alpha_c \text{ for all } c \text{ and } t \geq t_0]$ . That is, it is assumed that the episode and the past dynamics of the variable of interest are uncorrelated to current and future shocks and that the error terms are serially uncorrelated.

persistence of the variable of interest. We think the assumption of linearity is too strong, and see no reason to expect the effect of a sustained misalignment to be linear. Thus, the estimates given by the models of this section are not taken as our benchmark ones – although the results do broadly agree with the semiparametric estimations presented next. However, these estimations are particularly important to test the ability of different lags to control for pre-treatment trends and eliminate residual correlation, which will be important for the other methods used.

This form of estimating dynamic panels (henceforth *Within*) might be affected by the well-known Nickell bias, which emerges from the use of both individual fixed effects and autoregressive dynamics. We thus test a GMM estimator developed by Arellano and Bond (1991) (henceforth *AAB*), which produces consistent estimates of the dynamic panel model.<sup>14</sup> The results are presented in tables 2 and 3. In the first four sets of estimates for each approach we test different lags of GDP; in the last set – columns (5) and (10) – we control for variables that are (statistically) significant for the probability of episode occurrence and (theoretically) related to the GDP performance.<sup>15</sup>

A first piece of information that can be obtained in the tables is the number of lags that should be used to control for both pre-episode trends and residual serial correlation in the error term. This evaluation is made by: (i) the AR2 test for serial correlation in the residuals, which might indicate a lack of lags; and (ii) the p-values (including jointly) for the lags. In table 2, we can see that 4 lags are jointly significant in both *within* and *AAB* estimations, while the additional two lags are not significant. Looking at the AR2 test, it can also be seen that the serial correlation in the error terms is eliminated with the use of four lags. These are strong results in favor of the use of four lags as controls. In the case of overvaluation episodes, presented in table 3, the results are weaker: correlation in the error term is not completely eliminated with the use of four lags, although four lags are again jointly significant while additional lags are not. Considering these two results controlling for four lags seems to be the best option. Moreover, as indicated in appendix B,<sup>16</sup> after controlling for four lags, the correlation between episodes and transitory movements in the relevant variables (GDP and the capital stock) disappears.

Secondly, and keeping in mind the limitations indicated, the estimates also give us a first approximation of the effect of real exchange rate misalignment on long-term GDP growth. We will focus on the estimations controlling for four lags of the dependable variables, which will be

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<sup>14</sup>We should note, however, that the relatively large time dimension of our panel mitigates this bias.

<sup>15</sup>See table 4 and the associated discussion.

<sup>16</sup>See the section titled ‘Pre-treatment trends - ideal number of lags to control for.’

our baseline for the rest of the paper. In the case of undervaluation episodes, the *within* estimations indicate a long-run positive effect of 33.3% without other controls and 20.4% with other controls, with only the former being barely statistically significant at 10% (table 2). The *AAB* estimations yield qualitatively similar, although much smaller and statistically insignificant, results: 8.2% and 10.8%, without and with extra controls. In the case of overvaluation episodes (table 3), the long-run estimated effects range from  $-27.4\%$  (with extra controls) to  $-42.6\%$  (without extra controls), both highly statistically significant. The *AAB* estimates are again smaller,  $-12.7\%$  without extra controls and  $-6.4\%$  with them, the latter being statistically significant at 10%.

In addition to GDP and the capital stock, we are interested in variables that indicate structural change in economies during the episodes examined; however, to present all variables would be infeasible for space reasons. We will focus, therefore, mainly on presenting the effects on GDP and capital stock growth. Later, in section 6, we turn to variables that show a statistically significant effect that is consistent across the different methods used in sections 4 and 5. In the case of linear models, as indicated, our focus is less on the estimated effects and more on the information about pre-trend and serial residual correlation, and thus only the effect on GDP has been presented.

## 4 IPWRA Estimates

Our baseline results are achieved using a semiparametric method, the Inverse-Probability Weighted Regression Adjustment estimator, IPWRA (Imbens and Wooldridge (2009), Wooldridge (2007)).<sup>17</sup> The method is not fully parametric in the sense that we do not specify a parametric process for the variables of interest, however, it still requires the specification of a model for either the probability of the occurrence of an episode or the conditional expectation of future values of the variables of interest among countries that did not experience an episode. The choice of the IPWRA estimator takes into account the fact that it is ‘doubly robust’, that is, it is sufficient that one of the two models specified is valid for the estimator to be consistent.

Briefly put, the method can be understood as a combination of local projections (Jordà (2005)) with propensity-score methods to construct counterfactuals. A probit model is used to estimate the likelihood that a country will experience an episode; these probabilities are then

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<sup>17</sup>Some of the recent literature that has used this method for macro and international economics research includes Angrist and Kuersteiner (2011), Jordà and Taylor (2016), and Girardi et al. (2020).

Table 2: Effects of undervaluation on GDP (log points) - Linear estimations

|                                     | <i>Within</i>    |                   |                   |                   |                   |                  |                   |                   |                   |                   | <i>AAB</i> |  |  |  |  |  |  |  |  |  |
|-------------------------------------|------------------|-------------------|-------------------|-------------------|-------------------|------------------|-------------------|-------------------|-------------------|-------------------|------------|--|--|--|--|--|--|--|--|--|
|                                     | (1)              | (2)               | (3)               | (4)               | (5)               | (6)              | (7)               | (8)               | (9)               | (10)              |            |  |  |  |  |  |  |  |  |  |
| Undervaluation episode              | 0.006<br>(0.005) | 0.008<br>(0.005)  | 0.008<br>(0.005)  | 0.008<br>(0.005)  | 0.008<br>(0.006)  | 0.006<br>(0.009) | 0.008<br>(0.008)  | 0.011<br>(0.008)  | 0.010<br>(0.008)  | 0.010<br>(0.009)  |            |  |  |  |  |  |  |  |  |  |
| $\log GDP_{t-1}$                    | 0.982<br>(0.005) | 1.236<br>(0.047)  | 1.189<br>(0.036)  | 1.190<br>(0.041)  | 1.158<br>(0.040)  | 0.930<br>(0.017) | 1.147<br>(0.056)  | 1.104<br>(0.044)  | 1.101<br>(0.048)  | 1.072<br>(0.051)  |            |  |  |  |  |  |  |  |  |  |
| $\log GDP_{t-2}$                    |                  | -0.259<br>(0.045) | -0.157<br>(0.027) | -0.176<br>(0.026) | -0.150<br>(0.024) |                  | -0.221<br>(0.047) | -0.136<br>(0.024) | -0.157<br>(0.023) | -0.135<br>(0.021) |            |  |  |  |  |  |  |  |  |  |
| $\log GDP_{t-4}$                    |                  |                   | -0.046<br>(0.013) | -0.051<br>(0.026) | -0.046<br>(0.014) |                  |                   | -0.037<br>(0.014) | -0.041<br>(0.027) | -0.040<br>(0.015) |            |  |  |  |  |  |  |  |  |  |
| $\log GDP_{t-6}$                    |                  |                   |                   | 0.024<br>(0.027)  |                   |                  |                   |                   | 0.037<br>(0.031)  |                   |            |  |  |  |  |  |  |  |  |  |
| p-value lag 1 to last (up to 4)     |                  | [ 0.000]          | [ 0.000]          | [ 0.000]          | [ 0.000]          |                  | [ 0.000]          | [ 0.000]          | [ 0.000]          | [ 0.000]          |            |  |  |  |  |  |  |  |  |  |
| p-value lag 2 to last               |                  |                   | [ 0.001]          | [ 0.000]          | [ 0.003]          |                  |                   | [ 0.036]          | [ 0.066]          | [ 0.024]          |            |  |  |  |  |  |  |  |  |  |
| p-value lag 4 to last               |                  |                   |                   | [ 0.649]          |                   |                  |                   |                   | [ 0.436]          |                   |            |  |  |  |  |  |  |  |  |  |
| Long-run effect of (under) episode) | 0.318<br>(0.300) | 0.367<br>(0.232)  | 0.333<br>(0.204)  | 0.306<br>(0.211)  | 0.204<br>(0.154)  | 0.082<br>(0.137) | 0.109<br>(0.121)  | 0.156<br>(0.110)  | 0.128<br>(0.094)  | 0.108<br>(0.099)  |            |  |  |  |  |  |  |  |  |  |
| Persistence of y process            | 0.982<br>(0.005) | 0.977<br>(0.005)  | 0.975<br>(0.005)  | 0.975<br>(0.004)  | 0.963<br>(0.007)  | 0.930<br>(0.017) | 0.926<br>(0.015)  | 0.926<br>(0.013)  | 0.920<br>(0.017)  | 0.906<br>(0.016)  |            |  |  |  |  |  |  |  |  |  |
| AR2 test p-value                    |                  |                   |                   |                   |                   | 0.11             | 0.49              | 0.03              | 0.89              | 0.01              |            |  |  |  |  |  |  |  |  |  |
| Observations                        | 6039             | 5915              | 5667              | 5419              | 4768              | 5726             | 5602              | 5354              | 5106              | 4466              |            |  |  |  |  |  |  |  |  |  |
| Countries in sample                 | 124              | 124               | 124               | 124               | 119               | 124              | 124               | 124               | 124               | 118               |            |  |  |  |  |  |  |  |  |  |

*Note:* This table presents estimates of the effect of undervaluation episodes on log GDP *per capita*. Columns 1 to 4 present results from the within estimator. Columns 5 to 8 present results from Arellano and Bond's (1991) GMM estimator. The AR2 row reports the p-value for a test of serial correlation in the residuals of the GDP series. In all specifications we control for a full set of country and year fixed effects. Standard errors robust against heteroskedasticity and serial correlation at the country level are reported in parentheses.

Table 3: Effects of overvaluation on GDP (log points) - Linear estimations

|                                    | AAB               |                   |                   |                   |                   |                   |                   |                   |                   |                   |
|------------------------------------|-------------------|-------------------|-------------------|-------------------|-------------------|-------------------|-------------------|-------------------|-------------------|-------------------|
|                                    | Within            |                   |                   |                   |                   |                   |                   |                   |                   |                   |
|                                    | (1)               | (2)               | (3)               | (4)               | (5)               | (6)               | (7)               | (8)               | (9)               | (10)              |
| Overvaluation episode              | -0.007<br>(0.004) | -0.009<br>(0.003) | -0.010<br>(0.003) | -0.010<br>(0.003) | -0.009<br>(0.003) | -0.003<br>(0.004) | -0.006<br>(0.004) | -0.009<br>(0.004) | -0.008<br>(0.004) | -0.008<br>(0.004) |
| $\log GDP_{t-1}$                   | 0.982<br>(0.004)  | 1.219<br>(0.045)  | 1.182<br>(0.037)  | 1.182<br>(0.040)  | 1.150<br>(0.039)  | 0.930<br>(0.024)  | 1.093<br>(0.052)  | 1.081<br>(0.047)  | 1.082<br>(0.050)  | 1.010<br>(0.050)  |
| $\log GDP_{t-2}$                   |                   | -0.241<br>(0.043) | -0.158<br>(0.032) | -0.177<br>(0.033) | -0.152<br>(0.030) |                   | -0.171<br>(0.038) | -0.135<br>(0.032) | -0.157<br>(0.034) | -0.130<br>(0.027) |
| $\log GDP_{t-4}$                   |                   |                   | -0.050<br>(0.017) | -0.036<br>(0.036) | -0.053<br>(0.018) |                   |                   | -0.023<br>(0.019) | -0.022<br>(0.033) | -0.032<br>(0.018) |
| $\log GDP_{t-6}$                   |                   |                   |                   | 0.016<br>(0.029)  |                   |                   |                   | 0.047<br>(0.037)  |                   |                   |
| p-value lag 1 to last (up to 4)    |                   | [ 0.000]          | [ 0.000]          | [ 0.000]          | [ 0.000]          |                   | [ 0.000]          | [ 0.000]          | [ 0.000]          | [ 0.000]          |
| p-value lag 2 to last              |                   |                   | [ 0.011]          | [ 0.001]          | [ 0.008]          |                   |                   | [ 0.474]          | [ 0.148]          | [ 0.114]          |
| p-value lag 4 to last              |                   |                   |                   | [ 0.730]          |                   |                   |                   |                   | [ 0.446]          |                   |
| Long-run effect of (over) episode) | -0.400<br>(0.233) | -0.405<br>(0.162) | -0.426<br>(0.143) | -0.464<br>(0.142) | -0.274<br>(0.096) | -0.042<br>(0.062) | -0.082<br>(0.058) | -0.127<br>(0.069) | -0.120<br>(0.081) | -0.064<br>(0.032) |
| Persistence of y process           | 0.982<br>(0.004)  | 0.979<br>(0.004)  | 0.978<br>(0.004)  | 0.978<br>(0.004)  | 0.966<br>(0.006)  | 0.930<br>(0.024)  | 0.921<br>(0.023)  | 0.930<br>(0.021)  | 0.931<br>(0.031)  | 0.873<br>(0.028)  |
| AR2 test p-value                   |                   |                   |                   |                   |                   | 0.13              | 0.68              | 0.30              | 0.40              | 0.24              |
| Observations                       | 5787              | 5663              | 5415              | 5167              | 4474              | 5432              | 5308              | 5060              | 4812              | 4123              |
| Countries in sample                | 124               | 124               | 124               | 124               | 119               | 124               | 124               | 124               | 124               | 118               |

*Note:* This table presents estimates of the effect of undervaluation episodes on log GDP *per capita*. Columns 1 to 4 present results from the within estimator. Columns 5 to 8 present results from Arellano and Bond's (1991) GMM estimator. The AR2 row reports the p-value for a test of serial correlation in the residuals of the GDP series. In all specifications we control for a full set of country and year fixed effects. Standard errors robust against heteroskedasticity and serial correlation at the country level are reported in parentheses.

used to weight observations in the control group.<sup>18</sup> Subsequently, the counterfactual outcome is estimated using a linear regression method with the donors and their respective weights. We are, thus, constructing a counterfactual that is as similar to our treated units as possible (given the variables included in the probit), and our estimates correspond to the “treatment effects on the treated.”

The main assumption made with the use of this method is that the selection into an episode can be modeled as a function of observables, so that by taking into account those observables, the potential future values of the variables of interest for those countries that experience an episode are not different than for those countries that do not. This amounts to the “selection on observables” assumption. To have confidence that this assumption holds, one has to choose appropriate observables; that is, to control for variables that affect both the probability of an episode and the potential outcome of the variable of interest. Given that we have a set of 37 variables of interest,<sup>19</sup> and that we want to test the effects of episodes of both undervaluation and overvaluation for each of the three income groups (besides the general effect), we have a total of 296 ( $= 37 \times 2 \times 4$ ) different estimations. Our choice of the variables to construct the counterfactuals follows, thus, a trade-off between more precise specifications (which comes at the cost of clarity given the limited space to present the justification) and completely horizontal ones (that although being simpler and explicit, have the obvious drawback of giving us less confidence in making the “selection on observables” assumption).

We follow, thus, two procedures to give us some flexibility while avoiding the risk of excess subjectivity or lack of clarity. First, we determine the number of lags to control for pre-treatment trends. We perform two exercises to choose the adequate number of lags to be used in all estimations. The first is the dynamic linear models already presented in the previous section. The second, presented in appendix B, checks the number of lags of GDP and capital stock that are jointly significant predictors of contemporary misalignment episodes. The results of this second exercise increase our confidence in the use of four lags, as suggested by the linear model.

Secondly, we determine which variables to use in the propensity-score model. In this case, we allow greater flexibility both because it is hard to argue that the determinants are the same in all cases (undervaluation episodes in poor countries and overvaluation in high-income ones,

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<sup>18</sup>The weights assigned are the reciprocals of the probabilities of treatment.

<sup>19</sup>A list of the variables can be found in appendix A

for instance) and because we only have 8 different cases to examine. Thus, for each of the four categories of income (all, low, middle, and high) and for episodes of under and overvaluation, we test the relevance of up to 4 lags of five variables that are theoretically relevant to the probability of experiencing an episode and the potential outcome: GDP ( $y$ ), real exchange rate misalignment ( $Mis$ ), trade balance (% of GDP) ( $TB$ ), terms of trade ( $TOT$ ), and use or not of capital controls ( $CC$ ).<sup>20</sup> The variables were included if significant individually or jointly at 10%. The results can be seen in appendix B. The list of variables to be used in the propensity scores of our estimations in each case is presented in table 4.

Table 4: Variables used on IPWRA estimations

|                    | <i>Overvaluation</i>                  | <i>Undervaluation</i>                 |
|--------------------|---------------------------------------|---------------------------------------|
| <b>General</b>     | TOT (4), Mis (4), TB (4), CC          | GDP (4), Mis (4), TB (4), CC          |
| <b>Low Inc.</b>    | GDP (4), Mis (4), TB (4), CC, TOT (4) | GDP (4), Mis (4), TB (4)              |
| <b>Middle Inc.</b> | GDP (4), Mis (4), TB (4)              | Mis (4), CC                           |
| <b>High Inc.</b>   | GDP (4), Mis (4), TB (4), CC          | GDP (4), Mis (4), TB (4), TOT (4), CC |

*Note:* All variables are specified with four lags, except the dummy for capital control for the year of the beginning of the episode.

More formally, after calculating the weights based on the variables for each of the 8 cases and attributing them to each control unit, the estimation takes the following form:

$$\Delta X_{i,t+s} = \alpha_t^s + \beta^s E_{i,t} + \sum_{j=1}^4 \theta X_{i,t-j} + \epsilon_{i,t+s} \quad (3)$$

where  $\alpha_t^s$  are year dummies.<sup>21</sup> All growth variables of interest are in log terms, so that  $\Delta X_{i,t+s}$  gives the approximate percentage change in the variable of interest between the average of four years before the start of the episode and  $t + s$ .<sup>22</sup> The variables that are shares are not in log terms, and the effect of size X in these cases should be read as an increase or decrease of X percentage points. The option to use the average of four years before the episode instead of the year immediately before it as the comparison year follows from (i) the understanding that these episodes follow strict criteria but are not “natural experiments” with a sharp change in

<sup>20</sup>We use the measure suggested by Ilzetzki et al. (2019) given that it covers most of the period and countries that we use. Other indexes often used, such as the Chinn-Ito one, cover a smaller time frame.

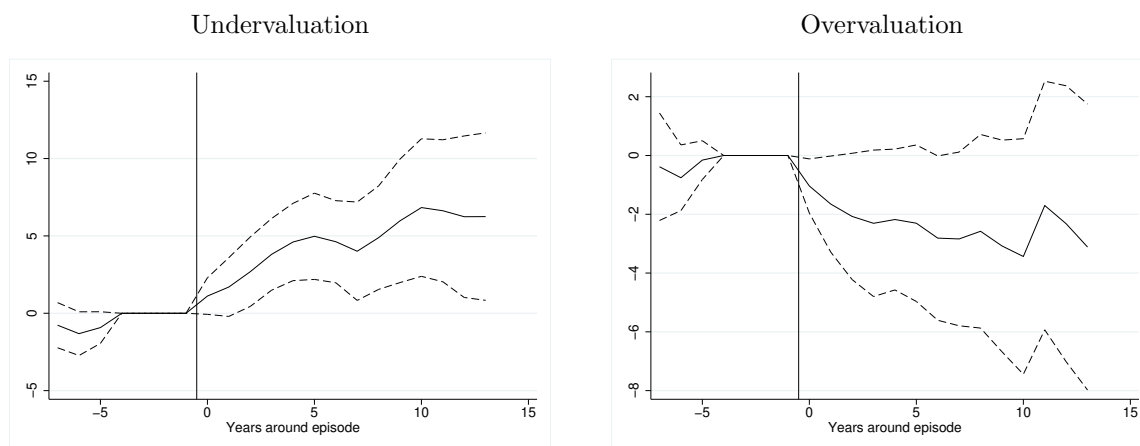
<sup>21</sup>Since we are differencing the outcome from the 4 years pre-treatment period, and because the treatment variable is conditioned on not being treated in this pre-treatment window, incorporating country fixed effects would not improve our identification strategy; the estimation is already set up to identify within country changes.

<sup>22</sup>We implemented all estimators in this section with Stata *teffects* command and computed standard errors by using 50 bootstrap samples in which we clustered the data at the country level.

the real exchange rate, so that in some particular cases historical knowledge suggests that the beginning of the analysis would be a couple of years before or after our identified year, and (ii), related to this, the objective of avoiding giving too much weight to one specific year.

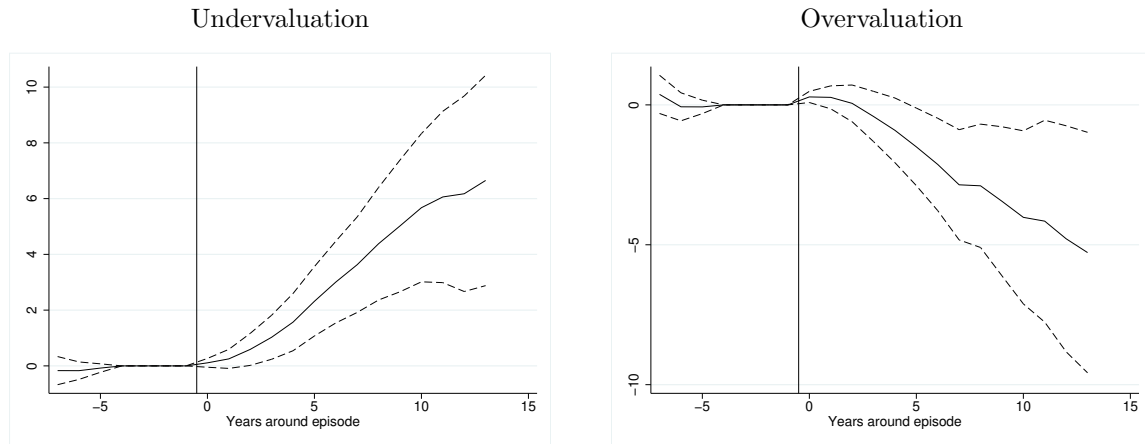
Figures 44 and 45 present the results. Undervaluation episodes generate, on average, a statistically significant long-run increase in GDP *per capita* of more than 6%, while overvaluations produce a reduction of about 2.5% that is not statistically significant. The results for capital stock are even starker, with an undervaluation episode causing an increase in the capital stock of more than 6% (and possibly more as there is no clear tendency of stabilization after the 14 years observed), while overvaluation reduces it by 4% by the end of the observable window.

