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Real Exchange Rate Overshooting in Large Depreciations: Determinants and Consequences

by Alexander Culiuc

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Abstract

The consequences of large depreciations on economic activity depend on the relative strength of the contractionary balance sheet and expansionary expenditure switching effects. However, the two operate over different time horizons: the balance sheet effect hits almost immediately, while expenditure switching is delayed by nominal rigidities and other frictions. The paper hypothesizes that the overshooting phase—observed early in the depreciation episode and driven by the balance sheet effect—is largely irrelevant for expenditure switching, which is more closely aligned with ex-post equilibrium depreciation. Given this, larger real exchange rate overshooting should signal a relatively stronger balance sheet effect. Empirical findings support this hypothesis: (i) overshooting is driven by factors associated with the balance sheet effect (high external debt, low reserves, low trade openness), (ii) overshooting-based measures of the balance sheet effect foreshadow post-depreciation output losses, and (iii) the balance sheet effect is strongest early on, while expenditure switching strengthens over the medium term.

JEL Classification Numbers: F32, F34, F43, G15, O24

Keywords: Exchange Rate; External Debt; Open Economy Growth

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I. INTRODUCTION

Easy financing conditions following the Global Financial Crisis (GFC) have contributed to rising indebtedness of Emerging Markets (EMs), increasing risks to financial stability.[2] The multiple economic shocks triggered by the ongoing Covid-19 pandemic—sharp declines in global demand, terms of trade shocks and tightening of global financial conditions—are leading to the realization of these risks are high. Accordingly, analyzing and learning from the salient features of EM crises of the late nineties and early naughts has never been more important than it is today. Specifically, large nominal and real depreciations[3] were a major feature of such crises and, often, their starting point. The real exchange rate rarely followed a step-like weakening; early on, it would often overshoot the new equilibrium.

In this paper, I empirically explore the determinants and consequences of overshooting in large depreciations. I address two questions: (i) what pre-shock settings are associated with large exchange rate overshooting? (ii) what does overshooting tell us about the output consequences of large depreciations? To answer them, I first establish a link between overshooting and the two channels through which large depreciations impact economic activity: expenditure switching effect and balance sheet effect.

Mundell-Fleming, the work horse model of international economics, predicts a *positive* response of output to a depreciation via the expenditure switching effects. However, output contractions in many large depreciations have established the existence of a strong *negative* balance sheet (BaS) effect, especially for EMs; Frankel (2005) provides an overview. Hence, the output response to a large depreciation depends on the relative strengths of the expansionary expenditure switching and the contractionary balance sheet effects. In most of the literature on currency crises, both effects respond simultaneously to the same real exchange rate. This, however, ignores that the two effects operate at different time horizons.

The balance sheet effect is nearly instantaneous, and the financial frictions (e.g., margin constraint) underpinning it drive up the REER[4], with the maximum depreciation reflecting the strength of the balance sheet effect. However, nominal rigidities (e.g., dollar invoicing) and other frictions delay the export response, and therefore the brief spike in the exchange rate early in the episode is of little or no consequence to expenditure switching. Instead, expenditure switching is more closely aligned with the ex-post equilibrium real exchange rate, i.e., the level at which the REER settles after the volatile part of the episode is over. De facto, the two effects are linked to different levels of the real exchange rate: the balance sheet effect is associated with maximum depreciation and expenditure switching with ex-post

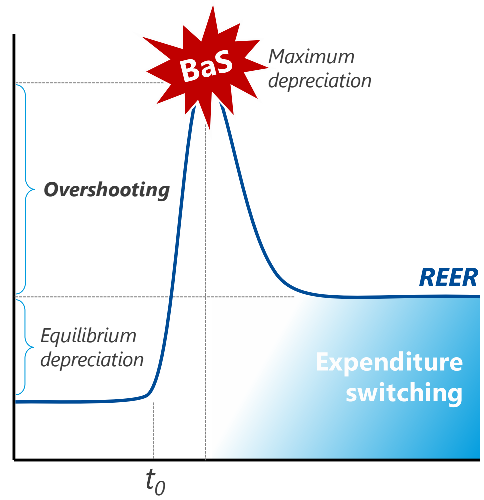
[2] See, for example, IMF (2015a) for a discussion on corporate external debt, IMF (2018) on public debt, and IMF (2019) on implications on global financial stability.

[3] Conceptually, "depreciation" and "devaluation" differ in the exchange rate regime in effect before the exchange rate moved: flexible and fixed, respectively. Since this distinction is of secondary importance for this study, the term "depreciation" is used to encompass both phenomena.

[4] Throughout the paper, an increase in the exchange rate denotes depreciation.

equilibrium depreciation. Overshooting—the difference between these two exchange rates—can then be viewed as a wedge between the BaS and expenditure switching effects. For a given real equilibrium depreciation, higher overshooting signals a relatively stronger BaS effect, and foreshadows a larger output loss. Figure 1 offers a highly stylized representation.

Figure 1. Stylized Representation of a Large Depreciation Episode



This insight informs several empirical findings. Based on the analysis of 122 large depreciations since 1980, I show that: (i) the size of overshooting is driven by factors associated with the balance sheet effect (high external debt, low reserves, low trade openness), (ii) overshooting-based measures of the balance sheet effect foreshadow post-depreciation output losses, and (iii) the balance sheet effect gradually dissipates, while expenditure switching simultaneously gains strength.

The paper is structured as follows. Section II reviews the literature to provide support for a simple empirical model laid out in section III. Section IV discusses the data, a subset of a new dataset of large depreciation episodes by Culiuc and Deb (2020). Section V presents empirical findings on the determinants of overshooting, and section VI establishes the link between overshooting and output loss. Section VII closes with policy implications.

II. The Dynamics of Contractionary Depreciations

Most models of contractionary depreciations—including Krugman (1999), Aghion et al. (2000, 2004), Cespedes et al. (2003, 2004)— construct the balance sheet effect by combining (i) currency mismatches arising from external borrowing, and (ii) financial frictions.[5]

The main source of currency mismatches is the extent to which an economy's liabilities are denominated in FX, while its assets (and revenues) are in local currency. It arises from the limited ability of EM borrowers—sovereigns and private sector—to raise funds externally in domestic currencies. Underlying reasons include a history of poor policies and institutions and/or "original sin" (Eichengreen and Hausmann, 1999; Eichengreen et al., 2005).[6]

Agents also face financial frictions. *Domestic borrowers'* demand for credit is constrained by their net worth (Bernanke and Gertler, 1989); the risk premium they face rises with the ratio of debt to net worth. If liabilities are in FX and assets and revenues are in local currency, a

[5] The balance sheet effect is the only channel from depreciations to output contraction analyzed here. However, other factors may also be at play. For instance, a strand of literature going back to Díaz Alejandro (1963) and Krugman and Taylor (1978) link depreciation to output loss via the redistribution effects of ensuing inflation.

[6] However, borrowing externally in own currency—which many EMs (at least the sovereigns) managed recently—does not fully eliminate the mismatch; it merely shifts it to the creditor's balance sheet.

depreciation reduces net worth and raises the cost of credit. *Domestic banks*—in addition to facing a similar net worth constraint on dollarized liabilities—follow a Value-at-Risk (VaR) rule, in which exposure is adjusted to maintain a constant probability of default (Adrian and Shin, 2014). The exchange rate affects the risk-weighted value of assets, and hence banks' decisions on the size of the balance sheet. *Foreign creditors* holding local currency assets face a margin constraint, which can be micro-founded in various ways.[7] The exchange rate moves the FX value of these assets, and a depreciation can trigger their rapid disposal.

Before the shock, capital inflows appreciate the domestic currency, raising the profitability (in FX terms) of domestic investment projects, especially in the non-tradable sector (which is not naturally hedged). The resulting higher net worth of entrepreneurs makes external financing even more attractive, including to local banks that face higher demand for credit. This sets off a cycle of capital inflows, real appreciation, credit expansion, investment and growth. However, if the appreciation reverses (e.g., due to deteriorating external financing conditions, a terms-of-trade shock or policy missteps), so does this cycle:

- *Debtor deleveraging.* The initial depreciation leads to a reduction in net worth (of the sovereign, corporates and/or households, depending of which sector faces currency mismatches). This raises the risk premium and lowers demand for credit.
- *Domestic credit crunch*. Banks, faced with deteriorating asset quality and ballooning value of FX debt, actively shed local assets to keep constant VaR relative to equity.[8]
- *Sudden stop.* In addition to demanding higher risk premia, foreign creditors cut back exposures to local assets to meet margin constraints; foreign financing dries up.[9]

The reduction in foreign credit and the fire sale of local currency assets lead to further depreciation, generating a vicious cycle. Put together, these processes constitute the balance sheet effect of depreciation. Importantly, the larger the currency mismatches—the more external debt the country has accumulated pre-shock—the stronger the deleveraging, the credit crunch and the sudden stop.[10] The severity of financial frictions also affects the

[7] The VaR is one approach to provide the micro-foundations for this margin constraint. Earlier work includes Aiyagari and Gertler (1999), who interpret the margin constraint as a ceiling on the leverage ratio imposed on financial intermediaries at every point in time. Cavallo et al. (2005) apply this version of the margin constraint to currency crises, and Mendoza and Smith (2004) and Mendoza (2010) to sudden stops. In Gabaix and Majiori (2015), international financiers' limited risk-bearing capacity induces them to demand a currency risk premium.

[8] Adrian, Colla and Shin (2012) show that supply-side frictions (e.g., VaR) contributed to US credit contraction during the Global Financial Crisis more than demand-side frictions (e.g., net worth constraint).

[9] In Mendoza and Smith (2004) and Mendoza (2010), "the occasionally-binding collateral constraint" kicks in during periods of high leverage, which explains the asymmetry between the gradual ramp-up in external borrowing and the immediate (sudden stop) contraction. Gopinath (2004) generates the same asymmetric pattern using a search model in which foreign investors incur costs in discovering investing opportunities.

[10] Krugman (1999), Aghion et al. (2000, 2004), Cespedes et al. (2004, 2005), Mendoza and Smith (2004) and Mendoza (2010) in theoretical work. Kaminsky and Reinhart (1996) show that indebtedness raises the likelihood of a sudden stop; additional evidence in Sahay et al. (2003) and Abiad et al. (2009), among others.

strength of these processes. Catão and Kapur (2004) show, for instance, that the net worth constraint is more acute in less developed countries. This can explain "debt intolerance" (Reinhart et al., 2003), the observation that less developed countries experience debt distress at lower levels of debt (Annex 1 provides evidence of debt intolerance in the data).

Crucially for this discussion, the net worth constraint (and associated risk premium spike), and the VaR and margin constraints (and associated fire sales) operate quickly; immediately in most theoretical models. These constraints are most binding at maximum depreciation, and they are also the factors *causing* the exchange rate to weaken.[11] In short, the maximum depreciation reflects the strength of the balance sheet effect, and it increases with the degree of currency mismatches and financial frictions. The result is a contemporaneous fall in economic activity, and particularly investment. The investment decline also affects future capital and hence future output. Additionally, Mendoza (2010) shows that the margin constraint reduces access to working capital, which induces contemporaneous drops in production and factor demands.

An important factor reducing the strength of the balance sheet effect is trade openness. Both Krugman (1999) and Cespedes et al. (2004) find that a larger tradable sector provides a natural hedge to a larger share of the economy against the balance sheet effect.[12] Cavallo and Frankel (2008) show empirically that openness reduces the likelihood of a sudden stop.