Figure 3: Semiparametric estimates of the effects over time of real exchange rate misalignment on the log of GDP.



*Note:* The solid line plots the estimated average effect on log GDP *per capita* on countries that had an undervaluation episode, with a 90 percent confidence interval in black dashed lines. Time (in years) relative to the year of the episode.

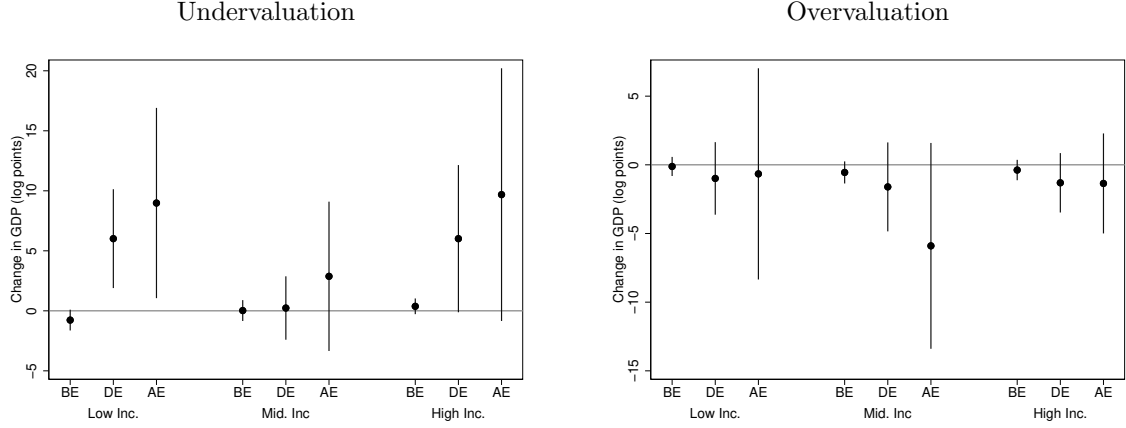
Figure 4: Semiparametric estimates of the effects over time of real exchange rate misalignment on the log of capital stock.



Note: The solid line plots the estimated average effect on log GDP *per capita* on countries that had an undervaluation episode, with a 90 percent confidence interval in black dashed lines. Time (in years) relative to the year of the episode.

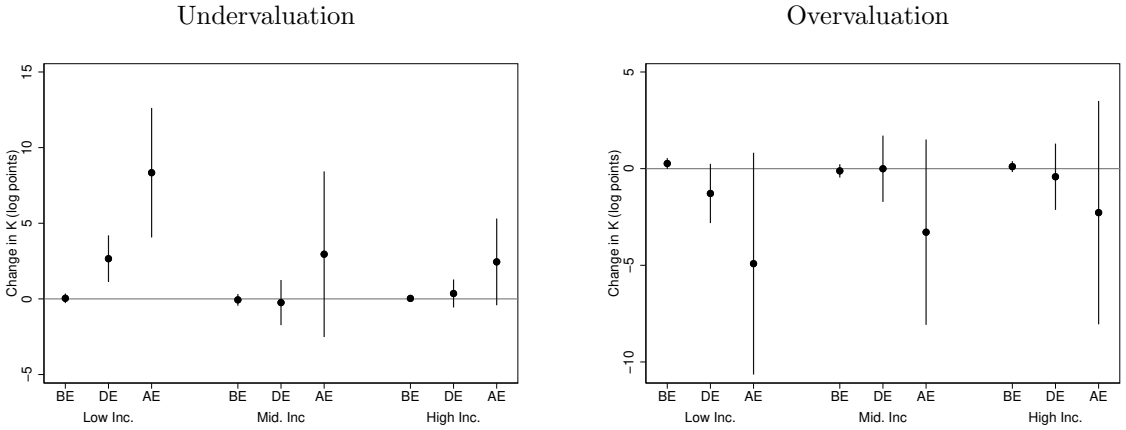
The effects are heterogeneous among income groups. Figure 5 indicates that low- and high-income countries have positive, lasting effects of undervaluation, while middle-income countries do not. Interestingly, while the effect is positive in all cases, only low-income countries have a significant increase in their capital stock in the medium-run (figure 6). This pattern of heterogeneity might suggest that while such episodes promote capital accumulation in low-income countries and thus influence their development path, in the case of rich economies, by contrast, the effects may show up as a boost in demand (via the trade balance) which stimulates the return of capacity utilization to normal levels after a negative shock. In other words, rather than boost investment, sustained undervaluations in these countries may help quicken recoveries and mitigate any negative hysteresis. Obviously any firm conclusions will require closer analysis and more robust evidence. In the case of overvaluation, the effects are statistically not different from zero for both GDP and capital stock, although the coefficients are negative.

Figure 5: Semiparametric estimates of the effects over time of real exchange rate misalignment on the log of GDP - average effect by income group



*Note:* BE = Before Episode (time -7 to -1); DE= During Episode (time 0 to 6); AE= After episode (time 7 to 13). The dot is the estimated coefficient and the lines indicate the 90% confidence interval.

Figure 6: Semiparametric estimates of the effects over time of real exchange rate misalignment on the log of K - average effect by income group



*Note:* BE = Before Episode (time -7 to -1); DE= During Episode (time 0 to 6); AE= After episode (time 7 to 13). The dot is the estimated coefficient and the lines indicate the 90% confidence interval.

## 5 Case-by-Case Analysis: Individual and Aggregate Estimates

In contrast to the baseline model where we estimate average effects across all the undervaluation and overvaluation episodes, we now move to a second method in order to separately estimate effects for each episode. This method gives us two sets of information that complement our baseline results: i) we can evaluate whether the general results are driven by specific cases, indicating the frequency with which the qualitative average results hold;<sup>23</sup> and ii) each episode,

<sup>23</sup>Note that, among other things, this also helps address the heterogeneity concern raised by Schröder (2013).

containing the ‘treated’ country and clean controls, can be stacked in order to calculate common treatment effects that can also serve as a robustness check for the baseline case.

We create specific datasets for each episode containing the country that had an episode and ‘clean’ controls, defined as other countries that:<sup>24</sup> (i) did not experience undervaluation or overvaluation episodes within an 8-year window around the episode that we are examining ( $s = -4, -3, \dots, 9, 10$ );<sup>25</sup> (ii) have data for the variable of interest for all those years; and (iii) have a similar GDP *per capita* (the ten countries with the closest GDP *per capita* that comply with the previous criteria). We also test shorter-term effects, i.e., a 12 year window ( $s = -5, -4, \dots, 5, 6$ ) instead of the 21 years baseline and reduce the pre-treatment period from 7 to 5 years in order to incorporate episodes involving variables that have more limited data availability.

### 5.1 Event-by-event - individual effects

For each of the datasets, we calculate a regular difference-in-differences estimation, still controlling for heterogeneity in the pre-treatment period, which can be formally presented as:

$$X_{i,t} = \beta E_{i,t} + \alpha_t + \gamma_i + \sum_{j=1}^4 \theta X_{i,t-j} + \epsilon_{i,t} \quad (4)$$

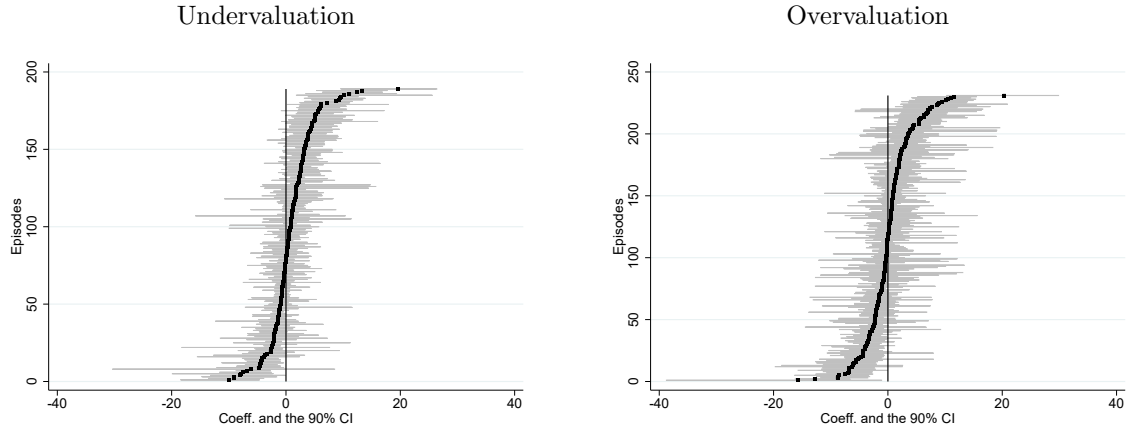
To calculate the standard errors, we follow the procedure proposed by Ferman and Pinto (2019), which is appropriate when estimating with only one treated unit. Figures 7 and 8 illustrate the distribution of the results for under and overvaluation cases for GDP and the capital stock.

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<sup>24</sup>A country can have multiple episodes in different years; for each episode a new dataset is created.

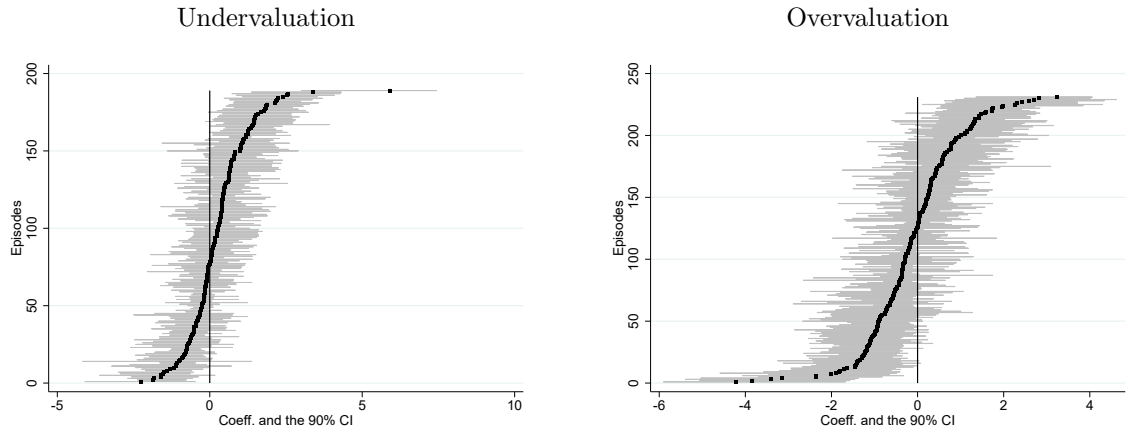
<sup>25</sup>The option for a window that is smaller than the 21 year windows explored earlier is driven by the fact that too few controls remain in each episode if that time frame is used.

Figure 7: Case-by-case estimates for the effect of an episode on log of GDP *per capita*



*Note:* Each black dot represents the coefficient for an episode and the gray area is the 90 percent confidence interval.

Figure 8: Case-by-case estimates for the effect of an episode on the log of capital stock



*Note:* Each black dot represents the coefficient for an episode and the gray area is the 90 percent confidence interval.

In the case of undervaluation and considering the entire period after the episode (14 years), 54 episodes have significant coefficients for both GDP and capital stock at a 10% confidence interval,<sup>26</sup> 65% being positive in both cases. The positive effects on GDP are also higher in low-income countries: 29 episodes are statistically significant, 72% positive, with an average coefficient of 7.3%. Middle-income countries have 20 significant episodes, with only 60% being positive, for an average effect of 4.3%. Only half of the significant cases are positive for high-income countries. The effects over capital stock are also markedly stronger in low-income countries: out of 33 significant cases, 73% have positive effects; the number of significant episodes

<sup>26</sup>Despite a smaller number of significant cases, the shares of positive and negative outcomes present a similar picture at the 5% level of significance.

drops sharply for middle and high-income countries.

Turning next to overvaluations, 64 episodes are statistically significant for GDP, 55% with negative coefficients; and 75 episodes for the capital stock, 65% with negative effects. With few significant cases (23), the majority (73%) of the significant effects on GDP in low-income countries are positive; although surprising in light of the results reported in the previous section, it is important to note that this represents only 17% of the total cases for this group. Middle-income countries have more significant cases, 29, with 65% negative; among high-income countries, 10 cases are significant, with 90% being negative. For the capital stock, we have 34 significant cases for low-income countries, with 59% showing negative effects. Middle-income countries have 23 significant episodes, with 65% being negative; high-income countries present only 19 statistically significant cases, 84% negative.

## 5.2 Event-by-event - aggregate effects

The second use of the event-by-event datasets is to stack each event in a wide format,<sup>27</sup> and estimate a common, average treatment effect which can be directly compared to our baseline estimation (see, for instance, Sun and Abraham (2020), Callaway and Sant’Anna (2020), and Appendix D of Cengiz et al. (2019)). The comparison should be made in qualitative terms rather than quantitative ones, given that the controls for the estimations with the IPWRA and ‘case-by-case’ (CBC henceforth) methods are deliberately different, chosen to estimate most accurately the direction of the effect in each case. The specification used in this section has the advantage of using stricter controls and tends to be less biased in the presence of heterogeneous treatment effects.

Having stacked the datasets, we have a similar regression equation to the one used in the baseline case, i.e., equation (3):

$$\Delta X_{i,t+s} = \alpha_{t,e}^s + \beta^s E_{i,t} + \sum_{j=1}^4 \theta X_{i,e,t-j} + \epsilon_{i,e,t+s} \quad (5)$$

the main difference being the interaction of episodes’ dummies (the subscript  $e$ ) with the controls (time fixed effects and the four lags of the variable of interest).

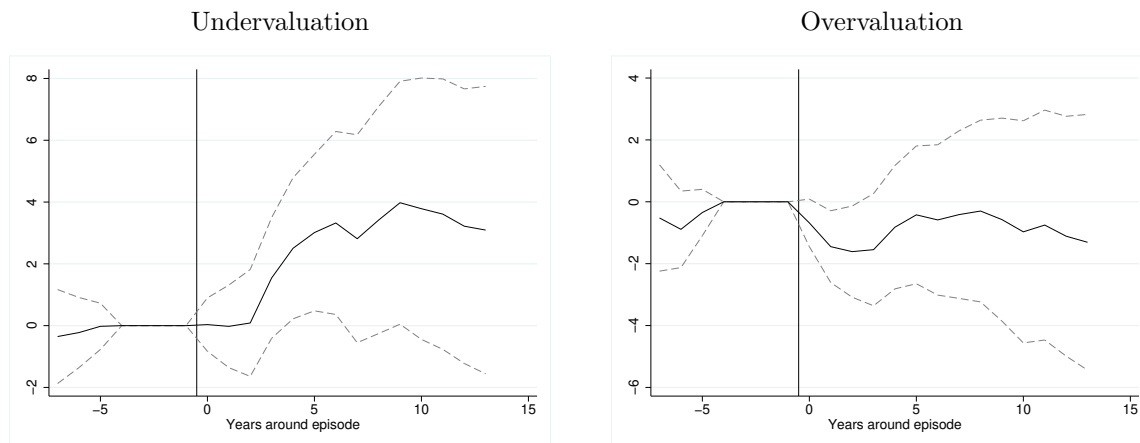
The general effects are qualitatively similar, although smaller (figures 9 and 10). The results by income level are also very similar (figures 11 and 12): undervaluation episodes have lasting

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<sup>27</sup>Meaning that each episode-specific dataset contains one observation for each country (for each year) - one treated country and the 10 controls that follow the 3 criteria indicated above for that particular episode.

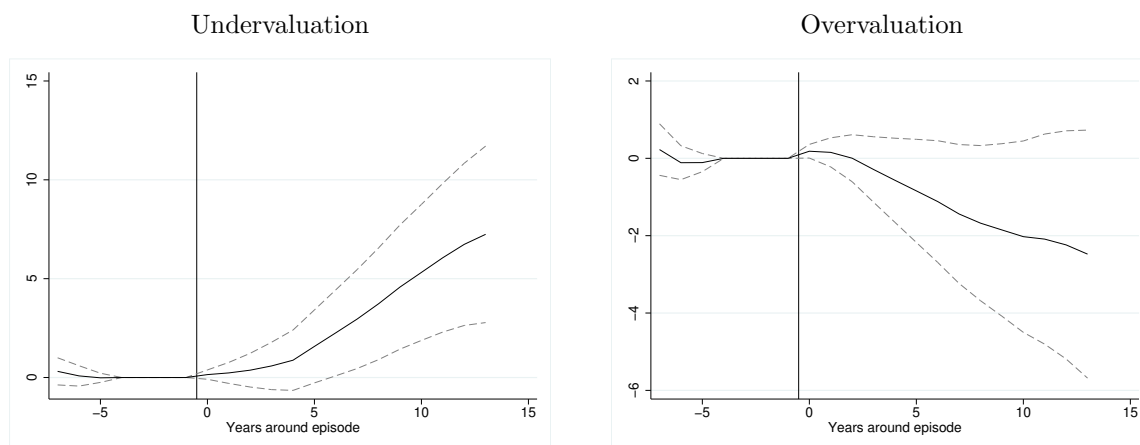
positive effects on GDP *per capita* of low and high-income groups, while in terms of the capital stock, only the former seem to benefit. Results are also very close to the baseline estimations in the case of overvaluations.

Figure 9: Local projections with stacked data of the effects over time of real exchange rate misalignment on the log of GDP



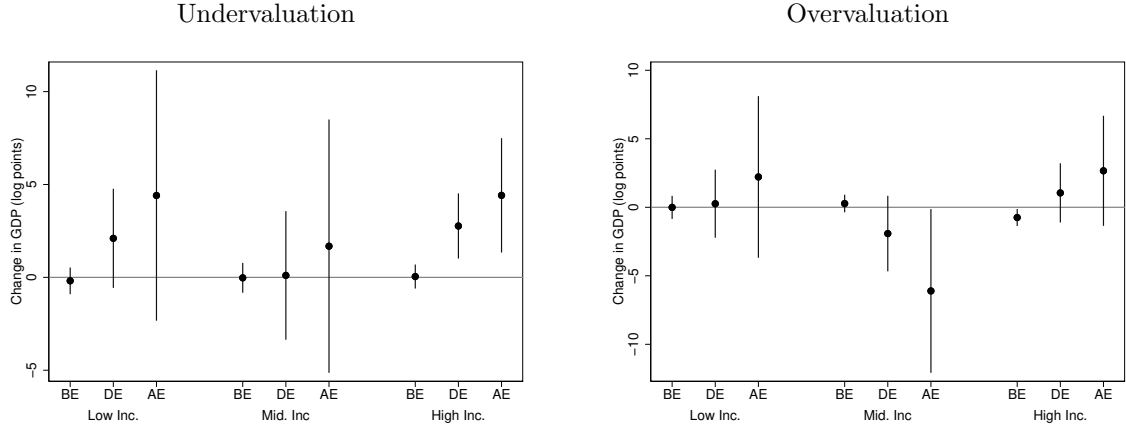
*Note:* The solid line plots the estimated average effect on log GDP *per capita* on countries that had an undervaluation episode, with a 90 percent confidence interval in black dashed lines. Time (in years) relative to the year of the episode.

Figure 10: Local projections with stacked data of the effects over time of real exchange rate misalignment on the log of capital stock.



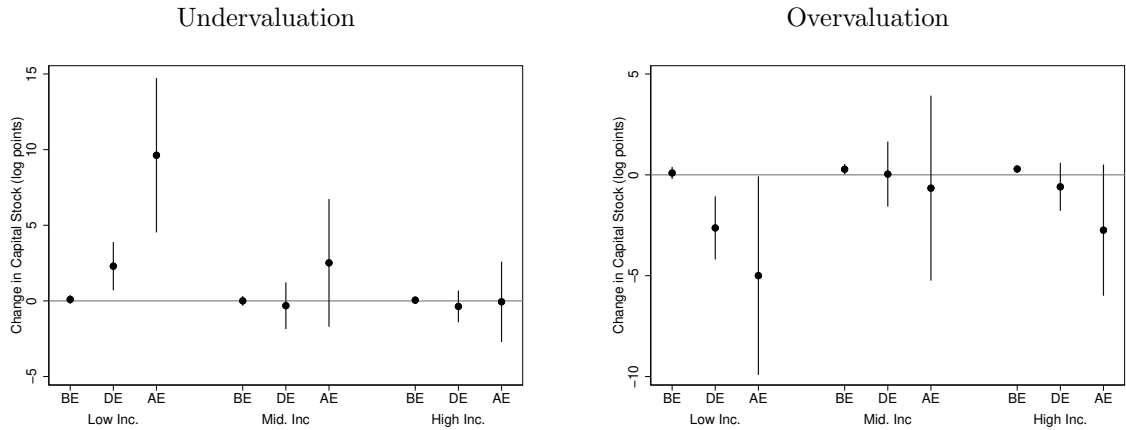
*Note:* The solid line plots the estimated average effect on log GDP *per capita* on countries that had an undervaluation episode, with a 90 percent confidence interval in black dashed lines. Time (in years) relative to the year of the episode.

Figure 11: Local projections with stacked data of the effects over time of real exchange rate misalignment on the log of GDP - average effect by income group



Note: BE = Before Episode (time -7 to -1); DE= During Episode (time 0 to 6); AE= After episode (time 7 to 13). The dot is the estimated coefficient and the lines indicate the 90% confidence interval.

Figure 12: Local projections with stacked data of the effects over time of real exchange rate misalignment on the log of the capital stock - average effect by income group



Note: BE = Before Episode (time -7 to -1); DE= During Episode (time 0 to 6); AE= After episode (time 7 to 13). The dot is the estimated coefficient and the lines indicate the 90% confidence interval.

## 6 Structural Changes

So far we have focused on two aggregate variables, GDP *per capita* and the level of capital stock. We now turn our attention to the effects of sustained RER misalignments on more disaggregated variables that are typically associated with structural change in an economy.

Tables 5 - 8 indicate the most relevant variables affected by the episodes of under and overvaluation – a list with all the items tested is given in appendix A.<sup>28</sup> The variables presented

<sup>28</sup>The number of episodes tested for each variable is smaller than the total indicated in section 2 as data for many variables are not as widely available as for GDP and capital stock. We also interpolate (linearly) the data

are those that are statistically significant in the IPWRA or CBC estimations, as long as they do not present contradictory signals (positive and significant using IPWRA and significantly negative in the CBC estimation, for instance). It is important to recall that, as indicated in section 5.2, we are more interested in the qualitative result than in its quantitative counterpart.

The most general effects of undervaluation episodes are a decrease in the shares of wages, the services sector, and consumption goods in the imports basket, and an increase in investment (particularly in machines). There is also some evidence, although weaker, that industrial employment and the share of capital and intermediate goods imported increase. The effects by income group tend to follow the general effect, but some particularities seem relevant. For low-income economies, the effect on investment is strongly positive and significant across different types of investment, while the effects are negative for middle-income countries. Moreover, the share of high-tech manufactured exports tends to decrease following undervaluation episodes only for middle- and high-income countries,<sup>29</sup> while there is some (weak) evidence that the share of exports of medium-tech manufactures tends to increase in the majority of significant cases for low-income countries.

In the case of overvaluations, the overall effects are: investment tends to decrease (particularly in structures - new plants, buildings, etc.), consumption (as a share of GDP) tends to increase, exports become more concentrated in commodities and manufactures related to natural resources, and less so in low and high-tech manufactures, while imports become more concentrated in consumption and capital goods and less in intermediate ones. There is also evidence of a positive effect on services (particularly in employment) and, to a lesser extent, a negative effect on manufacturing value-added. The effects follow a similar pattern across income groups with the exception of exports. While there are no significant changes in low-income countries, both middle and high-income countries experience a reduction in the share of low-tech exports.

Taken together, the effects of under- and overvaluation on export shares may reflect: (i) the fact that high-tech exports have a much smaller share, on average, in low-income countries (so that there is not much room for further decline in their share),<sup>30</sup> and (ii) the empirically-supported possibility that low-tech exports are more internationally substitutable, and hence

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for some variables as long as the gap is not larger than 3 years.

<sup>29</sup>In the case of high-income countries, this appears only in the CBC results where 80% of the significant cases represent a reduction, but not in the average results.

<sup>30</sup>See, for example, Demir and Razmi (2021).

more sensitive to relative price signals, so that their share increases (decreases) in response to undervaluations (overvaluations) in middle and high-income countries.<sup>31</sup> Combining these elements, one may tentatively hypothesize that, due to increased profitability in the tradable sector, sustained undervaluation allows poorer countries to produce and exports goods that are marginally more technologically demanding; in higher-income countries, on the other hand, undervaluation boosts the export of price-sensitive low-tech goods.<sup>32</sup>

Given the mixed results in terms of statistical significance, however, we are unable to derive any strong conclusions and further research is required to test this hypothesis.

## 7 Extensions and Robustness Exercises

So far we have analyzed effects on GDP, the capital stock, and variables associated with structural change. This section probes a bit deeper and then gauges the robustness of our main results to changes in the criteria that we employed in choosing the episodes and in addressing pre-treatment trends.

### 7.1 Primary commodity exports

To further explore whether the impact of real exchange rate misalignment is conditional on the type of exports a country is specialized in, we analyze how the effects vary depending on the share of commodities in exports. Given the large negative correlation between GDP and the export share of commodities, we further distinguish between *low income* (low or low-middle income according to the World Bank classification) and *high income* (middle-high or high income) countries. In order to have a more balanced sample, we adopt different thresholds in each income group. Low-income countries are considered specialized in commodities exports if their share is larger than 50% (at the beginning of the episode); for high-income countries, the threshold is 25%.<sup>33</sup>

The results presented in this section (see figures 13 and 14) follow our baseline method

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<sup>31</sup>See, for example, Carlin et al. (2001) for OECD countries and, more recently and for a larger sample of countries, Bottega and Romero (2021).

<sup>32</sup>Bergin (2022) proposes a model that, among other results, clarify this trade-off: an undervaluation can foster domestic manufacturing, but may discourage specialization in high-value added goods and favor specialization in non-differentiated manufactures with higher price elasticity.

<sup>33</sup>Among low income countries, we have 36 episodes for commodity exporters and 23 for non-commodity exporters; for the rich countries, the corresponding numbers are 45 and 36, respectively. The numbers of episodes are smaller than the baseline case because we do not have data for the share of commodity exports for some episodes.



Table 6: Average results - low-income countries

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Table 7: Average results - Middle-income countries

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Table 8: Average results - High-income countries

| UNDERVALUATION  |         |         |          |          |         |          |         |          |                   |
|-----------------|---------|---------|----------|----------|---------|----------|---------|----------|-------------------|
|                 |         |         |          |          |         |          |         |          |                   |
| IPWRA           |         |         |          |          |         |          |         |          |                   |
|                 | During  | Post    | CBC      |          | IPWRA   |          | CBC     |          | CBC - Freq. (%)   |
|                 |         |         | During   | Post     | During  | Post     | During  | Post     | Positive Negative |
| I               | 3.624   | 13.117+ | 0.676    | 3.213    | 0.676   | 3.213    | 4.555*  | 5.241*   | 100 0             |
| wage.share      | -1.274* | -0.737  | -1.179*  | -0.823   | 0.345*  | -0.438   | 0.018   | -0.473   | 46.7 53.3         |
| shareintgoodsM  | 1.480*  | 0.028   | 0.597    | 0.300    | -12.332 | -25.491* | -3.238  | -10.501  | 11.1 88.9         |
| shareconsgoodsM | -0.943* | -0.293  | -0.969*  | -1.558*  | -7.469  | -20.608* | 6.976   | -7.418   | 50 50             |
| sharemedlumtech | -1.725+ | -1.026  | -1.287*  | -2.796*  | -9.675  | -18.464  | -3.664  | -18.751+ | 30.8 69.2         |
| C.share         | -0.996+ | -2.379* | -0.553   | -1.618*  | 0.832*  | 1.155+   | 1.201*  | 1.830*   | 100 0             |
| L.Mach          | -4.782  | -8.943  | -11.054+ | -18.838* | -0.882  | -1.284*  | 0.033   | -0.048   | 30.8 69.2         |
| sharecomm       | 1.447   | 0.756   | 0.881    | 1.207    | -0.971  | -1.111   | -3.116* | -2.463*  | 35.7 64.3         |
| sharehightech   | -0.086  | -0.169  | -0.490   | 0.782    | 0.819   | 0.509    | 1.563*  | 0.984    | 63.6 36.4         |
|                 |         |         |          |          | 1.359   | 2.889    | 2.148*  | 4.841*   | 85.7 14.3         |
|                 |         |         |          |          | -0.346  | -0.192   | -2.357* | -5.658*  | 0 100             |

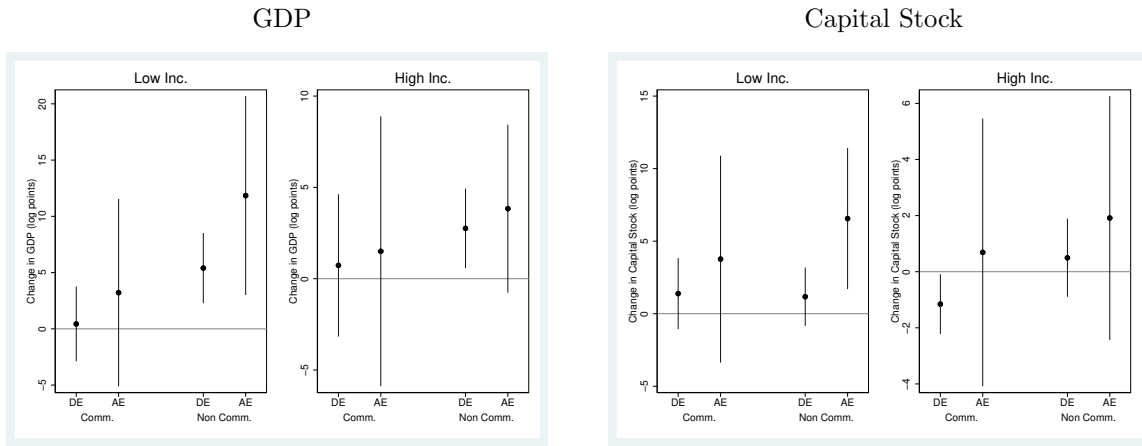
Note: \* p<0.05, + p<0.1. The numbers at IPWRA and CBC indicate the effect of episodes on the log of the variables. The coefficients are multiplied by 100.

(IPWRA).<sup>34</sup> Stacked data (CBC) estimations can be found in appendix C.

The results for undervaluation indicate that non-commodity exporters experience significantly higher GDP and capital stock growth following sustained undervaluations, and this is particularly true for low-income countries. This suggests that our aggregate results for the effects of undervaluation on growth are primarily being driven by low-income countries that are not dependent on commodity exports.

In the case of overvaluation episodes, countries specialized in commodity export also tend to be more negatively affected, for both low and high income groups.

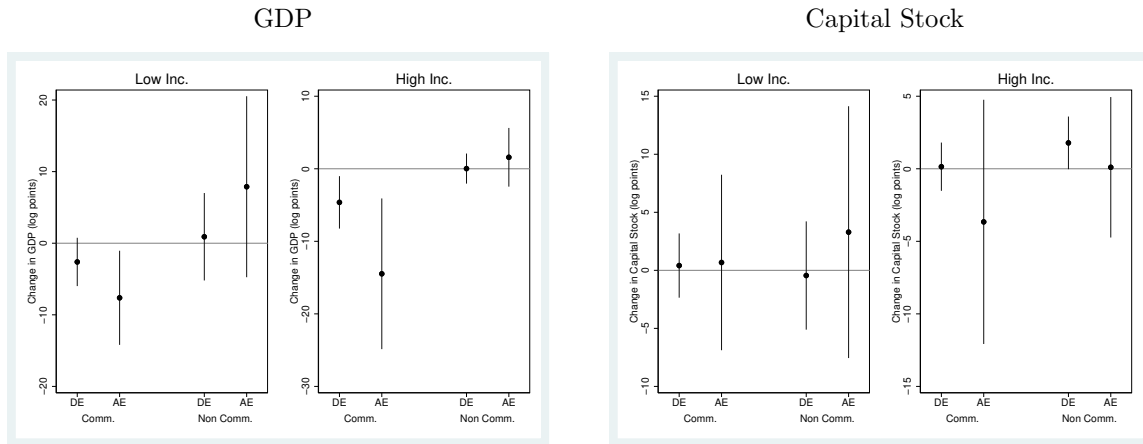
Figure 13: Semiparametric estimates of the effects over time of real exchange rate undervaluation episodes - average effect by type of exports and income group



Note: BE = Before Episode (time -7 to -1); DE= During Episode (time 0 to 6); AE= After episode (time 7 to 13). The dot is the estimated coefficient and the lines indicate the 90% confidence interval.

<sup>34</sup>For each of the estimations, the same procedure as in section 4 is used to find the relevant variables to be used for the propensity scores.

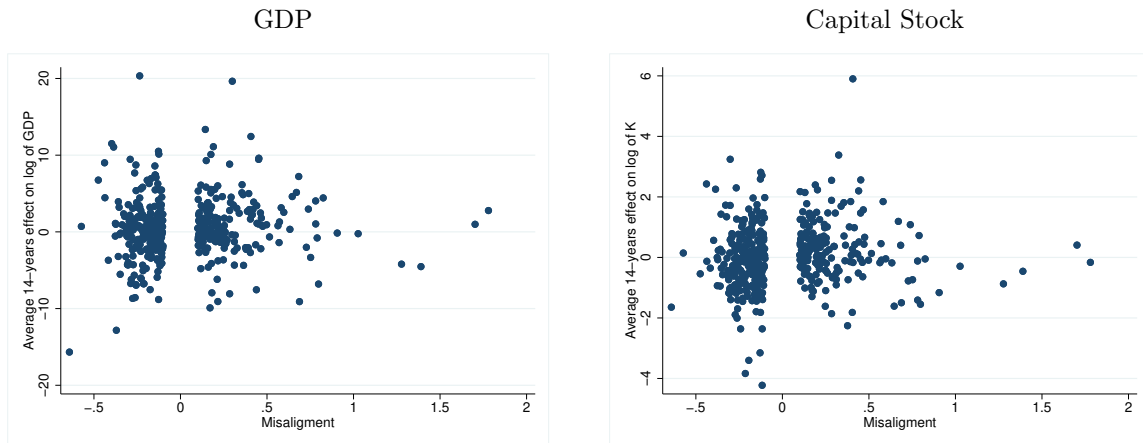
Figure 14: Semiparametric estimates of the effects over time of real exchange rate overvaluation episodes - average effect by type of exports and income group



Note: BE = Before Episode (time -7 to -1); DE= During Episode (time 0 to 6); AE= After episode (time 7 to 13). The dot is the estimated coefficient and the lines indicate the 90% confidence interval.

## 7.2 Misalignment size

Figure 15: Case-by-case difference-in-differences estimation for the effect of misalignment



Note: Each point is an episode of undervaluation or overvaluation. The are between -0.1 and 0.1 does not have episodes by definition (criteria 1, Section 2). **The controls for the estimations in each episode are defined using the same criteria used in section 5.1.**

Taking advantage of the case-by-case analysis, we examine if the size of the misalignment change<sup>35</sup> is correlated with the effect on GDP and capital stock.

As can be seen in figure 15, there is a wide dispersion of results. Simple OLS regressions indicate a positive relationship - a larger real exchange rate devaluation (overvaluation) is associated with a more positive (negative) effect on log of GDP and capital stock. The results are not statistically significant in the case of GDP, but positive and significant in the case of the

<sup>35</sup>The size is the percentage change in the 7-year episode window compared to the juxtaposed window.

capital stock (either using all episodes, or just those cases that are significant at 5% or 10%). When adding a quadratic effect, these results become stronger, with a positive linear effect (also on GDP now) and a negative quadratic one - that is, a larger undervaluation (overvaluation) is associated with a more positive (negative) effect on log of GDP and capital stock, but at a decreasing rate (i.e., the function is concave). Results can be seen in appendix [D](#).

### 7.3 Modified Criteria

In this section, we adjust the criteria that we employed in Section [2](#) to identify episodes of RER misalignment in order to investigate the robustness of our results. The associated estimates and graphs (for our baseline method, IPWRA) can be found in appendix [E](#).

#### Less strict misalignment criteria

Decreasing the required misalignment to 5%, instead of the baseline level of 10%, we get 226 cases of undervaluation and 282 of overvaluation (instead of 189 and 238, respectively, with the baseline criteria). It is striking to note that even with a relatively loose criterion that gives us a larger number of episodes, the results are very similar. Quantitatively, the estimates tend to be slightly smaller for the increase of GDP and capital stock in the case of undervaluation. The results by income level are also very similar, with the difference that the positive effect of undervaluation is smaller for high-income countries. It is interesting to note that for overvaluation, the general negative effect on GDP is slightly larger due to the stronger negative effect on middle and high-income groups for both GDP and capital stock.

#### Stricter misalignment criteria

By increasing the required misalignment to 20%, instead of the baseline level of 10%, the number of undervaluation (overvaluation) episodes drops to 122 (128). The general effects (for both GDP and capital stock) are very similar, indicating that, above some level, marginal RER misalignments are not significant. The results by income level are also very similar, with minor differences: the positive effect of undervaluation on high-income countries is weaker, and the negative effect of overvaluation on middle-income ones is stronger.

### Less strict volatility criteria

To test the role of the volatility criteria, we check how the estimates react within a one standard deviation of the volatility distribution. That is, we calculate the standard deviation of the RER movements during episodes that comply with criteria 1 (a 10% misalignment of the RER), and use it to create a less strict criteria (a half standard deviation higher volatility  $-0.19$  for undervaluation episodes, and  $0.13$  for overvaluation ones).<sup>36</sup>

Using the less strict criteria, we have 191 undervaluation episodes and 233 overvaluation ones. The general effects on capital stock and GDP are again very similar for both types of misalignment. For the effects by income group, there is a significant reduction in the positive effect of undervaluation after the episode for low-income countries. The results for capital stock are also the same as the baseline case.

### Stricter volatility criteria

With a stricter volatility criterion ( $0.12$  for undervaluation, and  $0.08$  for overvaluation), the number of undervaluation (overvaluation) cases drops to 162 (213). Again, the overall effects are very similar, although slightly smaller. The results by income level, however, change qualitatively for the undervaluation cases. Now, middle-income countries also have a significant positive effect on their GDP during the episode of about the same size as the one for low-income countries, and the positive effect for the high-income group is reduced. The positive effect on the capital stock for low-income countries falls significantly, making it insignificant for all income groups individually. The qualitative results for overvaluations are the same as the baseline ones.

The stricter criteria particularly affect the number of middle-income undervaluation episodes, leading to a 22.6% reduction in their occurrence; for low-income countries, the reduction is of 13.3%. It is interesting to note that the profile of episodes dropped using the new criteria are precisely the opposite for these two groups: those dropped within the low income group are those with more positive effects, particularly after the episode, while in the case of the middle-income group, those with neutral or negative effects are the ones dropped.

Given the relevant change in the results for undervaluation by income group, we test an additional threshold that is intermediate between the baseline case and the strictest one (namely, we impose a ceiling of a 25% standard deviation, with the threshold for the volatility now being

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<sup>36</sup>Recall that the original criteria were 0.17 and 0.12 for undervaluations and overvaluations.

0.135 for undervaluation and 0.1 for overvaluation). Figures 34 – 37 present the results. Now the low-income group has 8.9% fewer (undervaluation) episodes than the baseline case, and middle-income countries have 14.5% fewer cases. The qualitative results are now consistent with the baseline case, as are the results by income group. The positive effects are slightly smaller for the low-income group and higher for the middle-income one, indicating some continuity in the process of exclusion of episodes with more positive outcome for poorer countries and the opposite for middle-income ones.

## 7.4 Shorter time windows

A possible critique of our criteria is that, by setting a relatively large window, we may be creating a selection bias in the case of undervaluation: of all countries that experienced undervaluation, only those that benefited in terms of growth and investment would have pursued undervaluation-friendly policies for a longer period. First, there is, of course, a counter-argument to this claim: by the same logic the cases of overvaluation should be subject to a similar bias. This would imply either that the negative effects of RER appreciation are underestimated, or that countries have a greater capacity to sustain undervaluations compared to overvaluations, which does not seem plausible. Second, one should note that a successful (i.e., high) growth period should make it harder to maintain undervaluation since most macroeconomic theory would predict real appreciation following high growth.

Third, a way to explore the relevance of this claim empirically is to narrow the time window. We do so by shortening the time frame for episodes from 7 to 5 years. The results are presented in appendix F. The main qualitative results continue to hold, although the magnitude of the effect, not surprisingly, is smaller: after 14 years of the beginning of an episode, undervaluations increase GDP *per capita* by about 4.5% and capital stock by almost 4%, while overvaluations generate a fall in the capital stock of almost 5%. The effects by income group also follow the baseline results.

## 7.5 Larger pre-treatment periods

We increase the pre-treatment period from 7 to 10 years to further check the parallel trend assumption. Appendix G presents the results. The average pre-treatment effect continues to be statistically insignificant, and the effects 10 years before the beginning of the episodes are insignificant at the 5% level.

## 8 Concluding Discussion

The debate surrounding the effects of real exchange rate movements on growth and development is far from settled. By addressing several important gaps in the current literature, we provide significantly more robust evidence for these relationships, besides exploring the structural channels through which these macroeconomic effects appear over time.

First, we analyze episodes of sustained and stable misalignment, selected using formal criteria. This helps us incorporate the role of history, expectations, and inertial macroeconomic adjustment in a more satisfactory manner. Second, and on a related note, the use of semi-parametric estimations as our baseline method allows us to identify longer-run effects that might remain concealed when looking at average coefficients or when linear effects are assumed. Third, we investigate the consequences of misalignments in both directions and thus drop the assumption of symmetry between under- and overvaluations that is often implicitly made.

A fourth gap is the endogeneity problem associated with RER movements. To address this and the related pre-existing trends problem, we take advantage of multiple empirical methods that have been used to deal with similar issues, including propensity-score reweighting and event-by-event analysis. The broadly similar picture emerging from these and linear (OLS and GMM) regressions results gives us confidence that our estimates are robust and address this important concern.

Fifth, the issue of heterogeneity is explicitly dealt with by the adoption of an additional case-by-case event study approach.