The depreciation need not be recessionary, as the balance sheet effect is countered by expansionary expenditure switching. However, it is delayed by rigidities and uncertainty:

- *Dominant currency pricing* is the most often invoked reason: exports invoiced in foreign exchange (mostly U.S. dollars) do not get a competitiveness boost from the depreciation (Goldberg and Tille, 2008; Gopinath, 2015; Gopinath et al., 2019). Instead, the benefits accrue to exporters as higher profits. In time, higher profits incentivize investment in export activities both by incumbents and potential entrants (Benguria et al., 2020), but then other constraints (listed below) can come into play.
- *Rational expectations and uncertainty.* Firms factor in future partial REER recovery and, in the presence of adjustment costs, will dampen their investment response. Uncertainty related to where exactly the REER will ultimately land further reduces equilibrium investment (Baldwin and Krugman, 1989; Dixit, 1989; and, more recently, Das et al., 2007; Alessandria et al., 2013).
- *Financial rigidities.* Even if the tradable sector becomes more attractive, its expansion may be stifled by scarce financing, as banks deleverage and foreign capital dries up. Berman and Berthou (2009) find that exporting industries more dependent

[11] Using daily series, Annex Figure 1 illustrates the speed of the BaS effect and the very tight link—especially around peak depreciation—between the exchange rate and the risk premium (captured by the spreads).

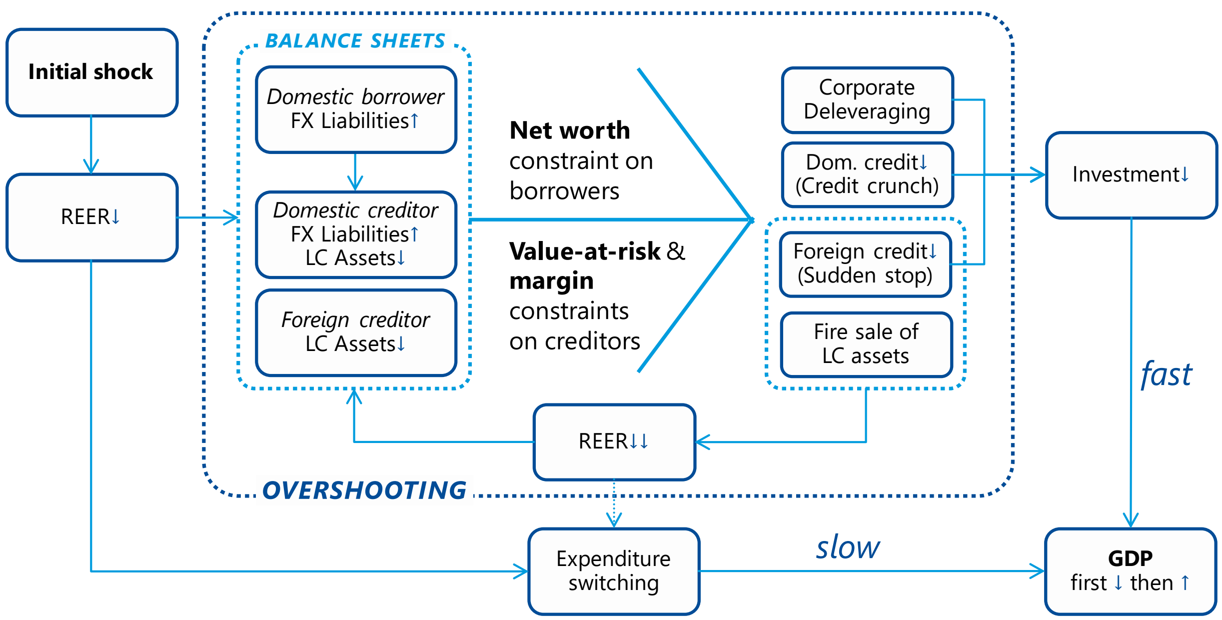
[12] In the Bernanke and Gertler (1989) setup, this is because the depreciation-induced increase in liabilities is partly offset by increased expected value of investment projects in tradable industries.

on external financing benefit less from the depreciation. In Alessandria et al. (2007), higher post-devaluation interest rates lead to lower export elasticities.

- *Structural rigidities.* Reallocation of resources towards the tradable sector can be constrained by rigidities in labor and product markets, weak protection of property right, and under-provision of complementary inputs (e.g., high skill labor, infrastructure, etc.). Culiuc and Kyobe (2017) document that export elasticities w.r.t. REER decrease with the strength of selected structural rigidities.

The combination of these factors delays expenditure switching. De facto, the expenditure switching effect “misses” the overshooting phase of the depreciation, and only responds to the level of the exchange rate in effect already *after* the acute phase of the crisis is over. As the strength of the balance sheet effect is manifested at (and through) maximum real depreciation, while expenditure switching is associated with the ex-post equilibrium, real exchange rate overshooting—the difference between the two exchange rates—signals the relative strength of the balance sheet effect and foreshadows future output losses. Figure 2 summarizes the processes at work in a large depreciation episode.

Figure 2. Dynamics of a currency crisis with balance sheet effect



Basu et al. (2020) model a small open economy subject to many of the financial constraints and nominal rigidities discussed above, as well as discuss the optimum use of a rich policy toolkit under a variety of scenarios. Cavallo et al. (2005) also come close to modeling this dynamic, with financial frictions affecting both borrowers and financial intermediaries. Additionally, their empirical work informs parts of the analysis that follows. They don’t, however, consider rigidities facing expenditure switching, which also affects their empirical strategy. In what follows, specific similarities to—and differences from—Cavallo et al. (2005) are highlighted in corresponding sections.

III. A Simple Empirical Setup

This section translates the discussion above into a testable setup. As discussed, the impact of depreciation on output depends on the relative strength of the negative balance sheet and positive expenditure switching effects. For simplicity, the two effects are assumed to be separable. The dependent variable of interest is output loss, defined as *negative* deviation from pre-crisis trend (construction of this variable is discussed in the next section).

$$LOSS_T = -\Delta Y_T = \underbrace{-\tau\Delta E_{eq} * Y_{T-1}}_{\substack{Expenditure\\ switching}} + \underbrace{\beta(\Delta E_{max} * D_{T-1})}_{\substack{Balance\\ sheet}} \tag{1}$$

Both expenditure switching and the balance sheet effect are captured by products of two terms, which can be viewed as quantity and price variables. For expenditure switching, the "price" is the equilibrium real depreciation ΔE_{eq}, and the relevant "base" of the effect is the pre-shock level of output Y_{T-1}.[13] [14] The BaS effect is proportional to the product between maximum real depreciation ΔE_{max} (the "price") and unhedged FX debt D_{T-1} to be repaid or rolled over during the period of stress; the default measure is external short-term debt. τ and β are coefficients associated with the two effects, and are to be estimated. Expressed in percent of $T - 1$ output, equation (1) becomes:

$$loss_T = -\Delta y_T = -\tau\Delta E_{eq} + \beta\Delta E_{max} * d_{T-1}, \text{ where } d = D/Y \times 100 \tag{2}$$

Maximum depreciation can be decomposed into equilibrium depreciation and overshooting:

$$\Delta E_{max} \equiv \Delta E_{eq} + \Delta E_{os} \tag{3}$$

Assume, for the moment, that uncovered interest parity (UIP) holds. Following Dornbusch (1976), overshooting is then proportional to equilibrium depreciation (λ is to be estimated):

$$\Delta E_{os} = \lambda\Delta E_{eq} \tag{4}$$

Equations (2), (3) and (4) can be combined as follows:

$$loss_T = -\tau\Delta E_{eq} + \beta\left(\Delta E_{os} + \frac{1}{\lambda}\Delta E_{os}\right)d_{T-1} = -\tau\Delta E_{eq} + \beta\left(\frac{1+\lambda}{\lambda}\right)\Delta E_{os} * d_{T-1} \tag{5}$$

The last term, overshooting*debt, is the overshooting-based measure of the balance sheet effect, and is the main variable of interest. Note that its coefficient, $\beta((1+\lambda)/\lambda)$, is strictly larger than β, the coefficient of max depreciation*debt in equation 2; this will be later tested.

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[13] T is the year when the large depreciation episode has occurred, and t (introduced later) is the starting month.

[14] One could argue that the base for the expenditure switching effect is only the traded sector. However, since the analysis covers the medium-term post-shock horizon, restricting the "base" of the expenditure switching to the traded sector would ignore the reallocation of resources over time from non-tradable to tradable sectors.

As discussed in section II, the net worth constraint leads to an endogenous risk premium, so the UIP assumption does not hold. To incorporate covered interest parity (CIP), equations 4 and 5 need to be amended as follows, with R capturing the risk premium[15]:

$$\Delta E_{os} = \lambda \Delta E_{eq} + R \tag{6}$$

$$loss_T = -\tau \Delta E_{eq} + \beta \left(\frac{1+\lambda}{\lambda}\right) \Delta E_{os} * d_{T-1} - \frac{\beta}{\lambda} R * d_{T-1} \tag{7}$$

Note that equation 7 contains a *negative* coefficient in front of the last debt term; this will be tested later. To incorporate the net worth constraint and debt intolerance, risk premium must increase with debt but decrease with income/capita (A_{T-1}), which proxies for higher financial development and therefore less severe financial frictions. Finally, after adding disturbance terms, I obtain the general form for the econometric specifications of interest:

$$\Delta E_{os,iT} = \lambda \Delta E_{eq,iT} + R(A_{iT-1}, d_{iT-1}) + \xi_{iT}, \text{ where } R'(A) < 0, R'(d) > 0 \tag{8}$$

$$loss_{iT} = -\tau \Delta E_{eq,iT} + \beta \left(\frac{1+\lambda}{\lambda}\right) \Delta E_{os,iT} * d_{iT-1} - \frac{\beta}{\lambda} R(A_{iT-1}, d_{iT-1}) * d_{iT-1} + \epsilon_{iT} \tag{9}$$

Informed by the discussion in section II, equations 8 and 9 lend themselves to a number of testable hypotheses concerning large depreciation episodes:

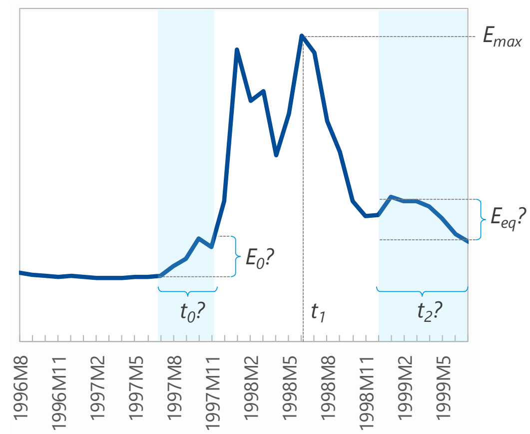
- RER overshooting increases with equilibrium depreciation (Dornbusch overshooting).
- Overshooting increases with pre-shock debt level (strength of balance sheet effect).
- Overshooting decreases with level of development (proxy for financial frictions).
- Output loss decreases with equilibrium depreciation, although the short-term effect may be weak given the delayed operation of expenditure switching.
- Output loss rises with overshooting*debt, which captures the BaS effect's strength.
- Output loss increases with level of development (a consequence of debt intolerance).

I test these hypotheses using cross-section OLS regressions. The use of lagged values for key variables (particularly external debt) reduces concerns of reverse causality. Nevertheless, section VI concludes with the presentation of two- and three-stage least squares results, which only reinforce main findings. Alternative estimation techniques are made impractical by the nature of the data, which is described in the next section. For instance, the event study nature of the study rules out time series analysis, while the small number of large depreciations per country (most have just one) rules out panel techniques.

[15] Cespedes et al. (2003) derive the link between the endogenous risk premium and the exchange rate. The intuition can also be glimpsed from Dornbusch (1976) where, in order to maintain UIP ($r - r^* = \dot{e}$) in the face of price stickiness, the exchange rate has to overshoot. The key equation is $e - \bar{e} = -(1/\lambda\theta)(p - \bar{p})$. With risk premium η, CIP: $r - r^* + \eta = \dot{e}$, and $(e - \bar{e})$ increases in η (adds an η/θ term to the Dornbusch equation).

IV. Large Depreciations Dataset

Figure 3. Large depreciation (Indonesia 1997)



I use a subset of the Culiuc and Deb (2020) dataset of large depreciation episodes. The dataset was constructed in two steps: (i) identifying the onset of large depreciation episodes, and (ii) characterizing key parameters of each episode, such as maximum and equilibrium depreciations, overshooting, etc. The two steps are straightforward for a textbook case like the one depicted in Figure 1. However, Figure 3 shows that erratic moves in the monthly exchange rate series make it difficult to pinpoint the onset of the episode (t_0 and the corresponding exchange rate E_0), equilibrium depreciation (ΔE_{eq}) and, therefore, overshooting ($\Delta E_{os} = E_{max} - E_{eq}$). This section explains how these issues are dealt with.

A. Identifying Large Depreciation Episodes

Large depreciations are defined as large and rapid increases in the bilateral exchange rate vis-à-vis the U.S. dollar, as it exhibits more discrete changes than trade-weighted indices (NEER and REER). This approach was introduced by Frankel and Rose (1996), and reused, with variations, by Laeven and Valencia (2013) and IMF (2015b) among others. However, except for Cavallo et al. (2005) discussed below, these studies identify episodes based on annual exchange rate series. Culiuc and Deb (2020) instead use monthly data, which allows for a richer characterization of depreciation episodes (next sub-section).

The start of depreciation episodes is identified on a three-month rolling basis, using four criteria that expand on Frankel and Rose (1996) to account for the realities of higher-frequency data (e.g., higher volatility, reversing trends). The depreciation must be (1) large (above the $\bar{e}_q$ cutoff), (2) accelerating relative to the previous three-month period ($\bar{e}_{qq}$ cutoff), (3) accelerating relative to the average depreciation in the preceding year ($\bar{e}_{qy}$ cutoff), and (4) significant on a year-on-year basis ($\bar{e}_{yy}$ cutoff). Annex 2 presents exact specification of these criteria, and illustrates how each of them matters in the identification of large depreciation episodes. This algorithm only identifies a three-month window in which a large depreciation has occurred; the month with the largest contribution to the depreciation is then used to pinpoint the onset of the episode.

The thresholds, presented in Table 1 (next page), are identified separately for advanced economies (AE) and the rest, as depreciation episodes in AEs are milder than those experienced by emerging and developing markets. The annual threshold $\bar{e}_{yy}$ is most directly comparable to the literature that identifies currency crises using annual data, and values are

close: Frankel and Rose (1996) used 0.25 and IMF (2015) used 0.13 for AEs, 0.2 for EMs and DMs.

Table 1. Criteria cutoffs

Cutoff	Advanced economies	Emerging and developing markets
$\bar{e}_q$	0.10	0.15
$\bar{e}_{qq}$	0.10	0.10
$\bar{e}_{qy}$	0.10	0.10
$\bar{e}_{yy}$	0.15	0.21

Note: See Annex 2 for details.

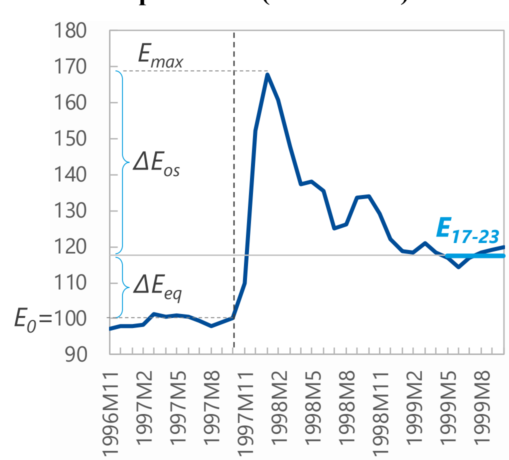
The process for identifying large depreciation episodes is closest to Cavallo et al. (2005), who also use monthly data and filters that analyze three-month windows. However, they only use the equivalents of criteria 1 and 2,[16] and do not attempt to identify the specific month within the three-month window that marks the onset of the episode. As a result, their dating of episodes is less accurate when compared against contemporaneous IMF Article IV staff reports and other sources. Finally, their dataset covers only 24 episodes altogether.

After eliminating a series of episodes where REER and output dynamics are unlikely to be driven by the processes discussed in section II (e.g., hyperinflation, economic transition; more details in Annex 2), the sample is reduced to 185 large depreciation episodes. However, the analyzed sample only covers the 122 episodes included in Annex Table 1 due to data availability for other variables; data sources are presented in Annex Table 2.

B. Characterizing Large Depreciation Episodes

Once episodes are identified, they are analyzed on a two-year window following the onset of the episode (months t through $t+23$). Key metrics include those describing the REER—maximum and equilibrium depreciations, overshooting, stability—and output loss.

Figure 4. REER path in a "textbook" large depreciation (Korea 1997)



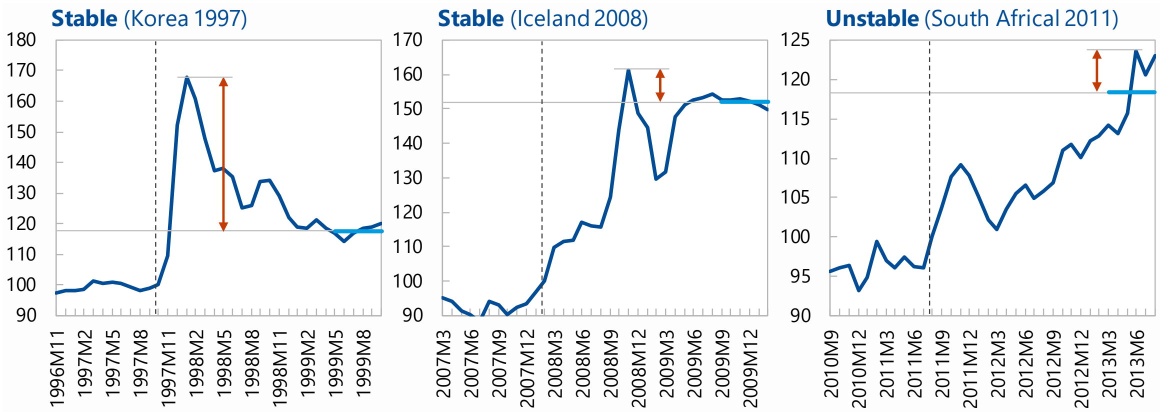
Note: The vertical dotted line marks $t-1$, the month preceding the large depreciation. The REER is normalized to 100 at $t-1$ (October 1997).

A "textbook" episode—where a depreciation spike is followed by a partial appreciation and stabilization at a new level (Figure 4)—is easy to characterize. Maximum depreciation is determined over the 24 months following the onset of the episode (t through $t+23$). Following Cavallo et al. (2005), the baseline definition of equilibrium is an ex-post one: it is defined as the average REER in months $t+17$ through $t+23$.[17] Overshooting is the difference between maximum and equilibrium levels.

[16] Their threshold values for both $\bar{e}_q$ and $\bar{e}_{qq}$ are 0.1, identical to those in Culiuc and Deb (2020) for AEs.

[17] The use of this interval is informed by the average duration of IMF-supported stabilization programs. An 18–24-month SBA targets regaining external balance (and REER achieving equilibrium) by the end of the program.

Figure 5. Baseline overshooting measure computed for stable and unstable large depreciations



Note: REER is normalized to 100 at $t-1$ (vertical dotted line). The red arrow marks the magnitude of overshooting.

Not all episodes feature an easy-to-interpret exchange rate path. Occasionally, the REER keeps depreciating throughout the 24 months window; Culiuc and Deb (2020) call such episodes unstable.[18] Figure 5 shows that the baseline measure of overshooting is less suitable for unstable episodes such as South Africa 2011. Note that the last six months of the two-year window—over which ex-post equilibrium is computed—are also the months with the most depreciated REER, so the baseline overshooting definition mostly captures noise in those months. Nevertheless, as the majority of analyzed episodes (96 of the total of 122) are stable, the main analysis uses this baseline definition of overshooting. Recognizing that it may be problematic for the minority of unstable cases, all results are presented both for the full sample and for the stable subsample alone. Additionally, seven other measures of REER equilibrium and overshooting are introduced and tested as part of robustness (Annex 3).

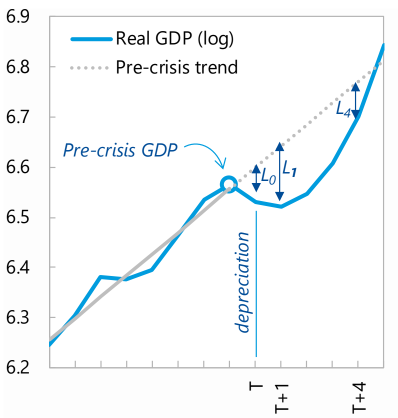
Output loss associated with large depreciations is estimated on annual data and is defined, broadly following Laeven and Valencia (2013, 2018) and Abiad et al. (2009), as deviation of real GDP from the pre-shock trend, expressed in percent of $T-1$ GDP.[19] The pre-shock output trend is constructed from the HP-filtered real GDP series computed for years $T-10$ through $T-1$, using trend growth in $T-1$.[20] The loss is computed for years T through $T+4$, as illustrated in Figure 6. The empirical analysis in the section VI focuses on $T+1$, since it typically corresponds to the year with the largest output loss (Figure 7).

[18] In Culiuc and Deb (2020), an episode is stable if: (i) REER peaks not later than $t+17$, (ii) REER trend-stabilizes by $t+23$. The trend (Hodrick-Prescott filter with a λ=400) is considered stable if it either (i) peaks before $t+23$ or (ii) depreciates by no more than 2.5 percent in months $t+18$ through $t+23$.

[19] T is the year of the depreciation. If the episode starts in the fourth quarter, T is shifted to the next year.

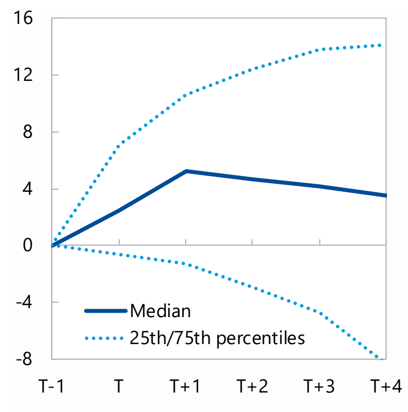
[20] Years immediately preceding the depreciation could potentially be years of overheating and, by pushing up trend growth, overstate output loss. However, Cerra and Saxena (2017) show that growth *slows down* in the three years preceding currency and banking crises. In any event, robustness tests where estimated trend growth only used observations through $T-2$ or $T-3$ did not alter results, but came at the cost of a reduced sample.