Finally, an important gap in the literature pertains to the identification of changes in the economic structure associated with RER misalignments that could then appear at the macroeconomic level in the form of output and capital stock growth. To advance in this direction, we estimate the effect of misalignment on 35 variables other than GDP *per capita* and capital stock. These variables capture GDP structure (from the demand and supply sides), functional income distribution, types of investment, profiles of imports and exports, besides indexes of complexity and export diversification and sophistication.

Our results indicate that sustained RER movements have long-run consequences for GDP and the capital stock, positive in the case of undervaluations and negative in that of overvaluations. We also detect some evidence that these effects strengthen with the size of the misalignment, although at a diminishing rate. Moreover, the effects are heterogeneous between

income groups; the positive effects on GDP take place only in low- and high-income countries, with the final effect after 14 years of the beginning of an episode surpassing 10 percent in both cases; the positive effects on capital stock, however, are seen only in low-income countries. The results suggest that this heterogeneity, particularly for undervaluation episodes, depends on the degree of RER volatility. Also, countries that are less specialized in commodities (compared to countries at a similar income level) experience the positive effects of sustained undervaluation to a greater extent. This is particularly true for low income economies.

In terms of structural characteristics, undervaluation episodes promote, on average, an increase in investment, exports, and in the import share of intermediate and capital goods; and a decrease in the consumption share, the wage-share and the relative size of the services sector. Overvaluation episodes are associated with an increase in the shares of consumption, services sector employment, primary commodity and natural resource exports, and consumption and capital goods imports. Furthermore, overvaluation episodes have a negative effect on investment, particularly on physical structures, and reduce the share of low-tech manufactures.

The results by income group can contribute to understanding the strengths and limits of using RER as a policy tool. In terms of the capital stock, only low-income countries appear to benefit from sustained undervaluations. The contrast between the effects on low and high-income countries suggests that while undervaluation promotes an increase in both the actual and the potential GDP of the former group, in the case of high income economies, the main effect of undervaluations may be that of preventing possible (negative) hysteresis effects. Another difference can also be identified in the structural effects: for richer countries, an undervaluation tends to be associated with a reduction in the share of high and medium-tech exports, while in low-income economies, there is some evidence of an increase in the share of medium-tech exports and employment in manufacturing, besides a boom in investment. These results may reflect the higher price elasticity of demand for the low-tech goods that constitute a larger share of low-income country exports. Needless to say, however, these hypotheses are initial attempts to interpret the data based on theory, and more research is necessary to evaluate their validity. The consequences of undervaluation in middle-income countries for development seems to be a more complex issue: in our baseline estimations, the effects are null; however, we find evidence that episodes with very low volatility tend to generate positive effects.

Our results have implications for future research. Case study analysis, particularly for low- and middle-income countries, could improve our understanding of the conditions that interact

with RER misalignment to produce positive or negative effects. Moreover, an analysis that takes into consideration which episodes were a result of exogenous shocks or followed from deliberate policy management could further enhance our understanding of the complementary role played by other elements, such as expectations and industrial policy.

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# Appendices

## A List of episodes and variables

Table 11: List of variables

| Variable        | Definition   | Source                                 |
|-----------------|--|--|
| y               | GDP <i>per capita</i> at constant national prices                                    | PWT 10.0                               |
| C               | Consumption <i>per capita</i> at constant national prices                            | PWT 10.0                               |
| G               | Government <i>per capita</i> at constant national prices                             | PWT 10.0                               |
| I               | Investment <i>per capita</i> at constant national prices                             | PWT 10.0                               |
| X               | Exports <i>per capita</i> at constant national prices                                | PWT 10.0                               |
| M               | Imports <i>per capita</i> at constant national prices                                | PWT 10.0                               |
| lexpy_na        | Sophistication index of the country's exports  | Hoyos, Libman, and Razmi (2021)        |
| lexpy_r         | Sophistication index of the country's exports  | Hoyos, Libman, and Razmi (2021)        |
| I.Struc         | Investment at constant national prices in residential and non-residential structures | PWT 10.0                               |
| I.Other         | Investment at constant national prices in other assets                               | PWT 10.0                               |
| I.TraEq         | Investment at constant national prices in transport equipment                        | PWT 10.0                               |
| I.Mach          | Investment at constant national prices in machinery and (non-transport) equipment    | PWT 10.0                               |
| K               | Capital stock at constant national prices  | PWT 10.0                               |
| wage_share      | Share of labour compensation at in GDP at current national prices                    | PWT 10.0                               |
| shareKgoodsM    | Share of capital goods imported  | Hoyos, Libman, and Razmi (2021)        |
| shareintgoodsM  | Share of intermediate goods imported   | Hoyos, Libman, and Razmi (2021)        |
| shareconsgoodsM | Share of consumption goods imported  | Hoyos, Libman, and Razmi (2021)        |
| sharenesM       | Share of other goods imported  | Hoyos, Libman, and Razmi (2021)        |
| sharecomm       | Share of commodities exported  | Hoyos, Libman, and Razmi (2021)        |
| sharehightech   | Share of high-tech manufactures exported   | Hoyos, Libman, and Razmi (2021)        |
| sharelowtech    | Share of low-tech manufactures exported  | Hoyos, Libman, and Razmi (2021)        |
| sharemediumtech | Share medium-tech manufactures   | Hoyos, Libman, and Razmi (2021)        |
| sharenatres     | Share of natural resource-based manufactures exported                                | Hoyos, Libman, and Razmi (2021)        |
| shareothertrans | Share of other goods exported  | Hoyos, Libman, and Razmi (2021)        |
| C_share         | Share of consumption on GDP  | Authors' elaboration based on PWT 10.0 |
| G_share         | Share of government on GDP   | Authors' elaboration based on PWT 10.0 |
| I_share         | Share of investment on GDP   | Authors' elaboration based on PWT 10.0 |
| X_share         | Share of exports on GDP  | Authors' elaboration based on PWT 10.0 |
| M_share         | Share of imports on GDP  | Authors' elaboration based on PWT 10.0 |
| Agr             | Agriculture, forestry, and fishing, VA (% GDP)                                       | World Bank                             |
| Man             | Manufacturing, VA (% GDP)  | World Bank                             |
| Serv            | Services, VA (% GDP)   | World Bank                             |
| Serv_emp        | Employment in services (% total)   | World Bank                             |
| Agr_emp         | Employment in agriculture (% total)  | World Bank                             |
| Ind_emp         | Employment in industry (% total)   | World Bank                             |
| eci             | Economic Complexity Index  | Atlas of Economic Complexity           |
| hhi             | Exports diversification index (Herfindahl-Hirschman Index)                           | Hoyos, Libman, and Razmi (2021)        |

Table 9: Undervaluation episodes

|                          |      |                 |      |                   |      |                      |      |
|--------------------------|------|-----------------|------|-------------------|------|----------------------|------|
| Albania                  | 1979 | Egypt           | 1973 | Mali              | 1994 | South Africa         | 1996 |
| Albania                  | 1990 | Egypt           | 1981 | Mexico            | 1976 | Spain                | 1960 |
| Algeria                  | 1991 | Egypt           | 1995 | Mongolia          | 1977 | Spain                | 1997 |
| Angola                   | 1977 | Egypt           | 2003 | Mongolia          | 1997 | Sri Lanka            | 1968 |
| Argentina                | 1972 | El Salvador     | 1961 | Morocco           | 1961 | Palestine            | 1978 |
| Argentina                | 1995 | El Salvador     | 1969 | Morocco           | 1984 | Palestine            | 1994 |
| Argentina                | 2004 | El Salvador     | 2003 | Morocco           | 1976 | Palestine            | 2003 |
| Australia                | 1980 | Ethiopia        | 1957 | Mozambique        | 1987 | Sweden               | 1982 |
| Australia                | 1997 | Ethiopia        | 1980 | Mozambique        | 2001 | Sweden               | 1997 |
| Austria                  | 1997 | Ethiopia        | 1993 | Myanmar           | 1975 | Switzerland          | 1997 |
| Bangladesh               | 2005 | Ethiopia        | 2001 | Myanmar           | 1986 | Syrian Arab Republic | 1985 |
| Belgium                  | 1981 | Finland         | 1993 | Myanmar           | 2003 | Taiwan               | 1959 |
| Belgium                  | 1997 | France          | 1997 | Nepal             | 1973 | Taiwan               | 1998 |
| Benin                    | 1997 | Germany         | 1981 | Nepal             | 1986 | Taiwan               | 2006 |
| Bolivia                  | 1993 | Germany         | 1997 | Netherlands       | 1981 | Thailand             | 1970 |
| Bolivia                  | 2003 | Ghana           | 1973 | Netherlands       | 1997 | Thailand             | 2001 |
| Brazil                   | 1960 | Guatemala       | 1986 | New Zealand       | 1997 | Togo                 | 1969 |
| Brazil                   | 1983 | Guinea          | 1974 | Nicaragua         | 1960 | Togo                 | 1977 |
| Brazil                   | 1999 | Haiti           | 1992 | Niger             | 1994 | Togo                 | 1994 |
| Bulgaria                 | 1977 | Honduras        | 1973 | Nigeria           | 1987 | Tunisia              | 1970 |
| Burkina Faso             | 1994 | Honduras        | 1990 | Nigeria           | 2003 | Tunisia              | 1981 |
| Burundi                  | 1967 | Hungary         | 1977 | North Macedonia   | 1998 | Tunisia              | 1993 |
| Burundi                  | 1988 | India           | 1966 | Norway            | 1979 | Turkey               | 1961 |
| Cambodia                 | 2003 | India           | 1974 | Norway            | 2000 | Turkey               | 1980 |
| Cameroon                 | 1981 | India           | 1991 | Pakistan          | 1972 | Tanzania             | 1987 |
| Cameroon                 | 1994 | Indonesia       | 2002 | Pakistan          | 1982 | Tanzania             | 2003 |
| Canada                   | 1978 | Indonesia       | 1986 | Pakistan          | 2005 | Tanzania             | 1990 |
| Canada                   | 1994 | Iran            | 1963 | Paraguay          | 1958 | Uganda               | 1998 |
| Central African Republic | 1981 | Iran            | 1985 | Paraguay          | 1989 | United Kingdom       | 2006 |
| Central African Republic | 1994 | Iran            | 2003 | Peru              | 1978 | United States        | 1973 |
| Chad                     | 1994 | Ireland         | 1998 | Peru              | 2003 | United States        | 2004 |
| Chile                    | 1958 | Israel          | 1962 | Philippines       | 1962 | Uruguay              | 1970 |
| Chile                    | 1982 | Italy           | 1976 | Philippines       | 1970 | Uruguay              | 1983 |
| Hong Kong                | 2004 | Italy           | 1997 | Philippines       | 1986 | Uruguay              | 2002 |
| China                    | 1974 | Jamaica         | 1984 | Poland            | 1980 | Venezuela            | 1964 |
| China                    | 1986 | Jamaica         | 2003 | Portugal          | 1977 | Venezuela            | 1987 |
| Colombia                 | 1958 | Japan           | 2001 | Republic of Korea | 1961 | Venezuela            | 2002 |
| Colombia                 | 1966 | Kenya           | 1983 | Republic of Korea | 1973 | Yemen                | 2005 |
| Colombia                 | 1975 | Lao People's DR | 1977 | Republic of Korea | 1998 | Zambia               | 1996 |
| Colombia                 | 1986 | Lao People's DR | 2001 | Romania           | 1980 |                      |      |
| Congo                    | 1974 | Lebanon         | 2004 | Rwanda            | 2002 |                      |      |
| Congo                    | 1994 | Liberia         | 1997 | Saudi Arabia      | 1986 |                      |      |
| Côte d'Ivoire            | 1981 | Madagascar      | 1984 | Saudi Arabia      | 2002 |                      |      |
| Côte d'Ivoire            | 1994 | Madagascar      | 2004 | Senegal           | 1981 |                      |      |
| Congo                    | 1972 | Malawi          | 1973 | Senegal           | 1994 |                      |      |
| Denmark                  | 1981 | Malawi          | 1982 | Sierra Leone      | 1968 |                      |      |
| Denmark                  | 1997 | Malaysia        | 1963 | Sierra Leone      | 1990 |                      |      |
| Dominican Republic       | 2003 | Malaysia        | 1971 | Singapore         | 1978 |                      |      |
| Ecuador                  | 1986 | Malaysia        | 2003 | Singapore         | 1998 |                      |      |
| Egypt                    | 1962 | Mali            | 1981 | Singapore         | 2006 |                      |      |

Table 10: Overvaluation episodes

|                          |      |                    |      |                 |      |                    |      |                      |      |
|--------------------------|------|--------------------|------|-----------------|------|--------------------|------|----------------------|------|
| Albania                  | 2004 | China              | 1959 | Indonesia       | 1976 | New Zealand        | 1970 | Sudan                | 1985 |
| Algeria                  | 1968 | China              | 1996 | Indonesia       | 2002 | New Zealand        | 1987 | Sudan                | 2001 |
| Algeria                  | 1976 | Colombia           | 1981 | Iran            | 1980 | New Zealand        | 2003 | Sweden               | 1960 |
| Algeria                  | 1984 | Colombia           | 1994 | Iraq            | 1983 | Nicaragua          | 1988 | Sweden               | 1975 |
| Algeria                  | 2004 | Congo              | 1986 | Iraq            | 2005 | Niger              | 1975 | Sweden               | 1990 |
| Angola                   | 1985 | Croatia            | 1998 | Ireland         | 1970 | Niger              | 1986 | Switzerland          | 1962 |
| Angola                   | 2000 | Czech Republic     | 2002 | Ireland         | 1990 | Niger              | 2003 | Switzerland          | 1978 |
| Armenia                  | 1998 | Côte d'Ivoire      | 1977 | Israel          | 1990 | Nigeria            | 1957 | Switzerland          | 1986 |
| Australia                | 1959 | Côte d'Ivoire      | 2002 | Italy           | 1962 | Nigeria            | 1970 | Syrian Arab Republic | 1977 |
| Australia                | 1973 | D.R. of the Congo  | 1983 | Italy           | 1990 | Nigeria            | 1983 | Syrian Arab Republic | 1991 |
| Australia                | 2003 | D.R. of the Congo  | 1994 | Italy           | 2003 | Nigeria            | 1993 | Taiwan               | 1987 |
| Austria                  | 1959 | Denmark            | 1959 | Jamaica         | 1966 | Norway             | 1959 | Tajikistan           | 1998 |
| Austria                  | 1978 | Denmark            | 1970 | Jamaica         | 1975 | Norway             | 1970 | Tajikistan           | 2006 |
| Austria                  | 1986 | Denmark            | 1990 | Jamaica         | 1993 | Norway             | 1986 | Tajikistan           | 2006 |
| Azerbaijan               | 1997 | Dominican Republic | 1967 | Jamaica         | 1993 | Norway             | 1986 | Thailand             | 1957 |
| Bangladesh               | 1970 | Dominican Republic | 1990 | Japan           | 1959 | Paraguay           | 1965 | Thailand             | 1990 |
| Bangladesh               | 1999 | Dominican Republic | 1990 | Japan           | 1972 | Paraguay           | 1981 | Togo                 | 1986 |
| Bangladesh               | 2005 | Ecuador            | 1974 | Japan           | 1986 | Paraguay           | 1994 | Turkey               | 1970 |
| Belarus                  | 1975 | Ecuador            | 1994 | Kazakhstan      | 1997 | Peru               | 1970 | Turkey               | 1990 |
| Belgium                  | 1975 | El Salvador        | 1976 | Kazakhstan      | 2006 | Peru               | 1987 | Turkey               | 2003 |
| Belgium                  | 1990 | El Salvador        | 1990 | Kazakhstan      | 1958 | Poland             | 1991 | Turkmenistan         | 2001 |
| Benin                    | 1975 | Estonia            | 2003 | Kenya           | 1970 | Poland             | 2005 | Tanzania             | 1981 |
| Benin                    | 1986 | Ethiopia           | 1985 | Kenya           | 1997 | Poland             | 1970 | Tanzania             | 1996 |
| Bolivia                  | 1960 | Finland            | 1975 | Kenya           | 2005 | Portugal           | 1990 | Tanzania             | 1963 |
| Bolivia                  | 2003 | Finland            | 1990 | Kyrgyzstan      | 2000 | Portugal           | 2003 | Uganda               | 1971 |
| Bosnia and Herzegovina   | 1973 | France             | 1990 | Kyrgyzstan      | 1991 | Portugal           | 1968 | Uganda               | 1981 |
| Brazil                   | 1989 | Georgia            | 1997 | Lao People's DR | 1991 | Republic of Korea  | 1978 | Uganda               | 2005 |
| Brazil                   | 2005 | Georgia            | 2006 | Latvia          | 2006 | Republic of Korea  | 1989 | Ukraine              | 1981 |
| Bulgaria                 | 1997 | Germany            | 1961 | Lebanon         | 1997 | Republic of Korea  | 2001 | United Kingdom       | 1958 |
| Bulgaria                 | 2006 | Germany            | 1970 | Liberia         | 1981 | Republic of Korea  | 1998 | United Kingdom       | 1990 |
| Bulgaria                 | 1987 | Germany            | 1986 | Liberia         | 1993 | Romania            | 2006 | United States        | 1981 |
| Burkina Faso             | 2003 | Germany            | 1965 | Lithuania       | 1997 | Romania            | 2006 | United States        | 1999 |
| Burkina Faso             | 1979 | Ghana              | 1982 | Lithuania       | 2006 | Russian Federation | 2004 | Uruguay              | 1960 |
| Burundi                  | 2005 | Ghana              | 2005 | Madagascar      | 1973 | Rwanda             | 1971 | Uruguay              | 1990 |
| Burundi                  | 1981 | Ghana              | 1990 | Madagascar      | 1996 | Rwanda             | 1984 | Venezuela            | 1981 |
| Cambodia                 | 1996 | Greece             | 2003 | Madagascar      | 1987 | Saudi Arabia       | 1980 | Venezuela            | 1997 |
| Cambodia                 | 1967 | Greece             | 1979 | Malawi          | 1975 | Saudi Arabia       | 1986 | Viet Nam             | 1985 |
| Cameroon                 | 1975 | Guatemala          | 1997 | Mali            | 1986 | Senegal            | 1996 | Viet Nam             | 1994 |
| Cameroon                 | 2003 | Guatemala          | 1970 | Mali            | 2004 | Senegal            | 2003 | Zambia               | 1969 |
| Canada                   | 1970 | Guinea             | 1981 | Mali            | 1958 | Sierra Leone       | 1978 | Zambia               | 1988 |
| Canada                   | 1989 | Guinea             | 2003 | Mexico          | 1970 | Sierra Leone       | 1999 |                      |      |
| Canada                   | 2006 | Haiti              | 1967 | Mexico          | 1993 | Singapore          | 1993 |                      |      |
| Central African Republic | 1975 | Haiti              | 1985 | Mexico          | 2001 | Slovakia           | 2003 |                      |      |
| Central African Republic | 1987 | Haiti              | 2006 | Morocco         | 1970 | Slovenia           | 2003 |                      |      |
| Central African Republic | 2003 | Honduras           | 1964 | Morocco         | 1999 | South Africa       | 1970 |                      |      |
| Chad                     | 1967 | Honduras           | 1983 | Mozambique      | 1968 | South Africa       | 1990 |                      |      |
| Chad                     | 1978 | Honduras           | 1997 | Myanmar         | 1969 | South Africa       | 2004 |                      |      |
| Chad                     | 2002 | Hungary            | 1990 | Nepal           | 1999 | Spain              | 1970 |                      |      |
| Chile                    | 1990 | Hungary            | 2002 | Netherlands     | 1961 | Spain              | 1978 |                      |      |
| Hong Kong                | 1970 | India              | 1978 | Netherlands     | 1969 | Spain              | 1990 |                      |      |
| Hong Kong                | 1992 | Indonesia          | 1967 | Netherlands     | 1986 | Spain              | 2003 |                      |      |
|                          |      |                    |      |                 |      | Sri Lanka          | 1994 |                      |      |



## B Pre-treatment trend and Selection on Variables Assumption

### Selection on Variables Assumption

Table 12: Undervaluation - General

| VARIABLES                     | (1)<br>Episode       | (2)<br>Episode       |
|-------------------------------|----------------------|----------------------|
| lag4y                         | -1.247*<br>(0.647)   | -1.277*<br>(0.661)   |
| lag3y                         | 1.567*<br>(0.944)    | 1.652*<br>(0.967)    |
| lag2y                         | 0.646<br>(0.861)     | 0.681<br>(0.881)     |
| lag1y                         | -1.051*<br>(0.589)   | -1.142*<br>(0.599)   |
| lag1Mis                       | 0.453**<br>(0.210)   | 0.458**<br>(0.208)   |
| lag2Mis                       | -0.258<br>(0.376)    | -0.237<br>(0.369)    |
| lag3Mis                       | 0.150<br>(0.408)     | 0.130<br>(0.404)     |
| lag4Mis                       | -1.291***<br>(0.284) | -1.304***<br>(0.279) |
| lag1TB_share                  | 0.938**<br>(0.453)   | 1.133**<br>(0.454)   |
| lag2TB_share                  | -0.079<br>(0.223)    | -0.091<br>(0.171)    |
| lag3TB_share                  | 0.187<br>(0.324)     | 0.067<br>(0.184)     |
| lag4TB_share                  | -0.219***<br>(0.077) | -0.243***<br>(0.082) |
| cap_cont_index                | 0.189**<br>(0.090)   | 0.197**<br>(0.090)   |
| lag4tot                       | 0.270<br>(0.362)     |                      |
| lag3tot                       | 0.297<br>(0.427)     |                      |
| lag2tot                       | -0.281<br>(0.406)    |                      |
| lag1tot                       | -0.461<br>(0.324)    |                      |
| Constant                      | -0.276<br>(0.498)    | -0.243<br>(0.492)    |
| Observations                  | 3,753                | 3,753                |
| Lags of GDP                   | 0.0130               | 0.00732              |
| Lags of RER Misalignment      | 0                    | 0                    |
| Lags of Trade Balance (% GDP) | 0.0281               | 0.0124               |
| Lags of ToT                   | 0.246                |                      |
| Pseudo R2                     | 0.141                | 0.138                |