Figure 6. Output loss calculation example



Note: Loss for $T+i$ is computed as $\exp(L_i)\ /GDP_{T-1}$.

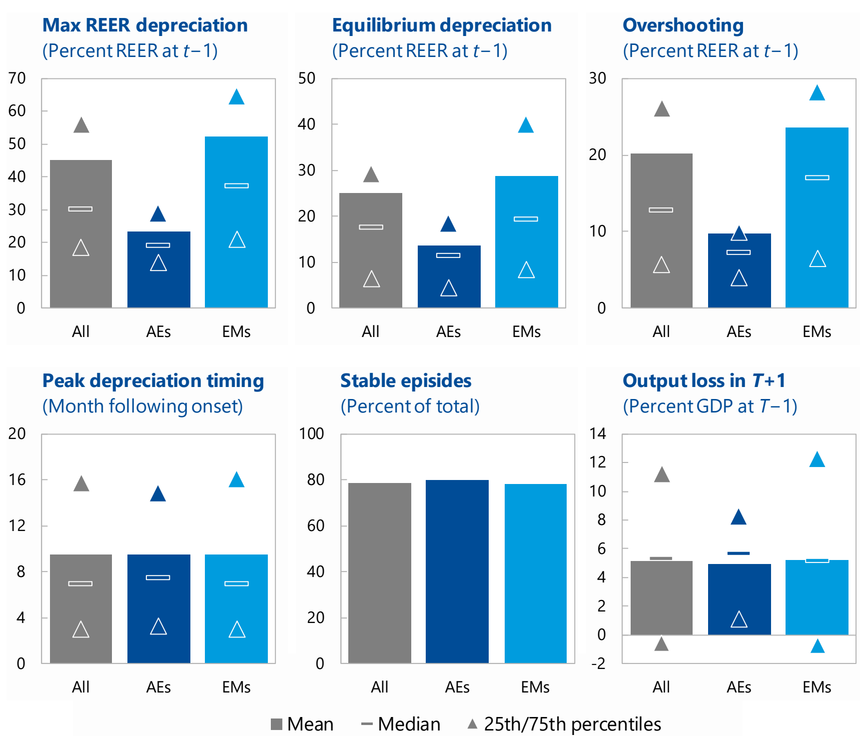
Figure 7. Output loss over time (% of $T-1$ GDP)



Note: Larger values indicate *worse* GDP outcomes.

Annex Table 1 provides key characteristics for each episode, while Figure 8 summarizes them, distinguishing between AEs and EMs. EMs exhibit larger maximum depreciation, equilibrium depreciation and overshooting.[21] However, the behavior of REER is more homogeneous across income groups: the REER peaks around the third quarter after the onset of the depreciation, and some 80 percent of episodes are stable. Finally, median output loss in $T+1$ is similar across the two groups, although EMs exhibit higher variance. Culiuc and Deb (2020) provide an expanded discussion of stylized facts of large depreciation episodes.

Figure 8. Summary statistics of key characteristics of large depreciation episodes



[21] Mechanically, this is due to lower threshold bilateral exchange rates used for identifying episodes in AEs. However, thresholds are determined at the same percentiles of exchange rate movements for both income groups (Annex 2). Therefore, differences in REER depreciations across income groups remain representative.

V. DETERMINANTS OF REAL EXCHANGE RATE OVERSHOOTING

Table 2 presents OLS regression results for exchange rate overshooting. As mentioned above, all estimations are presented for the full sample, and for the sub-sample of stable episodes, since the baseline definitions of overshooting and equilibrium depreciation are most appropriate for stable episodes. The usual reverse causality concerns are largely mitigated by the use of lagged explanatory variables.

First, there is strong support for Dornbusch-type overshooting in stable depreciation episodes. Across specifications, overshooting increases with equilibrium depreciation; each percentage point of additional equilibrium depreciation is associated with about ¼ percentage point of additional overshooting. It is not surprising that the same relationship is not statistically significant for the overall sample, which also includes unstable episodes.[22]

Table 2. OLS regressions on REER overshooting

REER Overshooting	All episodes				Stable episodes only			
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Equilibrium depreciation (percent)	0.060	0.061	0.038	0.048	0.275**	0.224*	0.230*	0.240*
	(0.083)	(0.094)	(0.099)	(0.100)	(0.134)	(0.130)	(0.131)	(0.133)
Peg (T-1)		12.538**	13.450**	14.048**		15.849**	17.075**	16.821**
		(5.216)	(6.161)	(5.986)		(6.522)	(7.188)	(7.231)
Reserves (percent GDP, T-1)		-0.134*	-0.191**	-0.188**		-0.140	-0.186**	-0.179**
		(0.073)	(0.075)	(0.077)		(0.087)	(0.087)	(0.090)
Trade openness (X+M in percent GDP, T-1)		-0.110**	-0.173***	-0.181***		-0.122***	-0.172***	-0.176***
		(0.045)	(0.052)	(0.053)		(0.046)	(0.053)	(0.054)
External ST Debt (percent GDP, T-1)			0.006	4.723**			-0.057	3.910*
			(0.076)	(2.177)			(0.080)	(2.058)
PPP GDP/capita * External ST Debt				-0.004**				-0.004*
				(0.002)				(0.002)
Constant	18.84***	24.19***	32.68***	29.58***	18.76***	24.82***	32.28***	29.47***
	(2.08)	(4.08)	(5.06)	(4.94)	(2.71)	(4.35)	(5.16)	(5.22)
Observations	141	126	93	93	111	101	75	75
R^2	0.010	0.102	0.137	0.162	0.087	0.199	0.239	0.257

Note: Robust standard errors in parentheses. *, **, *** indicate significance at 10, 5 and 1 percent levels respectively.
[1] PPP GDP/capita is logged and multiplied by 100, to allow interpreting the coefficient as a semi-elasticity.

Specifications 2 and 6 include variables which are likely to affect overshooting. Currencies coming off a peg experience larger overshooting.[23] Larger pre-shock official reserves reduce the magnitude of overshooting, while trade openness serves as a natural hedge against the balance sheet effect and hence lowers overshooting. Somewhat surprisingly, various

[22] For a given depreciation spike early in the episode, the overshooting measured using the baseline approach will be "eroded" if the REER keeps depreciating through the end of the two-year analysis window, as is the case in unstable depreciations (see the case of South Africa in Figure 5 for an extreme example).

[23] Exchange rate regime definition from Klein and Shambaugh (2010).

measures of capital account liberalization do not appear to affect overshooting (results not shown), whether entered directly or interacted with the exchange rate regime.

Specifications 3 and 7 provide initial—unsuccessful—tests of whether external indebtedness (proxy for currency mismatches) affects overshooting. However, debt intolerance implies that if richer countries *do* get into trouble, it must happen at higher levels of debt, since they can bear lower levels of debt with more ease. In the data, this is manifested through a strong correlation of the pre-shock debt and income/capita (Annex 1). In other words, a given level of debt is less detrimental for richer countries. Specifications 4 and 8 test this by adding an interaction term between debt and GDP/capita. As expected, external short-term debt does lead to higher overshooting, but less so for richer countries. An additional percentage point of external ST debt is associated with 4 to 5 percentage points higher overshooting, while an additional standard in the GDP/capita is associated with a 2 percentage point lower overshooting at the mean level of external ST debt (7 percent of GDP).

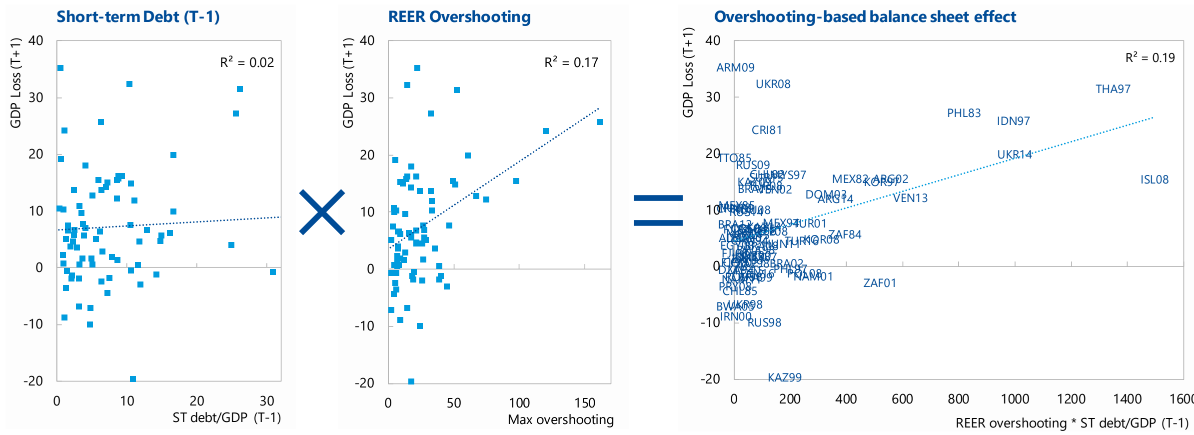
In short, the size of the overshooting is correlated with variables associated with larger balance sheet effects: high currency mismatches (as proxied by external short-term debt), low reserves, and low trade openness. However, while these "pre-existing conditions" affect the magnitude of overshooting, the relatively low R^2 suggests that many other factors matter. Policies implemented *after* the onset of the episode are the obvious suspects. Likely pervasive endogeneity makes it impossible to assess the impact of policy responses employing the simple OLS setup used here. This is left for subsequent work on the subject.

VI. Output Implications of Exchange Rate Overshooting

This section investigates the drivers of output loss following large depreciation episodes. The focus is on output loss in $T+1$—the year following the depreciation, as that is typically the year with the largest loss. However, later on I show results covering years T though $T+4$.

I start by illustrating the main result. As discussed in section III, the variable of interest is an overshooting-based measure of the balance sheet effect, computed as the product between overshooting and short-term debt $\Delta E_{os} * d_{T-1}$. The left two charts in Figure 9 show bivariate scatter plots for the two components of the balance sheet effect against output loss in $T+1$. The right chart plots a strong positive relationship between overshooting*debt and output loss; the econometrics that follows will enrich and nuance this finding.

Figure 9. The overshooting-based balance sheet effect and its components vs. output loss in $T+1$



Note: Plots includes 84 large depreciation episodes with non-zero external short term debt. In the right panel, individual episodes are identified by the 3-letter ISO code and the 2-digit year in which the episode had occurred.

A. Choosing the Balance Sheet Effect Measure

I first test whether the chosen measure of the balance sheet effect—overshooting*external ST debt—is the appropriate one. The only other study that links output loss to the *magnitude* of the depreciation is Cavallo et al. (2005). However, they test the equivalent of equation 2 from section III; their main explanatory variable is maximum depreciation*external debt.

Table 3 presents a comparison between the two measures. Broadly following Cavallo et al. (2005), specifications 1 and 5 use the maximum depreciation measure of the balance sheet effect, while specifications 2 and 6 the overshooting-based measure. As anticipated in section III, the coefficient for the overshooting-based measure is larger. But it also has a much higher t-statistics (4.7 vs. 1.8), and the fit of the regression improves considerably.

Table 3. OLS regressions on output loss in $T+1$: Comparison of balance sheet effect measures

GDP Loss (T+1)	**All episodes**				**Stable episodes only**			
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Equilibrium depreciation (percent)	-0.005	-0.000	-0.006	-0.020	0.048	0.040	0.020	0.017
	(0.032)	(0.027)	(0.027)	(0.021)	(0.041)	(0.034)	(0.050)	(0.049)
Max depreciation * External ST Debt/GDP (T-1)	0.002*				0.002*			
	(0.001)				(0.001)			
Overshooting * External ST Debt/GDP (T-1)		0.018***				0.019***		
		(0.004)				(0.004)		
Overshooting * External ST Debt on RMB/GDP (T-1)			0.012***				0.012***	
			(0.002)				(0.003)	
Overshooting * External Bank Debt/GDP (T-1)				0.029***				0.028***
				(0.005)				(0.006)
Constant	4.374**	2.059	1.615	1.524	3.414*	0.818	0.572	0.575
	(1.690)	(1.826)	(2.016)	(2.236)	(2.010)	(2.175)	(2.492)	(2.862)
Observations	88	88	69	68	71	71	55	54
R^2	0.040	0.160	0.136	0.151	0.052	0.182	0.148	0.152

Note: Robust standard errors in parentheses. *, **, *** indicate significance at 10, 5 and 1 percent levels respectively.

Why does the overshooting-based measure of the BaS perform better? Maximum depreciation gives little indication of how magnitude of the risk premium component of the depreciation. It also has lower variance, since all episodes in the sample have high maximum depreciations by construction. Overshooting, on the other hand, better captures the risk premium, which ultimately reflects the strength of the balance sheet effect.[24]

Table 3 also shows that the specific proxy for currency mismatches is not crucial. Short-term debt, short-term debt on remaining maturity basis (RMB) and external bank debt, all produce similar results. However, data on short-term debt on original maturity is available for a somewhat larger sample and therefore this variable is used henceforth.

B. Main Results

Table 4 shows main results, with specifications 2 and 5 drawing on equation 9 in section III.

Table 4. OLS regressions on output loss in $T + 1$: Main specifications

GDP Loss (T+1)	All episodes			Stable episodes only		
	(1)	(2)	(3)	(4)	(5)	(6)
Equilibrium depreciation (percent)	-0.000	-0.006	-0.005	0.038	0.033	0.036
	(0.027)	(0.029)	(0.030)	(0.035)	(0.041)	(0.039)
Overshooting * External ST Debt/GDP (T-1)	0.023***	0.025***	0.025***	0.024***	0.026***	0.026***
	(0.003)	(0.004)	(0.009)	(0.003)	(0.004)	(0.009)
External ST Debt (percent GDP, T-1)	-0.113***	-0.214***	-0.223**	-0.116***	-0.244***	-0.253**
	(0.025)	(0.056)	(0.102)	(0.028)	(0.061)	(0.100)
PPP GDP/capita (Log, T-1)		0.080*	0.079*		0.100**	0.100**
		(0.042)	(0.042)		(0.045)	(0.045)
Overshooting (percent)			-0.010			-0.010
			(0.088)			(0.087)
Constant	2.09	-70.95*	-70.63*	0.8	-91.35**	-90.89**
	(1.79)	(39.60)	(38.94)	(2.13)	(42.53)	(41.99)
Observations	88	88	88	71	71	71
R^2	0.179	0.307	0.307	0.203	0.375	0.375

Note: Robust standard errors in parentheses. *, **, *** indicate significance at 10, 5 and 1 percent levels respectively.

The overshooting*debt interaction term remains highly significant, and the size of the coefficient is persistent across specifications. As discussed in section II, the equilibrium depreciation does not reduce output loss in the immediate aftermath of the depreciation (this changes over the medium term, as discussed below). As predicted in section III, the estimated coefficient for the stand-alone external short-term debt term is negative. Also as expected, the estimated coefficient on GDP/capita is positive: *ceteris-paribus*, richer countries see larger output losses. This is a direct corollary of debt intolerance: more

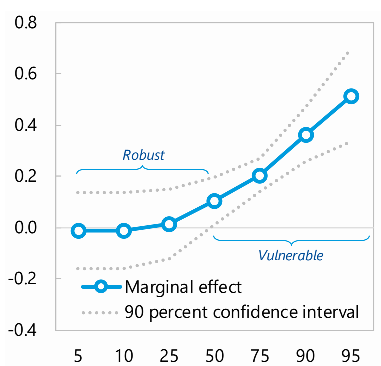
[24] Take two episodes with the same maximum depreciation, but the first one with zero overshooting and the second with full overshooting (i.e., exchange rate returns to pre-shock level). The first episode is likely driven by fundamentals (i.e., changes to the equilibrium) and lack of currency mismatches, whereas the latter is likely driven *only* by balance sheet effects. Clearly, the latter should have stronger effects on output. This will be captured by the overshooting-based measure of BaS, but not by the maximum depreciation-based measure.

developed countries experience debt distress at higher levels of debt, but *if* they do get into trouble, the additional debt that they had managed to accumulate pre-shock will inflict supplementary damage on the economy compared to a less developed economy that got into trouble at lower debt levels. The positive correlation between income/capita and output loss has been documented by Sahay et al. (2003) for currency crises and by Abiad et al. (2009) for financial/banking crises, although these studies do not link this result to debt intolerance.

A potential criticism of specifications 2 and 5 is that they include overshooting*debt and debt, but not overshooting, which could lead to bias. As foreshadowed by discussion section III, adding overshooting (specifications 3 & 6) does not improve the regression's fit, its coefficient is not significant, and the coefficient on the interaction term remains unchanged. However, this specification is useful for computing the marginal effects discussed below.

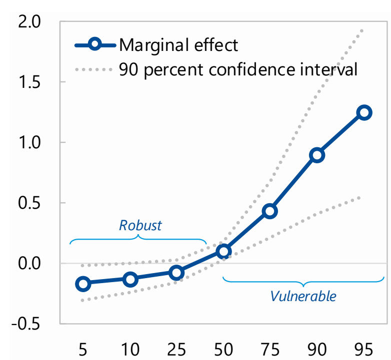
To quantify the output loss associated with a particular magnitude of overshooting, Figure 10 plots the marginal effect of overshooting on output loss at various percentiles of short-term debt, using specification 3 from Table 4.[25] The chart shows that the impact of overshooting on output is not significant below the 50th percentile of external short-term debt, or just under 5 percent of GDP. However, at the 75th percentile of the preferred debt measure (around 9 percent of GDP), an additional standard deviation of overshooting (around 5 p.p.) is associated with 1.7 percent of GDP larger output loss in the year following the shock.

Figure 10. Marginal effect of exchange rate overshooting on output loss in $T+1$ by percentile of external short-term debt (stable episodes only).



Note: The horizontal axis plots the percentiles of external ST debt a year prior to the onset of large depreciations. Larger values indicate larger *negative* deviation from pre-crisis output trend.

Figure 11. Marginal effect of pre-depreciation external short-term debt on output loss in $T+1$ by percentile of overshooting (stable episodes only).



Note: The horizontal axis plots the percentiles of overshooting in large depreciations. Larger values indicate larger *negative* deviation from pre-crisis trends of output/domestic demand/non-oil exports.

Since overshooting itself increases with external short-term debt, the two generally go together. Hence, the marginal effect on external short-term debt similarly varies with the magnitude of overshooting (Figure 11). The conclusion is that overshooting is only damaging when combined with significant currency mismatches, although that *is* generally the case. The variable impact of depreciation is in line with Cespedes et al. (2004), who distinguish

[25] Annex Figure 2 shows margin chart corresponding to specification 6 in Table 4 (stable episodes only).

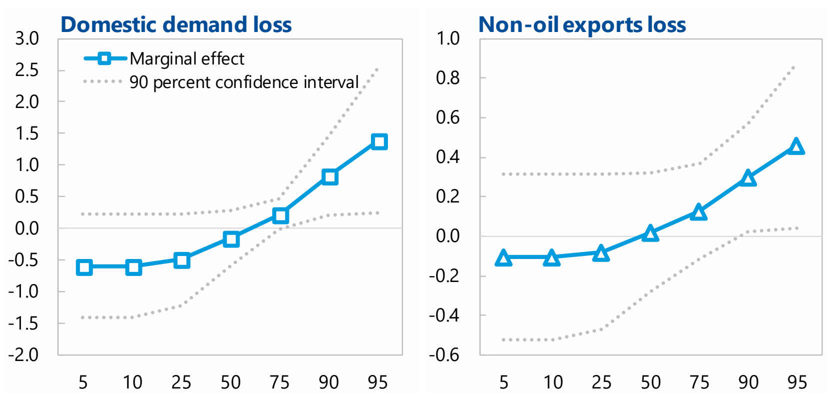
between financially "robust" and "vulnerable" countries. In the latter, the balance sheet effect dominates because of the currency mismatches associated with external borrowing.[26]

C. Domestic Demand vs. Export

The discussion in section II suggests that the balance sheet effect depresses output by affecting domestic demand, with investment hit particularly hard (e.g., Mendoza, 2010). At the other extreme, the naturally hedged export sector should be better insulated from the exchange rate shock, as the negative effect on the net worth from the liability side is partly offset by the positive effect on the asset and revenue side. This section tests this in the data.

Figure 12 plots the marginal effects of overshooting by the percentiles of ST debt on the loss of real domestic demand and real non-oil exports[27] for all episodes.[28] Both dependent variables are constructed analogously to output loss. The left chart show that the loss of domestic demand associated with a given overshooting is much larger than output loss: at the 75th percentile of external short-term debt, one additional percentage point of overshooting is associated with a loss of 0.9 percent of the pre-depreciation level of domestic demand, compared to 0.2 for output loss. On the other hand, positive the relationship between overshooting and non-oil exports loss becomes statistically significant only at very high percentiles of external short-term debt.

Figure 12. Marginal effects of overshooting on domestic demand loss and non-oil exports loss in $T+1$.



Note: Marginal effects are computed from specifications 2 and 3 in Annex Table 3. The horizontal axis plots the percentiles of external ST debt in $T-1$. Larger values indicate larger *negative* deviation from pre-crisis trends of respective variables.

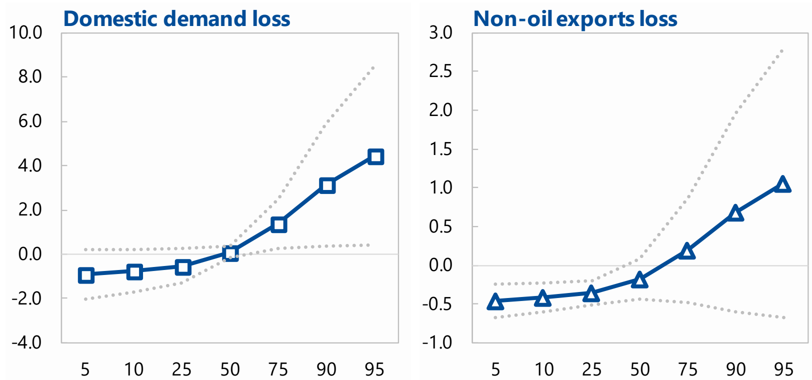
The marginal effect of external ST debt also differs between domestic demand and non-oil exports (Figure 13). In fact, when overshooting is low, external short-term debt is associated with an expansion—"negative loss" relative to pre-shock trend—of non-oil exports.

[26] Annex Figure 3 provides an alternative visualization of how the level of debt affects the output loss, by dividing the right plot in Figure 9 by quartiles of pre-shock external short-term debt. While the slope of the bivariate regression remains broadly unchanged, the fit improves dramatically at higher levels of debt.

[27] Use of non-oil exports attenuates somewhat the impact of dominant currency pricing and ToT shocks.

[28] Annex Figure 2 shows marginal effects for stable episodes only. Regression results are in Annex Table 3.