Table 13: Undervaluation - low-income countries

| VARIABLES                     | (1)<br>treat1        | (2)<br>treat1        |
|-------------------------------|----------------------|----------------------|
| lag4y                         | -2.987***<br>(0.923) | -2.943***<br>(0.924) |
| lag3y                         | 2.349*<br>(1.406)    | 2.250<br>(1.410)     |
| lag2y                         | 1.131<br>(1.338)     | 1.338<br>(1.316)     |
| lag1y                         | -0.871<br>(0.860)    | -1.009<br>(0.851)    |
| lag1Mis                       | 0.434<br>(0.290)     | 0.444<br>(0.293)     |
| lag2Mis                       | -0.478<br>(0.482)    | -0.493<br>(0.491)    |
| lag3Mis                       | 0.229<br>(0.621)     | 0.201<br>(0.635)     |
| lag4Mis                       | -1.032**<br>(0.444)  | -0.992**<br>(0.446)  |
| lag1TB_share                  | 0.820<br>(0.827)     | 0.941<br>(0.868)     |
| lag2TB_share                  | 0.537<br>(0.829)     | 0.359<br>(0.861)     |
| lag3TB_share                  | 0.139<br>(0.200)     | 0.129<br>(0.169)     |
| lag4TB_share                  | -0.326***<br>(0.094) | -0.288***<br>(0.094) |
| cap_cont_index                | 0.139<br>(0.115)     | 0.134<br>(0.115)     |
| lag4tot                       | -0.453<br>(0.456)    |                      |
| lag3tot                       | 1.035*<br>(0.565)    |                      |
| lag2tot                       | -0.244<br>(0.503)    |                      |
| lag1tot                       | -0.175<br>(0.480)    |                      |
| Constant                      | 2.190***<br>(0.736)  | 2.078***<br>(0.725)  |
| Observations                  | 1,794                | 1,794                |
| Lags of GDP                   | 7.37e-08             | 1.68e-07             |
| Lags of RER Misalignment      | 1.31e-05             | 1.41e-05             |
| Lags of Trade Balance (% GDP) | 0.00425              | 0.00522              |
| Lags of ToT                   | 0.344                |                      |
| Pseudo R2                     | 0.172                | 0.168                |

Robust standard errors in parentheses

\*\*\* p&lt;0.01, \*\* p&lt;0.05, \* p&lt;0.1

Table 14: Undervaluation - Middle-income countries

| VARIABLES                     | (1)                 | (2)                 | (3)                  | (4)                  |
|-------------------------------|---------------------|---------------------|----------------------|----------------------|
|                               | treat3              | treat3              | treat3               | treat3               |
| lag4y                         | 0.214<br>(0.584)    | 0.182<br>(0.609)    |                      |                      |
| lag3y                         | 0.544<br>(0.855)    | 0.567<br>(0.855)    |                      |                      |
| lag2y                         | -0.328<br>(0.761)   | -0.274<br>(0.770)   |                      |                      |
| lag1y                         | -0.381<br>(0.563)   | -0.407<br>(0.549)   |                      |                      |
| lag1Mis                       | 0.038<br>(0.295)    | 0.051<br>(0.297)    | 0.019<br>(0.291)     | 0.090<br>(0.278)     |
| lag2Mis                       | 0.275<br>(0.510)    | 0.284<br>(0.495)    | 0.288<br>(0.522)     | 0.264<br>(0.508)     |
| lag3Mis                       | -0.085<br>(0.538)   | -0.093<br>(0.516)   | -0.120<br>(0.542)    | -0.030<br>(0.513)    |
| lag4Mis                       | -0.705**<br>(0.350) | -0.697**<br>(0.339) | -0.620*<br>(0.328)   | -0.717**<br>(0.317)  |
| lag1TB_share                  | 0.689<br>(0.605)    |                     |                      |                      |
| lag2TB_share                  | -0.460<br>(0.947)   |                     |                      |                      |
| lag3TB_share                  | 0.419<br>(1.218)    |                     |                      |                      |
| lag4TB_share                  | -0.369<br>(0.663)   |                     |                      |                      |
| cap_cont_index                | 0.277*<br>(0.149)   | 0.267*<br>(0.150)   | 0.255*<br>(0.146)    | 0.285**<br>(0.142)   |
| lag4tot                       | 0.606<br>(0.469)    | 0.688<br>(0.469)    | 0.714<br>(0.461)     |                      |
| lag3tot                       | -0.502<br>(0.484)   | -0.561<br>(0.454)   | -0.556<br>(0.464)    |                      |
| lag2tot                       | -0.086<br>(0.659)   | -0.069<br>(0.642)   | -0.091<br>(0.668)    |                      |
| lag1tot                       | -0.440<br>(0.426)   | -0.522<br>(0.447)   | -0.540<br>(0.448)    |                      |
| Constant                      | -1.782**<br>(0.864) | -1.999**<br>(0.809) | -1.402***<br>(0.362) | -1.467***<br>(0.371) |
| Observations                  | 1,646               | 1,646               | 1,646                | 1,646                |
| Lags of GDP                   | 0.551               | 0.507               |                      |                      |
| Lags of RER Misalignment      | 0.000742            | 0.000817            | 0.00432              | 0.00344              |
| Lags of Trade Balance (% GDP) | 0.786               |                     |                      |                      |
| Lags of ToT                   | 0.206               | 0.146               | 0.125                |                      |
| Pseudo R2                     | 0.0841              | 0.0823              | 0.0792               | 0.0682               |

Robust standard errors in parentheses

\*\*\* p&lt;0.01, \*\* p&lt;0.05, \* p&lt;0.1

Table 15: Undervaluation - High-income countries

| VARIABLES                     | (1)<br>treat4         |
|-------------------------------|-----------------------|
| lag4y                         | 5.692<br>(3.983)      |
| lag3y                         | -3.810<br>(6.634)     |
| lag2y                         | 2.127<br>(8.791)      |
| lag1y                         | -2.242<br>(6.366)     |
| lag1Mis                       | 5.807**<br>(2.366)    |
| lag2Mis                       | -6.699*<br>(3.617)    |
| lag3Mis                       | 4.891<br>(3.425)      |
| lag4Mis                       | -6.175**<br>(2.491)   |
| lag1TB_share                  | 22.305***<br>(7.807)  |
| lag2TB_share                  | -38.606***<br>(9.664) |
| lag3TB_share                  | 15.549**<br>(6.596)   |
| lag4TB_share                  | -2.148<br>(5.499)     |
| cap_cont_index                | 0.924**<br>(0.361)    |
| lag4tot                       | 7.488**<br>(3.356)    |
| lag3tot                       | -2.553<br>(4.150)     |
| lag2tot                       | -4.259<br>(3.399)     |
| lag1tot                       | 1.329<br>(2.184)      |
| Constant                      | -18.278***<br>(5.700) |
| Observations                  | 420                   |
| Lags of GDP                   | 0.0164                |
| Lags of RER Misalignment      | 0.000718              |
| Lags of Trade Balance (% GDP) | 0.00249               |
| Lags of ToT                   | 0.0232                |
| Pseudo R2                     | 0.400                 |

Robust standard errors in parentheses

\*\*\* p&lt;0.01, \*\* p&lt;0.05, \* p&lt;0.1

Table 16: Overvaluation - General

| VARIABLES                     | (1)<br>Episode       | (2)<br>Episode       |
|-------------------------------|----------------------|----------------------|
| lag4y                         | 0.521<br>(0.565)     |                      |
| lag3y                         | 0.246<br>(0.866)     |                      |
| lag2y                         | -1.344*<br>(0.776)   |                      |
| lag1y                         | 0.583<br>(0.532)     |                      |
| lag1Mis                       | -0.950***<br>(0.362) | -0.871**<br>(0.363)  |
| lag2Mis                       | 0.706*<br>(0.378)    | 0.590*<br>(0.354)    |
| lag3Mis                       | -0.132<br>(0.230)    | -0.160<br>(0.218)    |
| lag4Mis                       | 0.725***<br>(0.200)  | 0.799***<br>(0.191)  |
| lag1TB_share                  | -0.028<br>(0.128)    | -0.046<br>(0.129)    |
| lag2TB_share                  | -0.110<br>(0.135)    | -0.104<br>(0.135)    |
| lag3TB_share                  | -0.013<br>(0.147)    | 0.004<br>(0.147)     |
| lag4TB_share                  | -0.344**<br>(0.157)  | -0.356**<br>(0.158)  |
| cap_cont_index                | -0.358***<br>(0.078) | -0.349***<br>(0.076) |
| lag4tot                       | -0.924**<br>(0.375)  | -0.901**<br>(0.373)  |
| lag3tot                       | 0.829<br>(0.544)     | 0.831<br>(0.537)     |
| lag2tot                       | 0.731<br>(0.591)     | 0.697<br>(0.588)     |
| lag1tot                       | -0.743<br>(0.476)    | -0.745<br>(0.479)    |
| Constant                      | -1.637***<br>(0.337) | -1.627***<br>(0.197) |
| Observations                  | 3,590                | 3,590                |
| Lags of GDP                   | 0.221                |                      |
| Lags of RER Misalignment      | 7.73e-08             | 1.58e-08             |
| Lags of Trade Balance (% GDP) | 0.000175             | 1.20e-05             |
| Lags of ToT                   | 0.0398               | 0.0434               |
| Pseudo R2                     | 0.137                | 0.135                |

Robust standard errors in parentheses

\*\*\* p&lt;0.01, \*\* p&lt;0.05, \* p&lt;0.1

Table 17: Overvaluation - low-income countries

| VARIABLES                     | (1)<br>treat1        |
|-------------------------------|----------------------|
| lag4y                         | 1.589**<br>(0.671)   |
| lag3y                         | -0.817<br>(1.072)    |
| lag2y                         | -1.092<br>(1.646)    |
| lag1y                         | -0.173<br>(1.091)    |
| lag1Mis                       | -1.769***<br>(0.551) |
| lag2Mis                       | 1.592***<br>(0.505)  |
| lag3Mis                       | -0.006<br>(0.389)    |
| lag4Mis                       | 0.979**<br>(0.402)   |
| lag1TB_share                  | -0.398<br>(0.711)    |
| lag2TB_share                  | 0.312<br>(0.729)     |
| lag3TB_share                  | 0.473<br>(0.551)     |
| lag4TB_share                  | -0.558***<br>(0.110) |
| cap_cont_index                | -0.374***<br>(0.127) |
| lag4tot                       | -0.566<br>(0.494)    |
| lag3tot                       | -0.139<br>(0.800)    |
| lag2tot                       | 2.314***<br>(0.803)  |
| lag1tot                       | -1.785***<br>(0.608) |
| Constant                      | 1.352**<br>(0.625)   |
| Observations                  | 1,775                |
| Lags of GDP                   | 2.25e-10             |
| Lags of RER Misalignment      | 9.31e-11             |
| Lags of Trade Balance (% GDP) | 2.44e-07             |
| Lags of ToT                   | 0.0144               |
| Pseudo R2                     | 0.185                |

Robust standard errors in parentheses

\*\*\* p&lt;0.01, \*\* p&lt;0.05, \* p&lt;0.1

Table 18: Overvaluation - Middle-income countries

| VARIABLES                     | (1)<br>treat3        | (2)<br>treat3        | (3)<br>treat3        |
|-------------------------------|----------------------|----------------------|----------------------|
| lag4y                         | -1.598**<br>(0.792)  | -1.626**<br>(0.759)  | -1.633**<br>(0.743)  |
| lag3y                         | 2.229*<br>(1.213)    | 2.280**<br>(1.136)   | 2.251**<br>(1.122)   |
| lag2y                         | -1.556<br>(0.986)    | -1.574<br>(0.993)    | -1.580<br>(0.979)    |
| lag1y                         | 1.067<br>(0.775)     | 1.060<br>(0.766)     | 1.108<br>(0.748)     |
| lag1Mis                       | -0.432<br>(0.336)    | -0.450<br>(0.345)    | -0.460<br>(0.337)    |
| lag2Mis                       | 0.479<br>(0.424)     | 0.508<br>(0.419)     | 0.512<br>(0.416)     |
| lag3Mis                       | -0.166<br>(0.267)    | -0.183<br>(0.268)    | -0.187<br>(0.270)    |
| lag4Mis                       | 0.510***<br>(0.176)  | 0.518***<br>(0.181)  | 0.513***<br>(0.181)  |
| lag1TB_share                  | 1.397*<br>(0.751)    | 1.429*<br>(0.740)    | 1.520**<br>(0.744)   |
| lag2TB_share                  | -1.104<br>(0.967)    | -1.059<br>(0.919)    | -1.064<br>(0.914)    |
| lag3TB_share                  | -2.164**<br>(0.965)  | -2.429**<br>(0.994)  | -2.416**<br>(1.005)  |
| lag4TB_share                  | 1.500<br>(0.995)     | 1.711*<br>(0.979)    | 1.644*<br>(0.985)    |
| cap_cont_index                | -0.092<br>(0.121)    | -0.080<br>(0.124)    |                      |
| lag4tot                       | -0.581<br>(0.613)    |                      |                      |
| lag3tot                       | 0.890<br>(0.632)     |                      |                      |
| lag2tot                       | -0.946<br>(0.818)    |                      |                      |
| lag1tot                       | 0.633<br>(0.705)     |                      |                      |
| Constant                      | -3.167***<br>(0.780) | -3.155***<br>(0.772) | -3.240***<br>(0.762) |
| Observations                  | 1,815                | 1,815                | 1,835                |
| Lags of GDP                   | 0.0769               | 0.0657               | 0.0446               |
| Lags of RER Misalignment      | 0.00303              | 0.00226              | 0.00223              |
| Lags of Trade Balance (% GDP) | 0.00648              | 0.00515              | 0.00573              |
| Lags of ToT                   | 0.525                |                      |                      |
| Pseudo R2                     | 0.114                | 0.111                | 0.109                |

Robust standard errors in parentheses

\*\*\* p&lt;0.01, \*\* p&lt;0.05, \* p&lt;0.1

Table 19: Overvaluation - High-income countries

| VARIABLES                     | (1)<br>treat4         | (2)<br>treat4         |
|-------------------------------|-----------------------|-----------------------|
| lag4y                         | 7.677**<br>(3.426)    | 7.803**<br>(3.512)    |
| lag3y                         | -3.930<br>(4.302)     | -4.332<br>(4.456)     |
| lag2y                         | -15.515***<br>(4.123) | -15.136***<br>(4.200) |
| lag1y                         | 13.433***<br>(3.390)  | 13.320***<br>(3.475)  |
| lag1Mis                       | -4.337***<br>(1.485)  | -4.422***<br>(1.418)  |
| lag2Mis                       | 6.176**<br>(2.481)    | 5.852**<br>(2.437)    |
| lag3Mis                       | -2.920<br>(2.026)     | -2.841<br>(2.158)     |
| lag4Mis                       | 0.631<br>(1.495)      | 0.967<br>(1.364)      |
| lag1TB_share                  | -3.293<br>(7.383)     | -2.618<br>(7.328)     |
| lag2TB_share                  | -10.227<br>(6.468)    | -11.134*<br>(6.383)   |
| lag3TB_share                  | -1.317<br>(8.048)     | -2.766<br>(7.428)     |
| lag4TB_share                  | 9.669<br>(7.402)      | 11.331<br>(6.976)     |
| cap_cont_index                | -0.510*<br>(0.270)    | -0.551*<br>(0.285)    |
| lag4tot                       | -3.347<br>(2.322)     |                       |
| lag3tot                       | 2.553<br>(3.423)      |                       |
| lag2tot                       | 0.916<br>(4.362)      |                       |
| lag1tot                       | -0.212<br>(2.072)     |                       |
| Constant                      | -19.081***<br>(4.272) | -19.027***<br>(4.200) |
| Observations                  | 464                   | 464                   |
| Lags of GDP                   | 4.58e-07              | 4.61e-07              |
| Lags of RER Misalignment      | 0.00550               | 0.00131               |
| Lags of Trade Balance (% GDP) | 0.0225                | 0.0150                |
| Lags of ToT                   | 0.659                 |                       |
| Pseudo R2                     | 0.312                 | 0.308                 |

Robust standard errors in parentheses

\*\*\* p&lt;0.01, \*\* p&lt;0.05, \* p&lt;0.1

## Pre-treatment trends - finding an appropriate number of lags to control for

Tables ??-?? reports within estimates of the effect of lagged variables of interest on episodes. In each column we add a different number of lags of the variable of interest - 2, 4, 6, and 8 lags. Below each model we report the p-value for three tests of joint significance: i) of the first two lags; ii) of the first 4 lags; iii) and the p-value of the additional lags. In all specifications we include a full set of country and year fixed effects. Standard errors robust against heteroskedasticity and serial correlation at the country level are in parentheses.

That is, we estimate models with episodes (of under or overvaluation) as dependent variable on different lags of log of GDP or log of capital stock, our main variables, as explanatory variables. These models test whether, once we control for a given number of lags (as well as country and year fixed affects), an episode is (conditionally) uncorrelated with past dynamics of the variable of interest.

As shown by the p-values reported at the bottom rows, for undervaluation episodes, the first four lags of the variable of interest are jointly significant predictors of a contemporary episode and deeper lags are non-significant. That is, after controlling for these lags, the correlation between episodes and transitory movements in the variables of interest disappears. On top of that, the idea that 4 lags are sufficient is strengthened by the results of the correlation of the residuals with episodes indicated in our liner estimations (tables 2 and 3).

In the case of overvaluation, the result indicates no correlation between the past dynamics of the variables and episodes. However, given the indications of correlations on the residuals in our linear estimation (table 3), we opted to also control for four lags.

Table 20: Undervaluation - GDP

| VARIABLES                    | (1)<br>Episode    | (2)<br>Episode       | (3)<br>Episode      | (4)<br>Episode      | (5)<br>Episode      |
|------------------------------|-------------------|----------------------|---------------------|---------------------|---------------------|
| L.y                          | -0.007<br>(0.007) | -0.097***<br>(0.036) | -0.113**<br>(0.045) | -0.130**<br>(0.051) | -0.128**<br>(0.053) |
| L2.y                         |                   | 0.091**<br>(0.038)   | 0.097<br>(0.063)    | 0.090<br>(0.070)    | 0.062<br>(0.071)    |
| L3.y                         |                   |                      | 0.039<br>(0.062)    | 0.057<br>(0.069)    | 0.079<br>(0.074)    |
| L4.y                         |                   |                      | -0.030<br>(0.043)   | -0.028<br>(0.066)   | -0.046<br>(0.073)   |
| L5.y                         |                   |                      |                     | 0.022<br>(0.061)    | 0.024<br>(0.066)    |
| L6.y                         |                   |                      |                     | -0.019<br>(0.040)   | -0.014<br>(0.057)   |
| L7.y                         |                   |                      |                     |                     | -0.043<br>(0.070)   |
| L8.y                         |                   |                      |                     |                     | 0.055<br>(0.050)    |
| Constant                     | 0.070<br>(0.063)  | 0.059<br>(0.065)     | 0.067<br>(0.071)    | 0.081<br>(0.078)    | 0.099<br>(0.083)    |
| Observations                 | 6,039             | 5,915                | 5,667               | 5,419               | 5,171               |
| R-squared                    | 0.045             | 0.046                | 0.046               | 0.046               | 0.050               |
| Number of id                 | 124               | 124                  | 124                 | 124                 | 124                 |
| p-value for the first 2 lags |                   | 0.0170               | 0.0238              | 0.0170              | 0.0141              |
| p-value for the first 4 lags |                   |                      | 0.0743              | 0.0540              | 0.0437              |
| p-value for additional lags  |                   |                      |                     | 0.894               | 0.712               |

Robust standard errors in parentheses

\*\*\* p&lt;0.01, \*\* p&lt;0.05, \* p&lt;0.1

Table 21: Undervaluation - Capital Stock

| VARIABLES                    | (1)<br>Episode       | (2)<br>Episode       | (3)<br>Episode      | (4)<br>Episode      | (5)<br>Episode      |
|------------------------------|----------------------|----------------------|---------------------|---------------------|---------------------|
| L.K                          | -0.013***<br>(0.005) | -0.270***<br>(0.085) | -0.265*<br>(0.156)  | -0.306*<br>(0.173)  | -0.259<br>(0.180)   |
| L2.K                         |                      | 0.257***<br>(0.086)  | -0.047<br>(0.339)   | -0.017<br>(0.378)   | -0.185<br>(0.415)   |
| L3.K                         |                      |                      | 0.565<br>(0.349)    | 0.547<br>(0.441)    | 0.746<br>(0.499)    |
| L4.K                         |                      |                      | -0.271<br>(0.164)   | -0.259<br>(0.437)   | -0.333<br>(0.481)   |
| L5.K                         |                      |                      |                     | 0.094<br>(0.375)    | 0.142<br>(0.453)    |
| L6.K                         |                      |                      |                     | -0.079<br>(0.158)   | -0.530<br>(0.439)   |
| L7.K                         |                      |                      |                     |                     | 0.764*<br>(0.452)   |
| L8.K                         |                      |                      |                     |                     | -0.372*<br>(0.224)  |
| Constant                     | 0.181***<br>(0.067)  | 0.186***<br>(0.070)  | 0.240***<br>(0.078) | 0.292***<br>(0.087) | 0.369***<br>(0.093) |
| Observations                 | 6,039                | 5,915                | 5,667               | 5,419               | 5,171               |
| R-squared                    | 0.046                | 0.047                | 0.048               | 0.048               | 0.053               |
| Number of id                 | 124                  | 124                  | 124                 | 124                 | 124                 |
| p-value for the first 2 lags |                      | 9.84e-05             | 0.000586            | 0.000513            | 0.000705            |
| p-value for the first 4 lags |                      |                      | 6.44e-05            | 0.00131             | 0.00246             |
| p-value for additional lags  |                      |                      |                     | 0.843               | 0.557               |