Figure 13. Marginal effects of $T-1$ external short-term debt on domestic demand loss and non-oil exports loss in $T+1$.

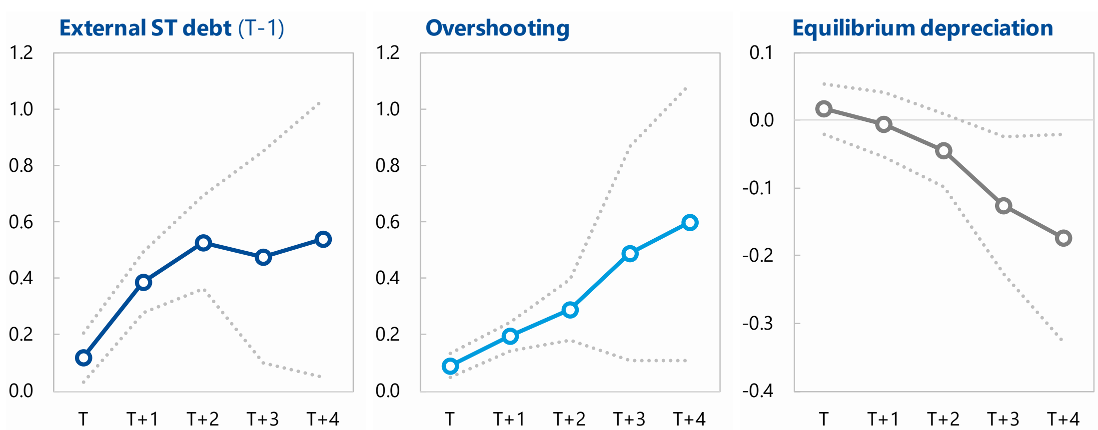


Note: Marginal effects are computed from specifications 2 and 3 in Annex Table 3. The horizontal axis plots the percentiles of overshooting. Larger values indicate larger *negative* deviation from pre-crisis trends of domestic demand/non-oil exports.

D. Output Loss Over the Medium Term

So far, the focus has been on output loss in $T+1$. However, the discussion in section II suggests that the relative strength of the expenditure switching and balance sheet effects should evolve, as the rigidities facing the latter recede over the medium term. To test this, I rerun output loss regression at different time horizons, from T through $T+4$. Regression results are in Annex Table 4 (specifications 1 through 5), while Figure 14 presents only marginal effects for the three key variables across specifications: external short-term debt, overshooting and equilibrium depreciation.

Figure 14. Marginal effect of pre-depreciation external short-term debt, overshooting and equilibrium depreciation on output loss in T through $T+4$.



Note: Dotted lines indicate 90 percent confidence intervals. Marginal effects are computed from specifications 1 through 5 in Annex Table 4. Marginal effects for ST external debt are computed at the average value of overshooting, and vice-versa. Larger values indicate larger *negative* deviation from pre-crisis output.

The impact of pre-shock debt and the magnitude of the overshooting are highly persistent and increasing through $T+2$. In other words, the balance sheet effect not only causes a level drop in GDP, but also affects the rate of growth in the early years. However, the rapidly

widening confidence bands beyond $T + 2$ suggest an increasing dispersion of outcomes as the original shock recedes into the past. On the other hand, the coefficient on equilibrium depreciation go from roughly zero in T to a statistically significant negative over the medium term; i.e., larger equilibrium depreciations are expansionary, but only over the medium term.

E. Extended Results and Robustness

Table 5 introduces additional controls informed by the empirical literature on currency and debt crises (results for stable episodes only are in Annex Table 5).

Specification 1 adds a dummy for large depreciations that coincide with banking crises, as identified in Laeven and Valencia (2018). As documented by Calvo and Reinhart (2000) and Cerra and Saxena (2008), dual crises are more damaging to output; in the analyzed sample, they raise the output loss by around 5 percentage points of pre-shock GDP. However, this does not affect the coefficient or significance of the overshooting*debt term. Specification 2 adds non-FDI flows cumulated over the three pre-shock years. It reproduces the finding of Sahay et al. (2003) that pre-currency crises portfolio inflows are a strong predictor of output loss. Specification 3 includes two external variables—trading partner growth and change in the terms of trade—with improvements in the latter associated with lower output loss.

Table 5. OLS regressions on output loss in $T + 1$: Extended specifications (all episodes)

GDP Loss (T+1)	(1)	(2)	(3)	(4)	(5)	(6)	(7)
Equilibrium depreciation (percent)	-0.015	-0.028	-0.029	-0.015	-0.014	0.024	-0.003
	(0.024)	(0.018)	(0.020)	(0.023)	(0.028)	(0.038)	(0.037)
Overshooting * External ST Debt/GDP (T-1)	0.021***	0.030***	0.024***	0.019***	0.020***		
	(0.004)	(0.005)	(0.004)	(0.004)	(0.004)		
External ST Debt (percent GDP, T-1)	-0.203***	-1.001**	-0.241***	-0.285***	-0.363***		
	(0.054)	(0.416)	(0.046)	(0.078)	(0.076)		
PPP GDP/capita (Log, T-1)	0.081*	0.136***	0.080**	0.078*	0.069*	0.032	0.024
	(0.042)	(0.042)	(0.038)	(0.040)	(0.040)	(0.023)	(0.023)
Dual Banking/currency crisis	4.859*	4.531	3.289	5.841**	5.179**		3.057
	(2.526)	(2.982)	(2.986)	(2.545)	(2.334)		(2.565)
Non-FDI Capital inflows (% GDP, cumulated T-3 to T-1)		0.283*					
		(0.157)					
Trading partner GDP (% change, T-1 to T+1)			-0.886				-0.769
			(0.640)				(0.481)
ToT (% change, T-1 to T)			-0.300*				-0.371***
			(0.168)				(0.114)
Domestic credit to private sector (% GDP, T-1)				0.066			
				(0.040)			
Domestic credit to private sector (p.p. GDP change, T-3 to T-1)					0.316***	0.038	-0.011
					(0.090)	(0.083)	(0.084)
Overshooting * Dom. credit to priv. sect. (p.p. GDP change, T-3 to T-1)						0.017***	0.015***
						(0.006)	(0.004)
Constant	-73.00*	-123.13***	-69.12*	-72.34*	-62.71*	-28.11	-17.80
	(39.93)	(40.12)	(36.90)	(38.05)	(37.61)	(22.47)	(22.94)
Observations	88	79	80	86	85	119	103
R^2	0.321	0.461	0.481	0.350	0.411	0.280	0.455

Note: Robust standard errors in parentheses. *, **, *** indicate significance at 10, 5 and 1 percent levels respectively.

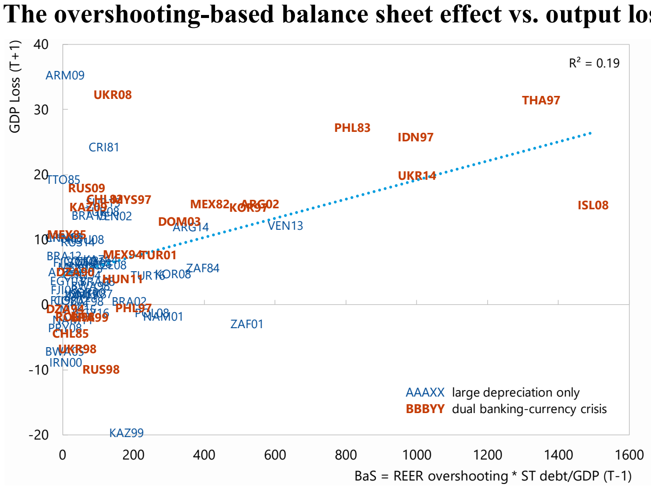
Specification 4 finds that the level of private credit/GDP is not a strong predictor of output loss. However, the *change* in private credit/GDP—a well-established early warning indicator of currency and banking crises (Frankel and Rose, 1996; Kaminsky and Reinhart, 1996)—is a good predictor of the damage inflicted by the shock (Specification 5). And the impact is significant: each additional percentage point of GDP increase in private credit over the three pre-shock years is associated with a 0.31 percent higher output loss in $T + 1$. In fact, change in private credit can be used as another proxy for currency mismatches (instead of ST debt), as rapid credit growth is almost invariably fueled by foreign financing. Specifications 7 and 8 replace the debt-based measure of the BaS with a credit growth-based measure; the main variable of interest is overshooting*credit growth. The coefficient is positive and significant at the 1 percent level. This specification has the added advantage of a larger regression sample, as WEO provides better coverage for private credit than for external short-term debt.

Additional robustness tests in Annex 3 confirm main findings. First, I rerun output loss regressions for sub-samples that exclude outliers or are built on definitions of currency crises previously utilized in the literature. Second, I test alternative measures of overshooting and equilibrium depreciation to address potential drawbacks of baseline measures in unstable episodes (section IV.B). One measure is based on ex-ante misalignment, which turns out to be a poor predictor of ex-post equilibrium depreciation; a notable finding in itself.

F. The Importance of Banking Crises

Table 5 above already showed that dual currency-banking crises exhibit larger losses. Despite this, controlling for banking crises did not affect the significance of the coefficient on the overshooting*debt term, and only marginally reduced its magnitude. However, dual crises differ on a number of dimensions from "currency-only" episodes, and larger output loss is only one such difference (see Annex Figure 5). Figure 15 revisits the scatter plot from Figure 9 to reveal that dual crises dominate the relationship between the overshooting-based measure of the BaS effect and output loss.

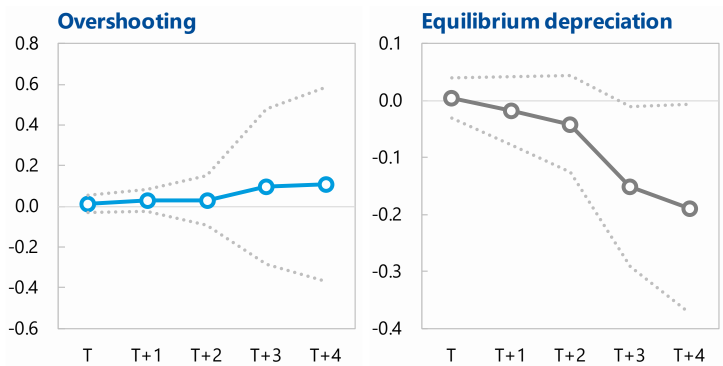
Figure 15. The overshooting-based balance sheet effect vs. output loss in $T + 1$.



Note: Chart includes 84 large depreciations with non-zero external short term debt.

Annex Table 4 specifications 6 through 10 rerun the medium-term output loss regressions for a subsample that excludes dual crises. Across years, the coefficient on the overshooting*debt term is no longer statistically significant. The left panel in Figure 16 shows that the marginal effect of overshooting retains the expected sign over the medium term, but loses in magnitude and significance. On the other hand, the expansionary effect of equilibrium depreciation—negative effect on output loss—is left intact.

Figure 16. Marginal effect of pre-depreciation external short-term debt, overshooting and equilibrium depreciation on output loss in T through $T + 4$ (dual crises excluded).



Note: Dotted lines indicate 90 percent confidence intervals. Marginal effects are computed from specifications 6 through 10 in Annex Table 4. Marginal effects for overshooting are computed at the average value of external short term debt.

Banking crises should not be interpreted as outliers; they account for a *third* of the sample.[29] Instead, dual crises should be seen as the ultimate manifestation of very strong balance sheet effects, driven by large indebtedness (and associated currency mismatches), characterized by large overshooting, and resulting in significant output losses.