Robust standard errors in parentheses

\*\*\* p&lt;0.01, \*\* p&lt;0.05, \* p&lt;0.1

Table 22: Overvaluation - GDP

| VARIABLES                    | (1)<br>Episode    | (2)<br>Episode    | (3)<br>Episode    | (4)<br>Episode     | (5)<br>Episode     |
|------------------------------|-------------------|-------------------|-------------------|--------------------|--------------------|
| L.y                          | -0.004<br>(0.006) | 0.056<br>(0.046)  | 0.051<br>(0.049)  | 0.043<br>(0.054)   | 0.050<br>(0.059)   |
| L2.y                         |                   | -0.059<br>(0.046) | -0.106<br>(0.077) | -0.141<br>(0.089)  | -0.137<br>(0.093)  |
| L3.y                         |                   |                   | 0.026<br>(0.072)  | 0.037<br>(0.084)   | 0.051<br>(0.093)   |
| L4.y                         |                   |                   | 0.030<br>(0.052)  | 0.079<br>(0.086)   | 0.076<br>(0.092)   |
| L5.y                         |                   |                   |                   | 0.062<br>(0.070)   | 0.095<br>(0.077)   |
| L6.y                         |                   |                   |                   | -0.080*<br>(0.047) | -0.146*<br>(0.082) |
| L7.y                         |                   |                   |                   |                    | -0.072<br>(0.089)  |
| L8.y                         |                   |                   |                   |                    | 0.090<br>(0.065)   |
| Constant                     | 0.028<br>(0.057)  | 0.022<br>(0.060)  | -0.009<br>(0.066) | -0.014<br>(0.076)  | -0.068<br>(0.088)  |
| Observations                 | 5,787             | 5,663             | 5,415             | 5,167              | 4,919              |
| R-squared                    | 0.073             | 0.073             | 0.073             | 0.074              | 0.078              |
| Number of id                 | 124               | 124               | 124               | 124                | 124                |
| p-value for the first 2 lags |                   | 0.420             | 0.386             | 0.224              | 0.312              |
| p-value for the first 4 lags |                   |                   | 0.569             | 0.345              | 0.417              |
| p-value for additional lags  |                   |                   |                   | 0.215              | 0.0830             |

Robust standard errors in parentheses

\*\*\* p&lt;0.01, \*\* p&lt;0.05, \* p&lt;0.1

Table 23: Overvaluation - Capital Stock

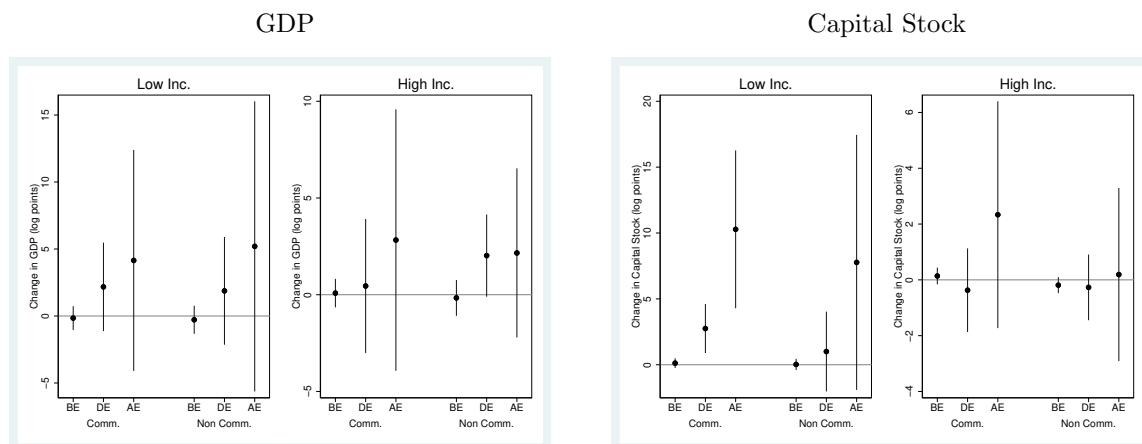
| VARIABLES                    | (1)<br>Episode    | (2)<br>Episode    | (3)<br>Episode    | (4)<br>Episode    | (5)<br>Episode       |
|------------------------------|-------------------|-------------------|-------------------|-------------------|----------------------|
| L.K                          | 0.002<br>(0.005)  | 0.132<br>(0.094)  | 0.244<br>(0.187)  | 0.247<br>(0.206)  | 0.223<br>(0.203)     |
| L2.K                         |                   | -0.129<br>(0.095) | -0.250<br>(0.369) | -0.263<br>(0.411) | -0.140<br>(0.416)    |
| L3.K                         |                   |                   | -0.109<br>(0.407) | -0.255<br>(0.534) | -0.177<br>(0.478)    |
| L4.K                         |                   |                   | 0.121<br>(0.209)  | 0.564<br>(0.664)  | 0.183<br>(0.513)     |
| L5.K                         |                   |                   |                   | -0.395<br>(0.553) | 0.446<br>(0.526)     |
| L6.K                         |                   |                   |                   | 0.111<br>(0.216)  | -1.055*<br>(0.582)   |
| L7.K                         |                   |                   |                   |                   | 0.377<br>(0.503)     |
| L8.K                         |                   |                   |                   |                   | 0.167<br>(0.220)     |
| Constant                     | -0.039<br>(0.068) | -0.048<br>(0.072) | -0.098<br>(0.083) | -0.137<br>(0.098) | -0.345***<br>(0.112) |
| Observations                 | 5,787             | 5,663             | 5,415             | 5,167             | 4,919                |
| R-squared                    | 0.073             | 0.073             | 0.073             | 0.073             | 0.079                |
| Number of id                 | 124               | 124               | 124               | 124               | 124                  |
| p-value for the first 2 lags |                   | 0.296             | 0.328             | 0.384             | 0.290                |
| p-value for the first 4 lags |                   |                   | 0.458             | 0.584             | 0.394                |
| p-value for additional lags  |                   |                   |                   | 0.763             | 0.0820               |

Robust standard errors in parentheses

\*\*\* p&lt;0.01, \*\* p&lt;0.05, \* p&lt;0.1

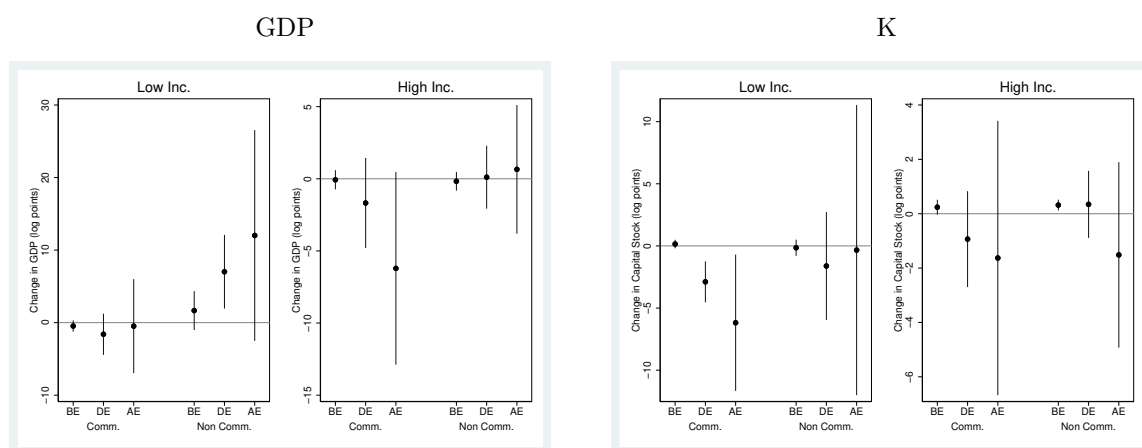
## C Commodity exporters - Stacked data

Figure 16: Local projections with stacked data of the effects over time of real exchange rate undervaluation - average effect by type of exports and income group



*Note:* BE = Before Episode (time -7 to -1); DE= During Episode (time 0 to 6); AE= After episode (time 7 to 13). The dot is the estimated coefficient and the lines indicate the 90% confidence interval.

Figure 17: Local projections with stacked data of the effects over time of real exchange rate overvaluation - by type of exports and income group



*Note:* BE = Before Episode (time -7 to -1); DE= During Episode (time 0 to 6); AE= After episode (time 7 to 13). The dot is the estimated coefficient and the lines indicate the 90% confidence interval.

## D size

Regression (1) is a simple regression with all the episodes; (2) considers only the episodes that are statistically significant at 10% and (3) those significant at 5%; regression (4) considers only the undervaluation cases and (5), only overvaluation ones.

Table 24: Effects of the size of misalignment change on GDP

|  | (1)             | (2)              | (3)              | (4)             | (5)               |
|--|-----------------|------------------|------------------|-----------------|-------------------|
| <i>Panel A: Without Quadratic Effect</i> |                 |                  |                  |                 |                   |
| Mis                                      | 0.93<br>(0.68)  | 1.46<br>(1.87)   | 0.90<br>(2.00)   | -0.49<br>(1.09) | 2.28<br>(3.02)    |
| R-squared                                | 0.01            | 0.01             | 0.00             | 0.00            | 0.00              |
| <i>Panel B: With Quadratic Effect</i>    |                 |                  |                  |                 |                   |
| Mis                                      | 1.78+<br>(1.01) | 4.64*<br>(2.31)  | 4.21<br>(2.67)   | 0.97<br>(2.89)  | -10.63<br>(10.82) |
| Mis-squared                              | -1.60<br>(1.09) | -7.07*<br>(3.13) | -6.43+<br>(3.48) | -1.08<br>(1.98) | -24.40<br>(19.62) |
| R-squared                                | 0.01            | 0.05             | 0.04             | 0.00            | 0.01              |

Note: + indicates statistical significant at 10% and \* at 5%.

Table 25: Effects of the size of misalignment change on Capital Stock

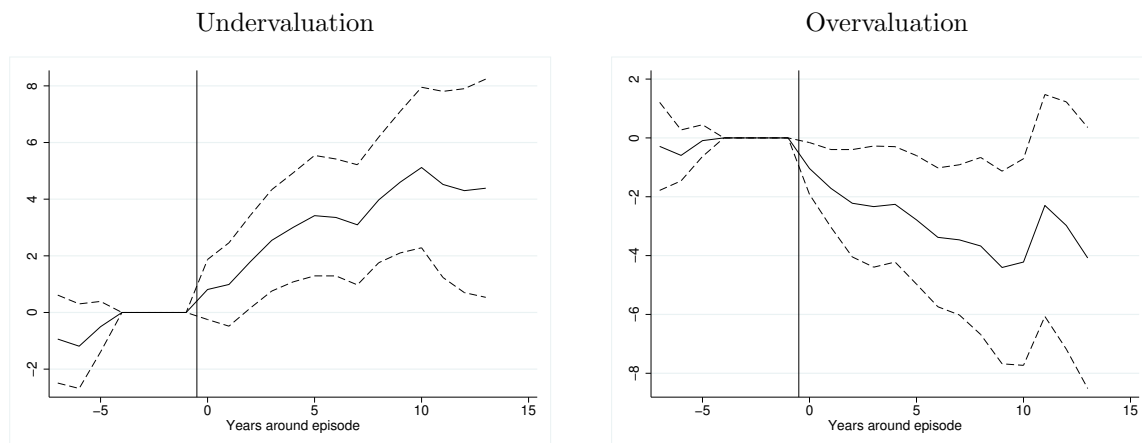
|  | (1)              | (2)              | (3)              | (4)              | (5)             |
|--|------------------|------------------|------------------|------------------|-----------------|
| <i>Panel A: Without Quadratic Effect</i> |                  |                  |                  |                  |                 |
| Mis                                      | 0.32+<br>(0.17)  | 0.87+<br>(0.46)  | 1.03+<br>(0.54)  | -0.51+<br>(0.28) | 0.09<br>(0.80)  |
| R-squared                                | 0.01             | 0.03             | 0.03             | 0.02             | 0.00            |
| <i>Panel B: With Quadratic Effect</i>    |                  |                  |                  |                  |                 |
| Mis                                      | 0.68*<br>(0.22)  | 1.78*<br>(0.59)  | 2.01*<br>(0.69)  | -0.56<br>(0.74)  | -0.01<br>(2.86) |
| Mis-squared                              | -0.67*<br>(0.22) | -2.37*<br>(0.99) | -2.51*<br>(1.12) | 0.04<br>(0.51)   | -0.18<br>(5.19) |
| R-squared                                | 0.03             | 0.07             | 0.08             | 0.02             | 0.00            |

Note: + indicates statistical significant at 10% and \* at 5%.

## E Alternative criteria

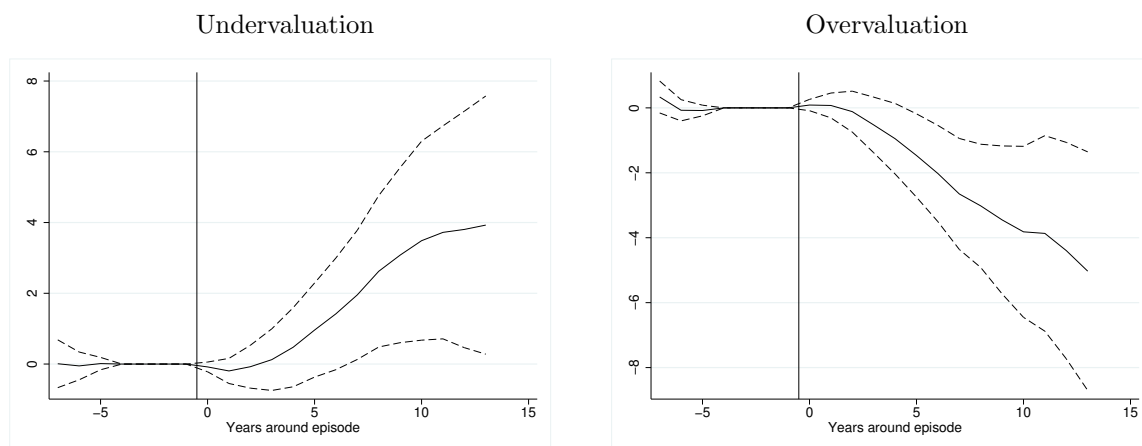
### Less strict misalignment criteria

Figure 18: Semiparametric estimates of the effects over time of real exchange rate misalignment on the log of GDP.



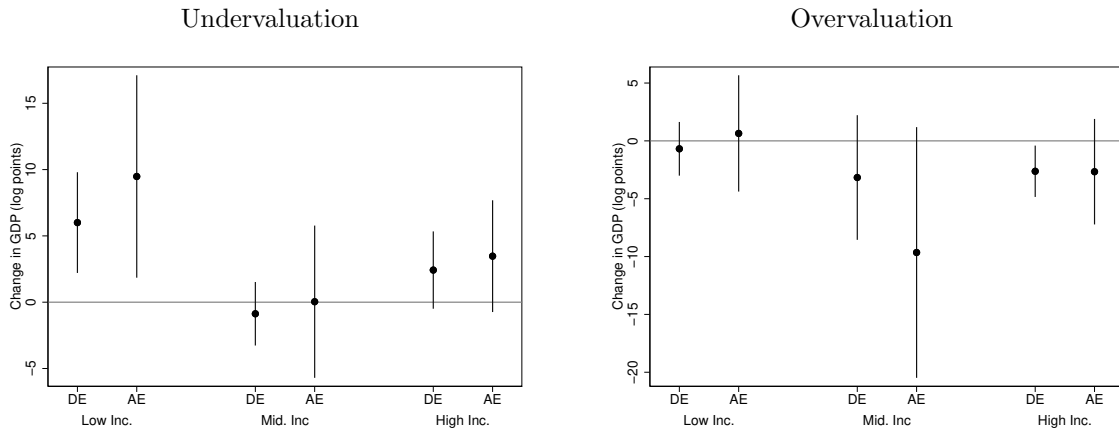
*Note:* The solid line plots the estimated average effect on log GDP *per capita* on countries that had an undervaluation episode, with a 90 percent confidence interval in black dashed lines. Time (in years) relative to the year of the episode.

Figure 19: Semiparametric estimates of the effects over time of real exchange rate misalignment on the log of capital stock.



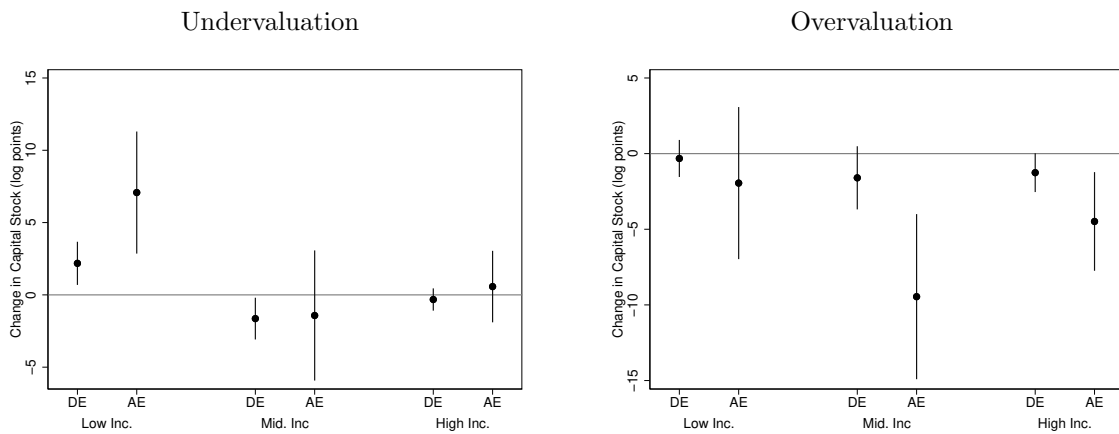
*Note:* The solid line plots the estimated average effect on log GDP *per capita* on countries that had an undervaluation episode, with a 90 percent confidence interval in black dashed lines. Time (in years) relative to the year of the episode.

Figure 20: Semiparametric estimates of the effects over time of real exchange rate misalignment on the log of GDP - average effect by income group



Note: BE = Before Episode (time -7 to -1); DE= During Episode (time 0 to 6); AE= After episode (time 7 to 13). The dot is the estimated coefficient and the lines indicate the 90% confidence interval.

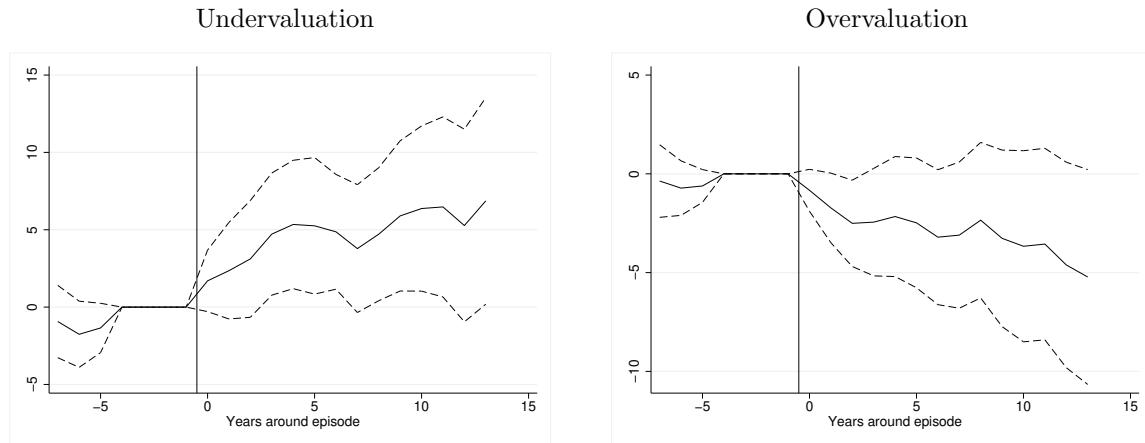
Figure 21: Semiparametric estimates of the effects over time of real exchange rate misalignment on the log of capital - average effect by income group



Note: BE = Before Episode (time -7 to -1); DE= During Episode (time 0 to 6); AE= After episode (time 7 to 13). The dot is the estimated coefficient and the lines indicate the 90% confidence interval.

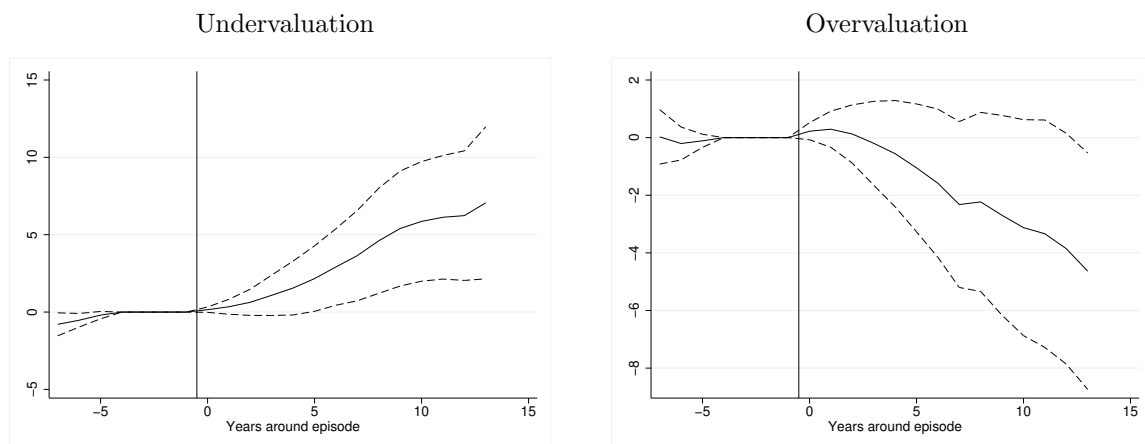
## Stricter misalignment criteria

Figure 22: Semiparametric estimates of the effects over time of real exchange rate misalignment on the log of GDP.



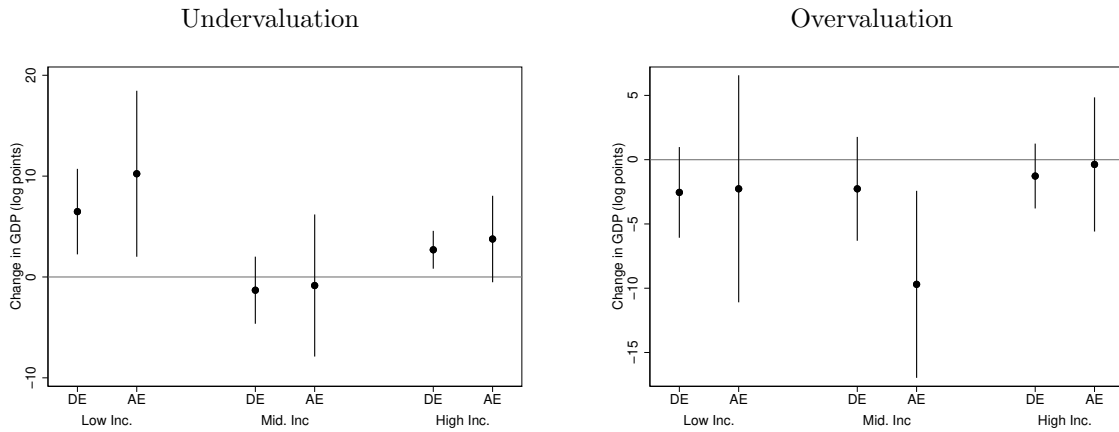
*Note:* The solid line plots the estimated average effect on log GDP *per capita* on countries that had an undervaluation episode, with a 90 percent confidence interval in black dashed lines. Time (in years) relative to the year of the episode.

Figure 23: Semiparametric estimates of the effects over time of real exchange rate misalignment on the log of capital stock.



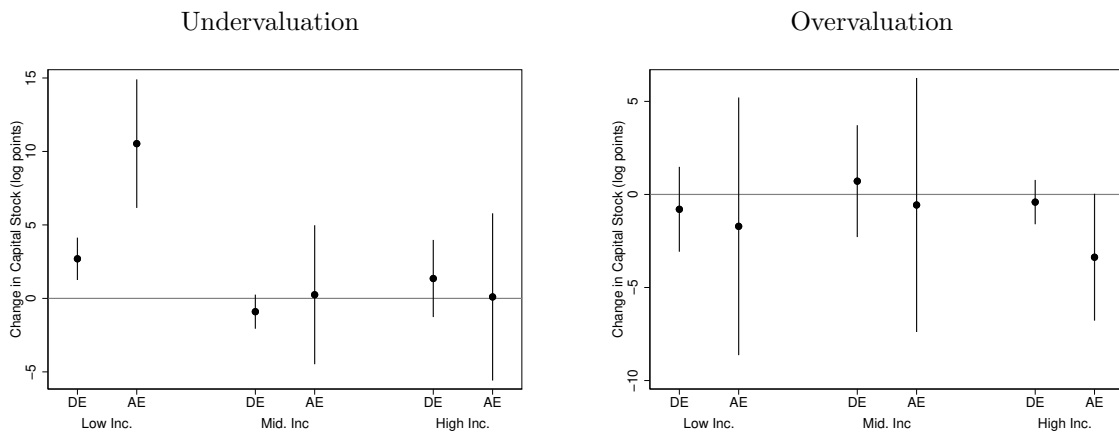
*Note:* The solid line plots the estimated average effect on log GDP *per capita* on countries that had an undervaluation episode, with a 90 percent confidence interval in black dashed lines. Time (in years) relative to the year of the episode.

Figure 24: Semiparametric estimates of the effects over time of real exchange rate misalignment on the log of GDP - average effect by income group



Note: BE = Before Episode (time -7 to -1); DE= During Episode (time 0 to 6); AE= After episode (time 7 to 13). The dot is the estimated coefficient and the lines indicate the 90% confidence interval.

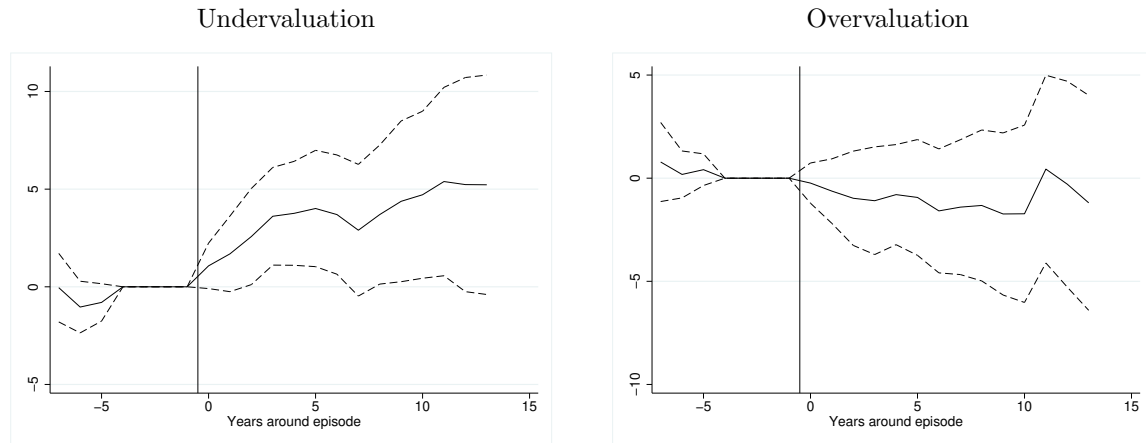
Figure 25: Semiparametric estimates of the effects over time of real exchange rate misalignment on the log of capital - average effect by income group



Note: BE = Before Episode (time -7 to -1); DE= During Episode (time 0 to 6); AE= After episode (time 7 to 13). The dot is the estimated coefficient and the lines indicate the 90% confidence interval.

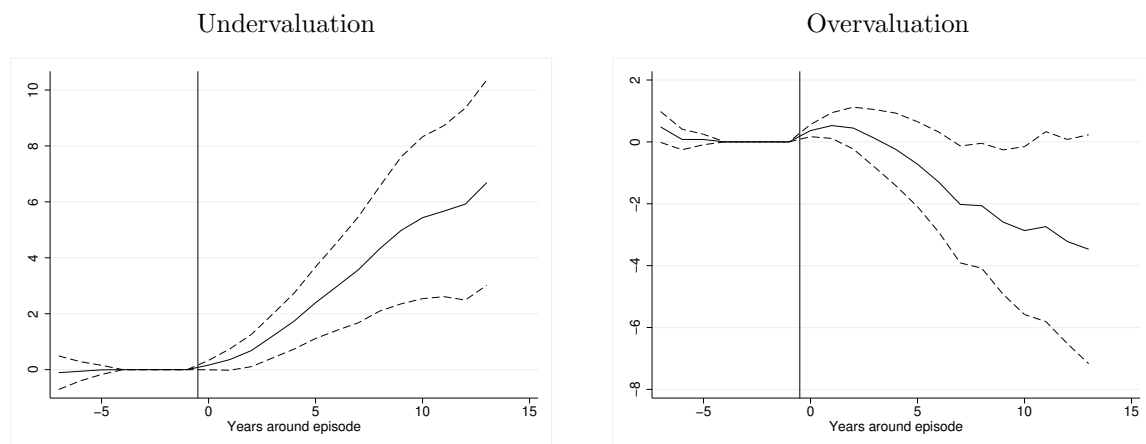
## Less strict volatility criteria

Figure 26: Semiparametric estimates of the effects over time of real exchange rate misalignment on the log of GDP.



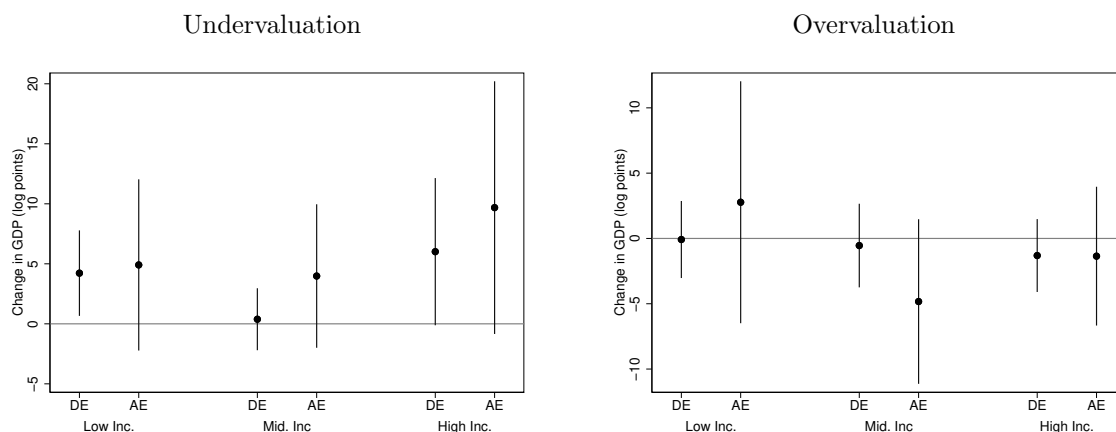
*Note:* The solid line plots the estimated average effect on log GDP *per capita* on countries that had an undervaluation episode, with a 90 percent confidence interval in black dashed lines. Time (in years) relative to the year of the episode.

Figure 27: Semiparametric estimates of the effects over time of real exchange rate misalignment on the log of capital stock.



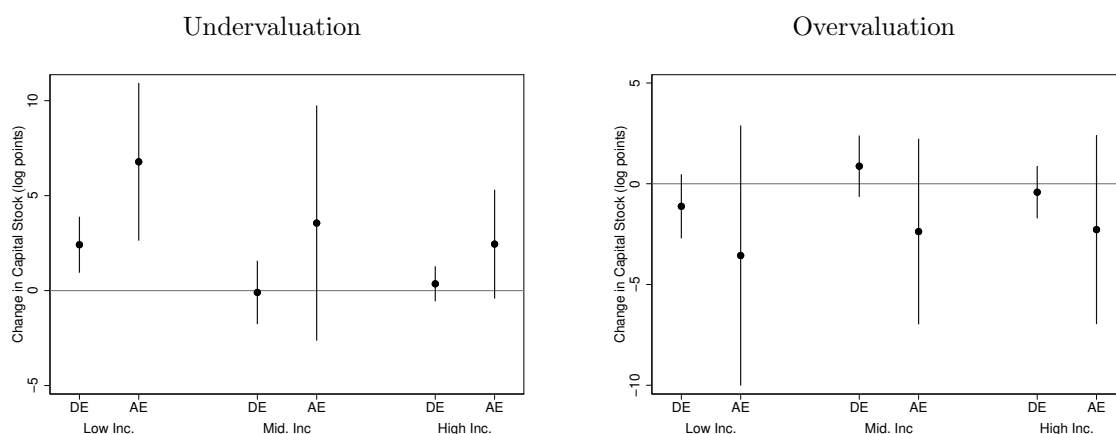
*Note:* The solid line plots the estimated average effect on log GDP *per capita* on countries that had an undervaluation episode, with a 90 percent confidence interval in black dashed lines. Time (in years) relative to the year of the episode.

Figure 28: Semiparametric estimates of the effects over time of real exchange rate misalignment on the log of GDP - average effect by income group



Note: BE = Before Episode (time -7 to -1); DE= During Episode (time 0 to 6); AE= After episode (time 7 to 13). The dot is the estimated coefficient and the lines indicate the 90% confidence interval.

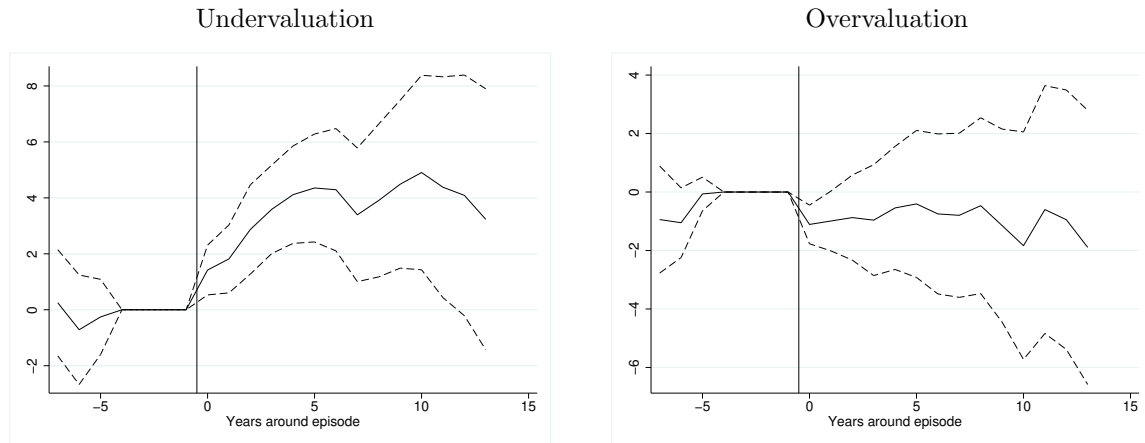
Figure 29: Semiparametric estimates of the effects over time of real exchange rate misalignment on the log of capital - average effect by income group



Note: BE = Before Episode (time -7 to -1); DE= During Episode (time 0 to 6); AE= After episode (time 7 to 13). The dot is the estimated coefficient and the lines indicate the 90% confidence interval.

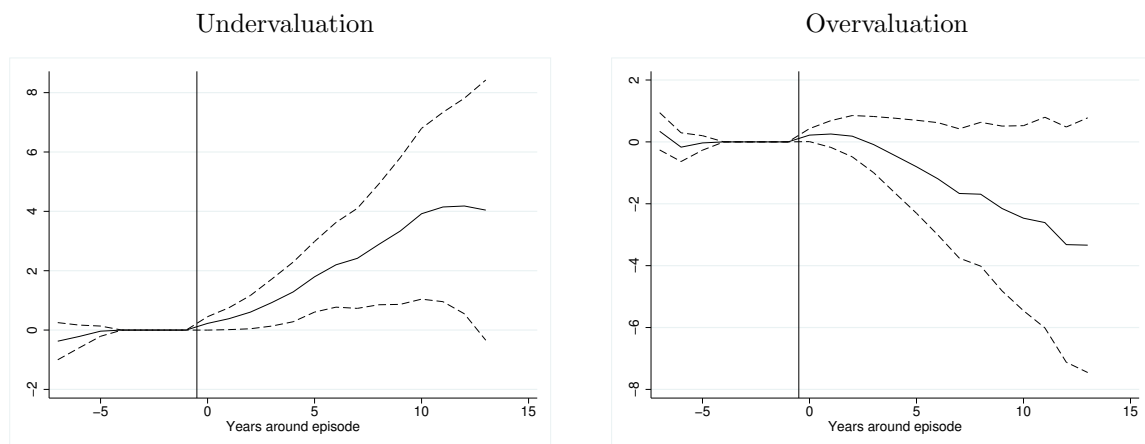
## Stricter volatility criteria

Figure 30: Semiparametric estimates of the effects over time of real exchange rate misalignment on the log of GDP.



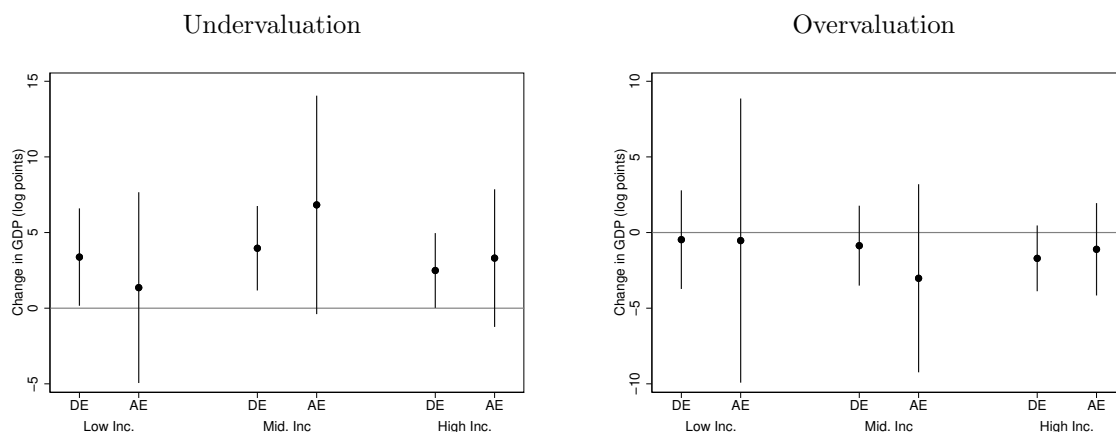
*Note:* The solid line plots the estimated average effect on log GDP *per capita* on countries that had an undervaluation episode, with a 90 percent confidence interval in black dashed lines. Time (in years) relative to the year of the episode.

Figure 31: Semiparametric estimates of the effects over time of real exchange rate misalignment on the log of capital stock.



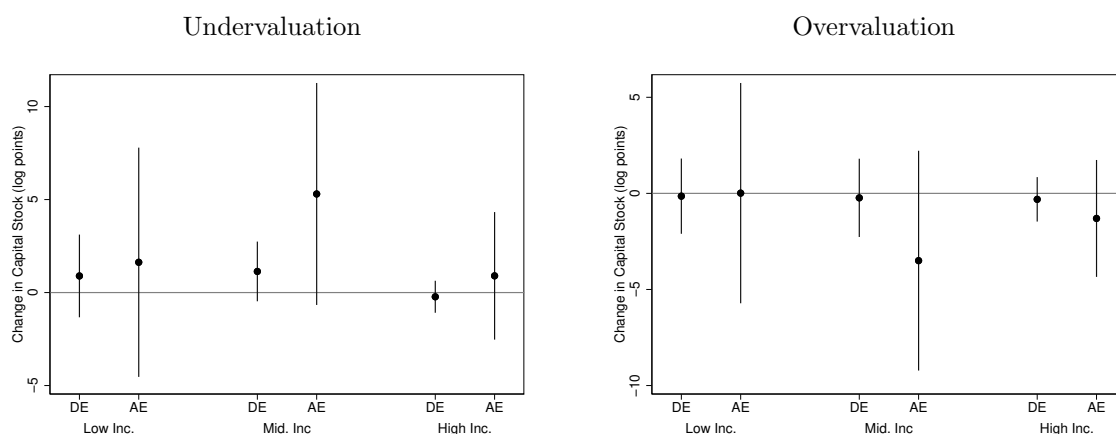
*Note:* The solid line plots the estimated average effect on log GDP *per capita* on countries that had an undervaluation episode, with a 90 percent confidence interval in black dashed lines. Time (in years) relative to the year of the episode.

Figure 32: Semiparametric estimates of the effects over time of real exchange rate misalignment on the log of GDP - average effect by income group



Note: BE = Before Episode (time -7 to -1); DE= During Episode (time 0 to 6); AE= After episode (time 7 to 13). The dot is the estimated coefficient and the lines indicate the 90% confidence interval.

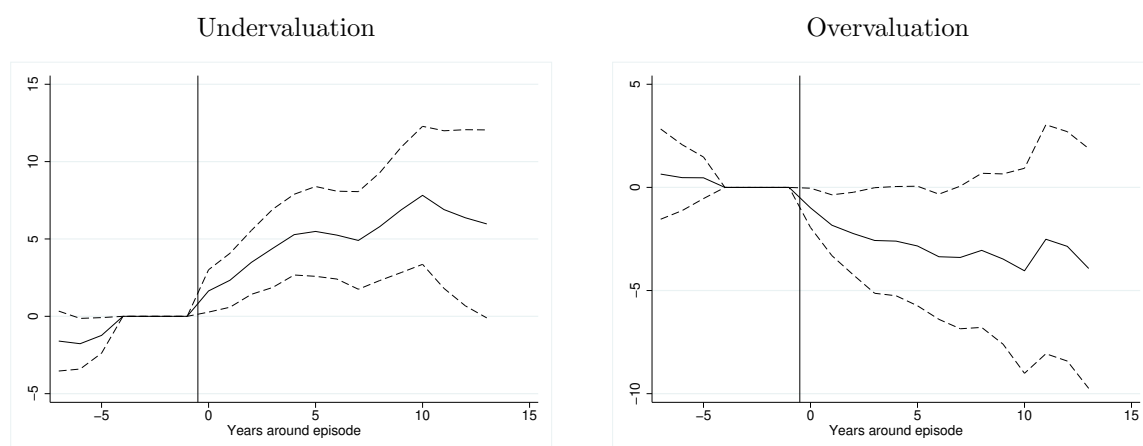
Figure 33: Semiparametric estimates of the effects over time of real exchange rate misalignment on the log of capital - average effect by income group



Note: BE = Before Episode (time -7 to -1); DE= During Episode (time 0 to 6); AE= After episode (time 7 to 13). The dot is the estimated coefficient and the lines indicate the 90% confidence interval.