G. Addressing Endogeneity Concerns

Endogeneity is pervasive whenever measures of exchange rate movements are used as explanatory variables. In fact, the discussion in section II makes it clear that the relationship from overshooting to output loss is not necessarily causal. Overshooting is a *manifestation* of the processes underlying the balance sheet effect, and at the same time an element perpetuating it. The size of overshooting carries useful information about the strength of the balance sheet effect, and that's why an overshooting-based measure of the BaS is a strong predictor of output loss. Establishing a simple correlation between overshooting and output loss—which the OLS setup does—is sufficient to support the paper's thesis. However, not addressing endogeneity puts a question mark on estimated coefficients.

Equations (8) and (9) in section III lay out the general setup for using two- and three-stage least square (2SLS and 3SLS) regressions to address bias: one equation for the magnitude of overshooting (which serves as the first stage in 2SLS), and one for output loss. An important assumption underpinning 2SLS is that output loss does not affect the magnitude of

[29] Elimination of true outliers—episodes with largest overshooting*debt—leaves results intact (Annex 4).

overshooting. However, agents can imply from current fundamentals that output loss is likely to be significant, pushing the currency to depreciate further and hence raising overshooting. This makes 3SLS more suitable, as it explicitly allows for two-way causality.

Table 6 presents both 2SLS and 3SLS estimation results. These show that, if anything, OLS regressions bias down the size of the coefficient on overshooting*debt. Both two- and three-stage least square estimations produce coefficients (0.030 to 0.044, depending on estimator and sample) that are considerably larger than those obtained from OLS regressions (around 0.025). Other OLS findings, such as the negative impact of ST debt and the positive impact of GDP/capita on the output loss regression, also survive under these alternative estimators.

Table 6. 2SLS and 3SLS regressions on overshooting and output loss in $T + 1$

	All episodes				Stable episodes only			
	2SLS		3SLS		2SLS		3SLS	
	Overshooting	Output loss	Overshooting	Output loss	Overshooting	Output loss	Overshooting	Output loss
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Equilibrium depreciation (percent)	0.048	-0.096	0.044	-0.005	0.240*	-0.033	0.231**	0.087
	(0.100)	(0.154)	(0.067)	(0.033)	(0.133)	(0.163)	(0.105)	(0.077)
External ST Debt (percent GDP, T-1)	4.605**	-0.363*	5.224*	-0.416***	3.747*	-0.423*	4.453	-0.461***
	(2.139)	(0.195)	(3.021)	(0.152)	(2.015)	(0.233)	(3.098)	(0.166)
Peg (T-1)	14.143**	-4.199	15.704**		16.953**	-5.685	19.576***	
	(5.987)	(9.976)	(6.112)		(7.196)	(11.417)	(6.961)	
Reserves (percent GDP, T-1)	-0.175**	0.088	-0.261		-0.178**	0.130	-0.289	
	(0.076)	(0.118)	(0.190)		(0.084)	(0.132)	(0.197)	
Trade openness (X+M in percent GDP, T-1)	-0.186***	0.069	-0.182**		-0.178***	0.067	-0.156*	
	(0.055)	(0.108)	(0.091)		(0.055)	(0.122)	(0.091)	
PPP GDP/capita * External ST Debt	-0.004**		-0.005*		-0.004*		-0.004	
	(0.002)		(0.003)		(0.002)		(0.003)	
Overshooting (percent)		0.325		-0.134		0.279		-0.223
		(0.685)		(0.198)		(0.769)		(0.217)
Overshooting * External ST Debt/GDP (T-1)		0.030**		0.041***		0.034**		0.044***
		(0.012)		(0.013)		(0.015)		(0.014)
PPP GDP/capita (Log, T-1)		0.126***		0.114***		0.129***		0.114***
		(0.041)		(0.024)		(0.042)		(0.027)
Constant	29.73***	-126.08**	30.40***	-100.95***	29.61***	-128.87**	29.49***	-101.00***
	(4.96)	(50.96)	(6.81)	(24.07)	(5.23)	(51.84)	(7.05)	(26.54)
Observations	93	83	83	83	75	67	67	67
R^2	0.160	0.373	0.173	0.344	0.256	0.419	0.274	0.337

Note: For 3SLS regressions, endogenous variables include overshooting, output loss and overshooting*external ST debt. Standard errors in parentheses. *, **, *** indicate significance at 10, 5 and 1 percent levels respectively.

To conclude, the relationship between the overshooting-based BaS and output loss is not due to OLS's inherent weaknesses in dealing with endogeneity. In fact, OLS likely provides lower-bound estimates of the link between the overshooting-based BaS and output loss.

VII. CONCLUSIONS AND POLICY IMPLICATIONS

In this paper, I propose a novel approach to interpreting large depreciation episodes, in which real exchange rate overshooting signals the relative strength of the balance sheet and expenditure switching effects. I then successfully test several implications of this insight. First, the magnitude of real exchange rate overshooting is driven by factors generally associated with the balance sheet effect: high external short-term debt, low reserves, low

trade openness. Second, overshooting-based measures of the balance sheet effect are a powerful predictor of output loss in large depreciation episodes. The effect is persistent and, as expected, affects domestic demand stronger than exports. This finding is robust to additional controls, alternative estimation techniques, sample restrictions, various proxies for currency mismatches, and definitions of overshooting. Third, the balance sheet effect dissipates over the medium term, while expenditure switching takes time to materialize.

Does the finding that an overshooting-based measure of the balance sheet effect is negatively correlated with subsequent output imply that it's optimum to resist overshooting? Not necessarily. First, the paper is silent on how policy interventions affect overshooting, although it does identify pre-existing policy settings that are likely to help contain it: flexible exchange rate, ample reserves. Second, I show that overshooting is not damaging if it is not associated with—and driven by—currency mismatches, as proxied by high external short-term debt. Therefore, if mismatches are *known* to be limited, large movements in the real exchange rate should not be feared. This also underscores the crucial importance of containing currency mismatches in the first place. Third, the baseline definition of overshooting is computed with the benefit of 20/20 hindsight. In the midst of the episode, it is anyone's guess where the exchange rate will settle a year or two later (and hence what overshooting will be), and ex-ante estimates of misalignment are unlikely to provide accurate guidance (Annex 3). Fourth and finally, overshooting is most damaging when a large depreciation is accompanied by a banking crisis, which is the ultimate manifestation of strong balance sheet effects. So avoiding a dual crisis is likely the best defense against large output losses.

The fact that results are largely driven by dual crises may have policy implications and should be further investigated. One interpretation of this finding is that a large depreciation reduces output primarily by destabilizing the financing sector. This would suggest that crisis interventions should focus directly on preserving financial stability instead of resisting overshooting. Taking this argument beyond what is directly supported by the paper, this could suggest that scarce international reserves should be used in ways that raises the probability of preserving financial stability. For example, providing FX emergency liquidity assistance to well-capitalized banks may prove superior to intervening in the broad FX market. That's because FX interventions help *all* market participants close their currency mismatches—including foreign investors and intermediaries—and so only a portion of used reserves ends up easing balance sheet strains of domestic agents, and domestic financial intermediaries in particular. If confirmed, this result would contribute to the ongoing discussions on integrated policy frameworks (Gopinath 2019), which analyzes policy options in settings that deviate from the Mundell-Fleming model. However, endogeneity is pervasive in this discussion, and forming a definitive view would require incorporating policy interventions—particularly on the financial sector side—into the analysis of both determinants and consequences of overshooting.

The paper focuses on testing one fundamental hypothesis—that overshooting captures the relative strength of the balance sheet effect and foreshadows subsequent output losses—and leaves ample room for future work. One venue has been mentioned above: adding crisis policy interventions into the analysis, which would require identifying reasonably exogenous policy measures. A second obvious venue is underpinning the empirical analysis with a theoretical model, in which financial frictions that give rise to the balance sheet effect are combined with rigidities that delay and attenuate expenditure switching; Basu et al. (2020) provide all the necessary ingredients for that.

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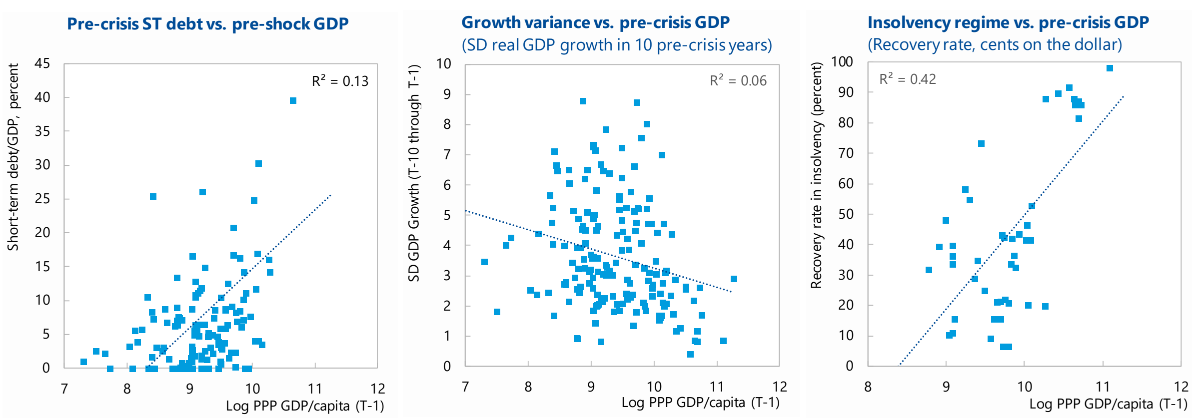
Annex 1. Debt Intolerance as Consequence of Financial Frictions

Reinhart, Rogoff and Savastiano (2003) document that less developed countries encounter debt sustainability issues and face default at much lower levels of external debt. They link this "debt intolerance" to countries' credit history (i.e., number of defaults). However, it can be traced directly to the net margin constraint underpinning the balance sheet effect.

In Townsend (1979), which underpins many models of contractionary currency crises, the sensitivity of the risk premium to the debt-to-net worth ratio depends positively on (i) the distribution of shocks, which gives rise to information asymmetry, and (ii) the verification (bankruptcy) costs the lender has to incur in case of default. Both factors vary across countries, with less developed economies suffering from both higher information asymmetries and higher verification costs. Higher "information asymmetry" can be driven by greater variance of shocks, and hence a larger share of ex-post outcomes falling below the bankruptcy threshold. Catão and Kapur (2004) model this and find empirical evidence for the link between GDP volatility experienced by EMs and spreads. "High verification costs" means that the creditor loses a larger share of the investment if the borrower goes bankrupt.

As shown in the figure below, the sample of analyzed large depreciations supports the link between severity of financial frictions and debt intolerance. Richer countries get into trouble at higher levels of external ST debt (left panel); i.e., debt intolerance is present in the data. Richer countries had lower growth variability pre-depreciation (middle panel), as well as more developed insolvency regimes, as documented by higher recovery rates for creditors.

Figure. Debt intolerance and its drivers



Note: Countries with SD of GDP growth above 10 are excluded (these mostly include conflict and post-conflict states).

The very terms *emerging* and *developing* markets suggest that financial markets are more prone to frictions and have less developed institutions for mitigating them (e.g., credit bureaus, bankruptcy courts and out-of-court debt restructuring mechanisms). Ultimately, for a certain reduction in net worth, interest rates increase more in less developed countries, making even moderate levels of debt potentially unsustainable. In short, "debt intolerance" can be (largely) attributed to cross-country variations in the severity of financial frictions.