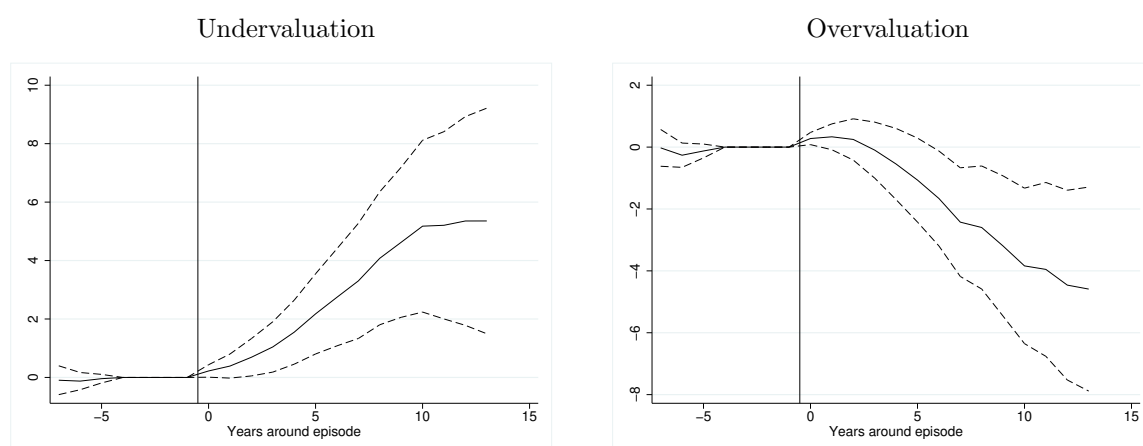
With a 25% standard deviation stricter only:

Figure 34: Semiparametric estimates of the effects over time of real exchange rate misalignment on the log of GDP.



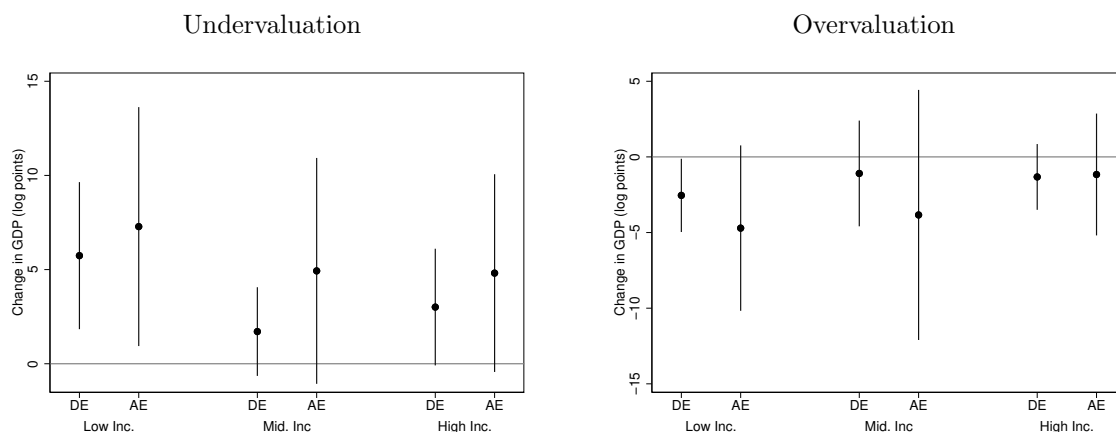
Note: The solid line plots the estimated average effect on log GDP *per capita* on countries that had an undervaluation episode, with a 90 percent confidence interval in black dashed lines. Time (in years) relative to the year of the episode.

Figure 35: Semiparametric estimates of the effects over time of real exchange rate misalignment on the log of capital stock.



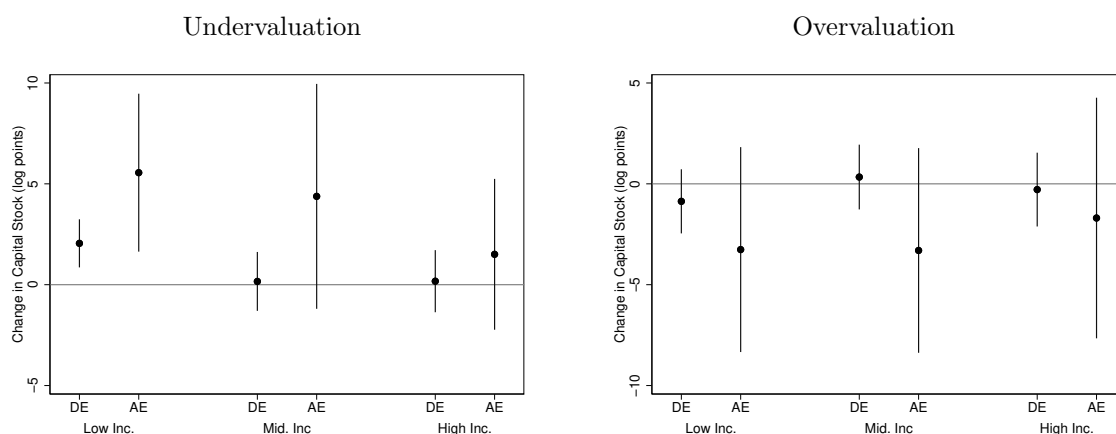
Note: The solid line plots the estimated average effect on log GDP *per capita* on countries that had an undervaluation episode, with a 90 percent confidence interval in black dashed lines. Time (in years) relative to the year of the episode.

Figure 36: Semiparametric estimates of the effects over time of real exchange rate misalignment on the log of GDP - average effect by income group



Note: BE = Before Episode (time -7 to -1); DE= During Episode (time 0 to 6); AE= After episode (time 7 to 13). The dot is the estimated coefficient and the lines indicate the 90% confidence interval.

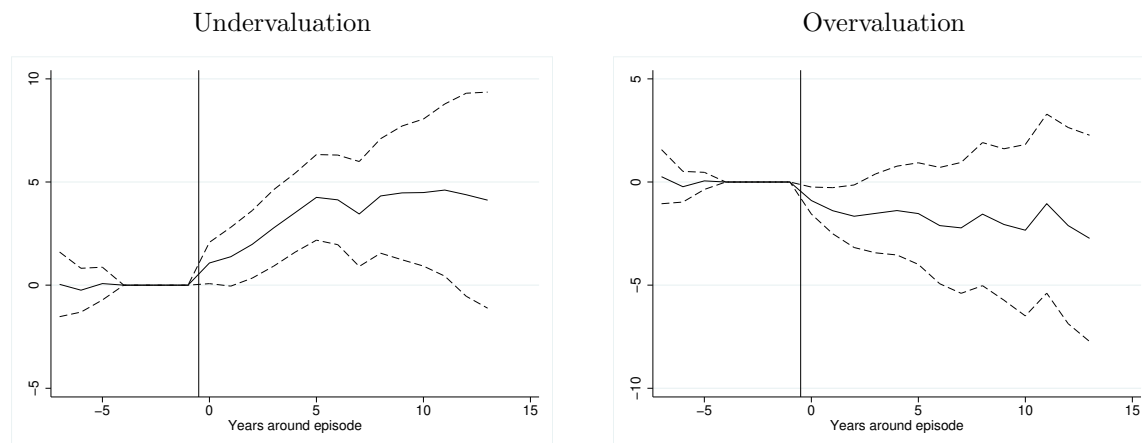
Figure 37: Semiparametric estimates of the effects over time of real exchange rate misalignment on the log of capital - average effect by income group



Note: BE = Before Episode (time -7 to -1); DE= During Episode (time 0 to 6); AE= After episode (time 7 to 13). The dot is the estimated coefficient and the lines indicate the 90% confidence interval.

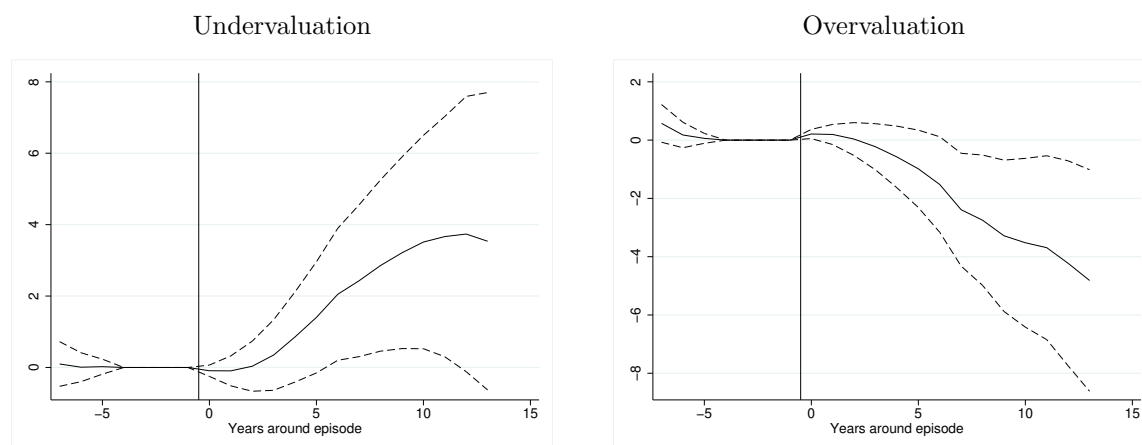
## F Smaller time windows

Figure 38: Semiparametric estimates of the effects over time of real exchange rate misalignment on the log of GDP.



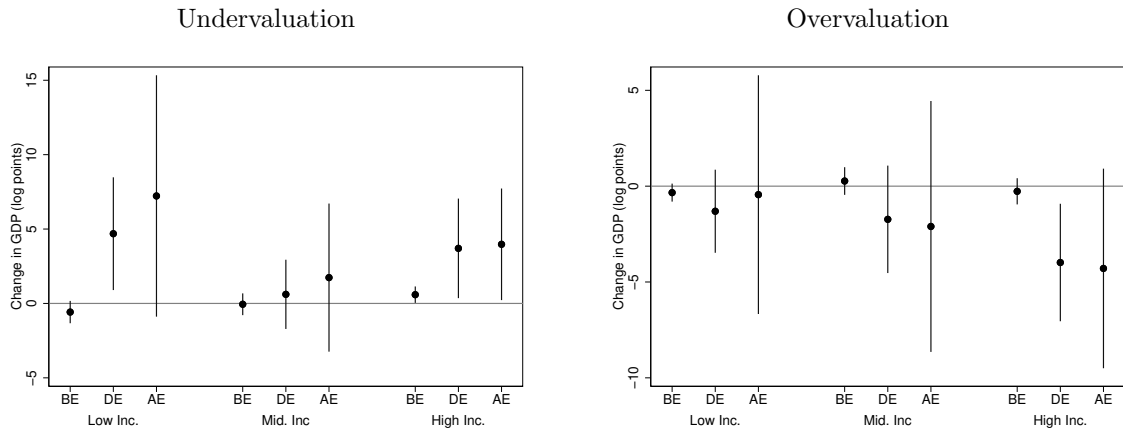
*Note:* The solid line plots the estimated average effect on log GDP *per capita* on countries that had an undervaluation episode, with a 90 percent confidence interval in black dashed lines. Time (in years) relative to the year of the episode.

Figure 39: Semiparametric estimates of the effects over time of real exchange rate misalignment on the log of capital stock.



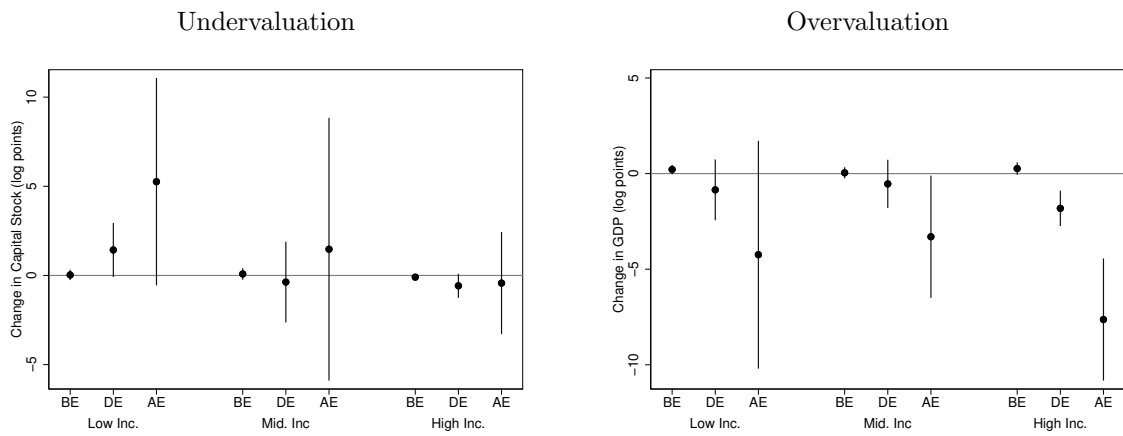
*Note:* The solid line plots the estimated average effect on log GDP *per capita* on countries that had an undervaluation episode, with a 90 percent confidence interval in black dashed lines. Time (in years) relative to the year of the episode.

Figure 40: Semiparametric estimates of the effects over time of real exchange rate misalignment on the log of GDP.



Note BE = Before Episode (time -7 to -1); DE= During Episode (time 0 to 6); AE= After episode (time 7 to 13). The dot is the estimated coefficient and the lines indicate the 90% confidence interval.

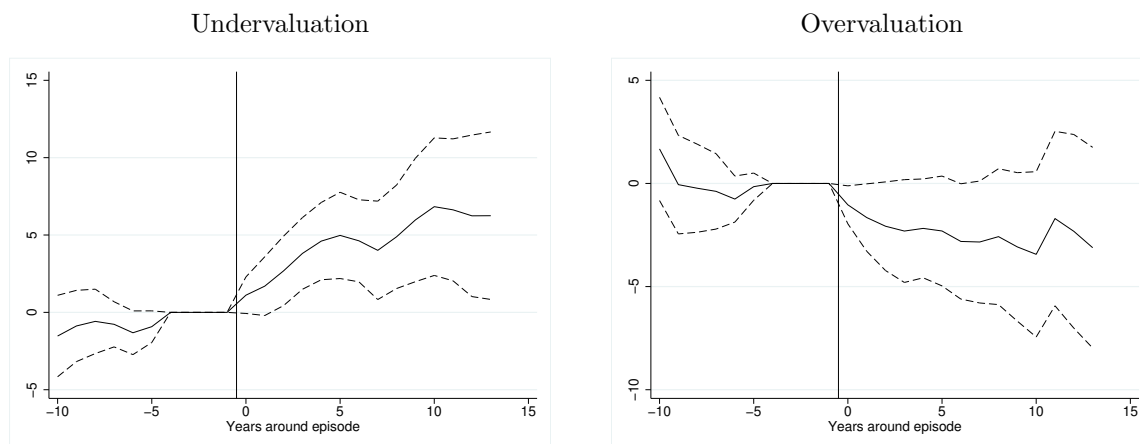
Figure 41: Semiparametric estimates of the effects over time of real exchange rate misalignment on the log of capital stock.



Note BE = Before Episode (time -7 to -1); DE= During Episode (time 0 to 6); AE= After episode (time 7 to 13). The dot is the estimated coefficient and the lines indicate the 90% confidence interval.

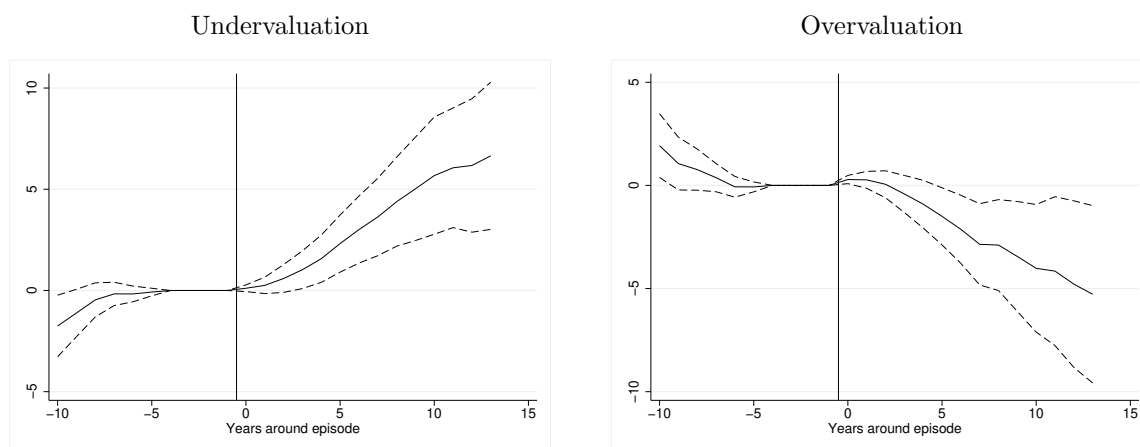
## G Longer pre-treatment periods

Figure 42: Semiparametric estimates of the effects over time of real exchange rate misalignment on the log of GDP.



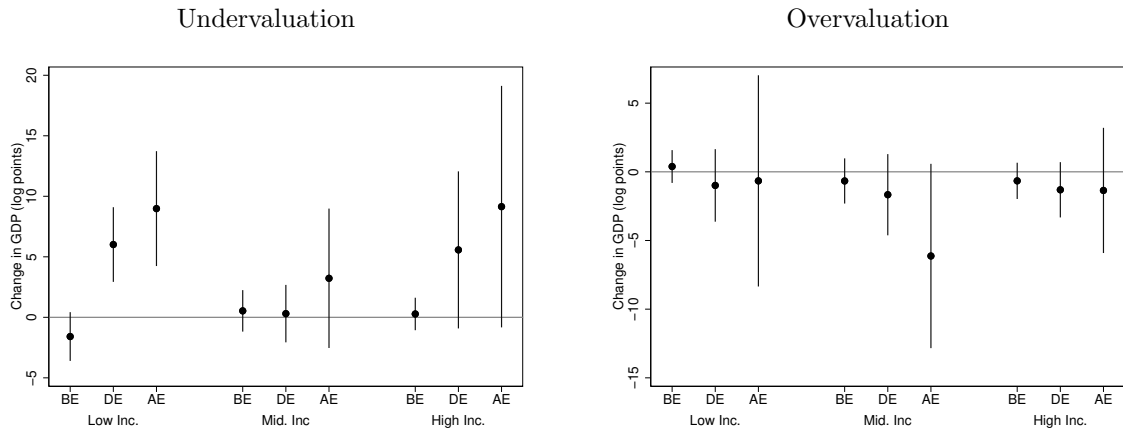
*Note:* The solid line plots the estimated average effect on log GDP *per capita* on countries that had an undervaluation episode, with a 90 percent confidence interval in black dashed lines. Time (in years) relative to the year of the episode.

Figure 43: Semiparametric estimates of the effects over time of real exchange rate misalignment on the log of capital stock.



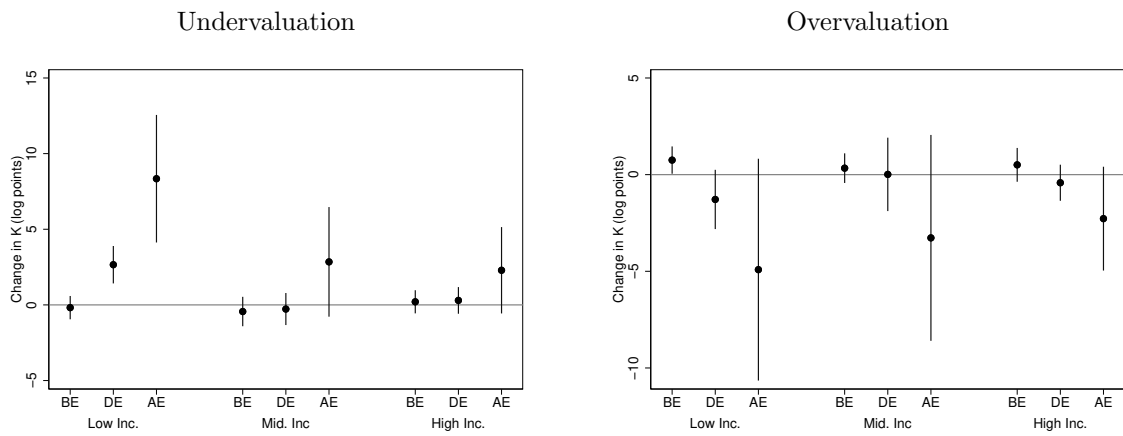
*Note:* The solid line plots the estimated average effect on log GDP *per capita* on countries that had an undervaluation episode, with a 90 percent confidence interval in black dashed lines. Time (in years) relative to the year of the episode.

Figure 44: Semiparametric estimates of the effects over time of real exchange rate misalignment on the log of GDP.



Note BE = Before Episode (time -7 to -1); DE= During Episode (time 0 to 6); AE= After episode (time 7 to 13). The dot is the estimated coefficient and the lines indicate the 90% confidence interval.

Figure 45: Semiparametric estimates of the effects over time of real exchange rate misalignment on the log of capital stock.



Note BE = Before Episode (time -7 to -1); DE= During Episode (time 0 to 6); AE= After episode (time 7 to 13). The dot is the estimated coefficient and the lines indicate the 90% confidence interval.