ANNEX 2. CRITERIA FOR INCLUSION OF LARGE DEPRECIATION EPISODES[30]

Large depreciation episodes are identified on the log series of the end-of-period monthly bilateral exchange rate vis-à-vis the US dollar. Four criteria have to be met, with the first two conceptually identical to Frankel and Rose (1996) and Cavallo et al. (2005).

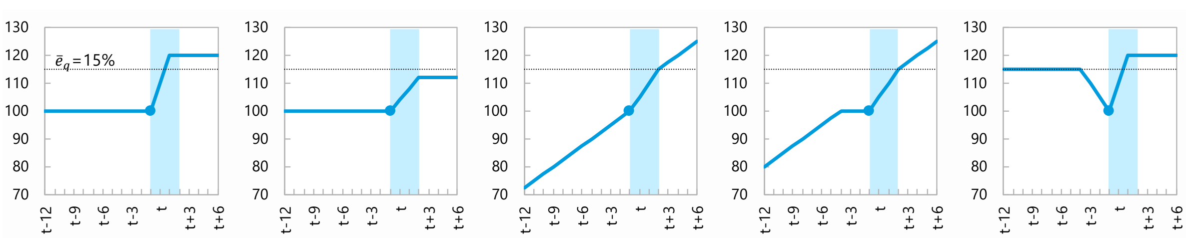
1. *The depreciation must be large.* $\Delta e_{q,t}$, the three-month (quarterly) growth, must be above $\bar{e}_q$, the 90th percentile cutoff. This ensures that the depreciation is significant enough in magnitude to be considered "large".
   $\Delta e_{q,t} = e_t - e_{t-3} > \bar{e}_q$, where $e_t = \ln(E_t)$ and $\bar{e}_q = P_{90}(\Delta e_q)$

2. *The depreciation must accelerate relative to the previous period.* Δe_{qq}, the 3 month-on-3 month depreciation, must be above the 90th percentile, but not exceed the cutoff from the first criterion $\bar{e}_q$. This eliminates episodes where the exchange rate depreciates continuously (e.g., in a high inflation environment).
   $\Delta e_{qq,t} = (e_t - e_{t-3}) - (e_{t-3} - e_{t-6}) > \ \bar{e}_{qq}$, where $\bar{e}_{qq} = \min\left(P_{90}\left(\Delta e_{qq}\right), \bar{e}_q\right)$

3. *The depreciation must accelerate relative to the average in the preceding year.* Δe_{qy}, the 3-month-on-preceding year's average depreciation (expressed in terms of three month), must be above the 90th percentile, but not exceed $\bar{e}_q$. This eliminates episodes where depreciation resumes following a short-lived period of stability.
   $\Delta e_{qy,t} = (e_t - e_{t-3}) - (e_{t-3} - e_{t-15})/4 > \bar{e}_{qy}$, where $\bar{e}_{qy} = \min\left(P_{90}\left(\Delta e_{qy}\right), \bar{e}_q\right)$

4. *The depreciation must be significant on an annual basis.* The year-on-year depreciation in at least one of the first six months into the episode must be above the 75th percentile. This excludes rebounds following short-lived appreciations.
   $\Delta e_{yy,t} = e_s - e_{s-12} > \bar{e}_{yy}$ for at least one $s = (t-2, t+6)$, where $\bar{e}_{yy} = P_{75}(\Delta e_{yy})$

Figure. Large depreciation episode identification criteria illustrated



All criteria met

Criterion 1 not met: depreciation too small

Criterion 2 not met: quarter-on-quarter acceleration is too small.

Criterion 3 not met: exchange rate catching up to previous depreciation trend following brief period of stability.

Criterion 4 not met: depreciation is mostly a rebound following short appreciation.

Note: The shaded area marks the three-month rolling window over which the four criteria are assesses. The thresholds used are $\bar{e}_q = 15\%$, $\bar{e}_{qq} = 10\%$, $\bar{e}_{qy} = 10\%$, $\bar{e}_{yy} = 21\%$.

[30] Adapted from Culiuc and Deb (2020).

A number of episodes identified in Culiuc and Deb (2020) are excluded, as their origins and/or output dynamics are unlikely to be driven by processes discussed in section II:

- Developing markets, as they are less exposed to private capital flows, which are an important ingredient of analyzed processes.
- Nominal peak depreciation exceeding 1,000 percent within the 24 months from the onset of the episode. This eliminates cases with hyper- and very high inflation.
- Episodes in transition economies between 1987 and 1996, as large depreciations at the time where driven by the pains of massive structural transformations.
- Episodes with peak NEER depreciation under 10 percent. This eliminates cases where interlinked countries depreciated together vis-à-vis the dollar, but where dollar transactions and debt were limited (European countries during the 1992 ERM crisis).
- GFC-era episodes where in the second year the currency is more appreciated to the dollar than pre-shock, as the GFC represented a brief but large *appreciation* episode of the US dollar, relative to which most floating currencies depreciated.

ANNEX 3. ADDITIONAL ROBUSTNESS

A. Restricted Samples

A potential concern stems from the new dataset used to identify large depreciation episodes. Here I test the sensitivity of results to the analyzed sample. It also takes the opportunity to test the robustness of the overshooting*credit growth measure of the BaS discussed in section VI.E. The three approaches described below are tested, and results are presented in Annex Table 6.

- *Eliminating outliers.* I eliminate the top 10 percent of observations in terms of the magnitude of the balance sheet effect (overshooting*debt in specification 1 and overshooting*credit growth in specification 2). The coefficient on the BaS is lower (0.020 vs. 0.025 in Table 4 specification 2), but remains significant at the 5 percent level. Results for the credit growth-based measure of the BaS (specification 2) are even stronger compared to the full sample results (Table 5 specification 6).
- *Identifying episodes on annual bilateral exchange rate series* (specifications 3 and 4). Here, I only take the subset of episodes that are also flagged using the currency crisis definition in Laeven and Valencia (2013), which in turn builds on Frankel and Rose (1996): a nominal depreciation vis-à-vis the U.S. dollar of at least 30 percent in a year that is also at least 10 percentage points higher than the rate of depreciation in the year before. This does not alter the results: coefficients on the BaS terms remain identical to those under the baseline, and are significant at the 1 percent level.
- *Identifying episodes on annual REER series* (specifications 5 and 6). Chapter 3 in IMF (2015b) identifies large depreciations on the annual REER series (instead of the bilateral rate vis-à-vis the U.S. dollar), by applying another variation of the Frankel and Rose (1996) approach.[31] This only reinforces main results: coefficients on both measures of the BaS are slightly higher than under baseline specifications.

B. Alternative Measures of Overshooting

To address potential drawbacks of the baseline definition of overshooting when applied to unstable episodes (see section IV.B), I test alternative definitions in output loss regressions (Annex Table 7). The measures are detailed below; most are illustrated in Annex Figure 6.

- *Peak REER minus REER in month* $t + 23$ (specifications 2 & 10 in Annex Table 7). This reproduces the ex-post equilibrium measure used in Cavallo et al. (2005).

[31] Specifically, a large depreciation in one in which (1) a real effective depreciation at or above the 90th percentile of all annual depreciation rates (6 percent for advanced economies and 10 percent for emerging markets) and (2) a change in the real effective depreciation at or above the 90th percentile of all changes in annual depreciation rates (7 percentage points for AEs and 12 percentage points for EMs).

- *Peak REER minus the post-max minimum* (specifications 3 & 11). Equilibrium is defined as minimum REER (within 24 months) following peak depreciation.
- *Peak REER minus trend REER in month* $t + 23$. Specifications 4 & 12 use the HP-filtered trend, and specifications 5 & 13 use a Christiano-Fitzgerald (CF) trend.[32]
- *Maximum positive deviation from trend* (specifications 6 & 14 for HP trend and 7 & 15 for CF trend). In some cases (e.g., South Africa in Figure 5), REER deviates significantly early in the episode, while subsequent movements are much smaller. A natural measure of overshooting is then the maximum spike above this trend.[33]
- *Peak REER minus ex-ante REER misalignment* (specifications 8 & 16). Policy discussions often focus on ex-ante REER misalignment, i.e., the REER depreciation necessary to bring the economy into external balance. IMF's External Balance Assessment (EBA) is the best-known methodology for computing the misalignment (IMF, 2013; Phillips et al., 2013; Cubeddu et al., 2019). However, due to significant data requirements, it has a relatively narrow country and time coverage. Instead, I compute the equilibrium REER in the year preceding the large depreciation using an augmented Balassa-Samuelson regression,[34] and then adjust to account for REER changes through the pre-shock month. Overshooting is computed as the difference between maximum depreciation and this ex-ante equilibrium level.

Across all eight measures of overshooting, the coefficient on the overshooting*debt term remains significant at least at the 5 percent level. The point estimates of the coefficient remain within the narrow range of 0.022–0.025 for all but the last specification.

Specification 8, based on an ex-ante concept of equilibrium, exhibits a lower coefficient on the overshooting*debt term (0.016), although it remains significant at the 1 percent level. It also shows a positive and significant correlation between the misalignment-based equilibrium exchange rate and subsequent output loss, which is not as expected. The reason for the lower coefficient is related to the fact that estimated ex-ante misalignments are generally lower than ex-post equilibrium depreciations: the means are 9.3 and 20 percent respectively, while medians are 9.5 and 16.2 (also see Annex Figure 7). Lower ex-ante equilibrium depreciation translates into larger overshooting, and hence lower estimated coefficient on the BaS term.

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[32] HP filter has λ=400 and CF filters out stochastic cycles below 2 and above 24 months.

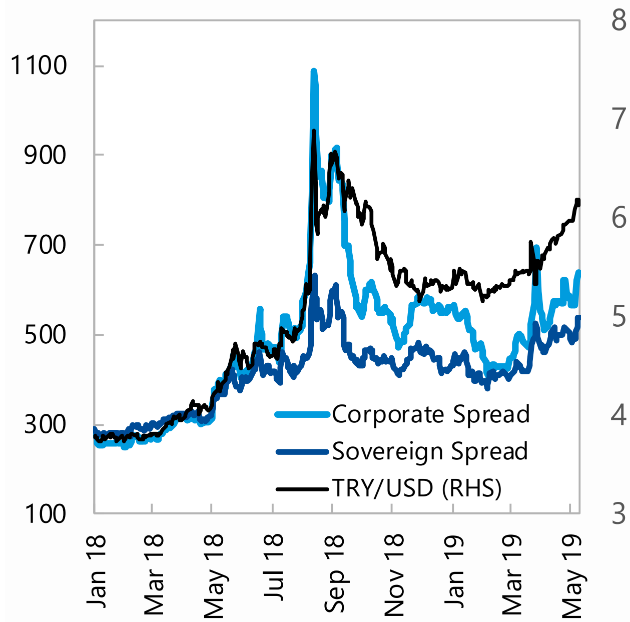
[33] This definition of overshooting can be linked to the "leaning against the wind" objective often motivating exchange rate interventions. Central Banks generally don't resist fundamental depreciations, but reduce excess volatility. In that sense, the trend can be viewed as the "policy-preferred" adjustment path of the REER.

[34] I start with the Bluedorn et al. (2013) implementation of the approach first proposed by Rodrik (2008). I regress the RER—measured by the price level relative to that of the United States from the Penn World Table—on real GDP per capita relative to that of the United States. Predicted values provide the equilibrium level of the real exchange rate, whereas the and residuals capture misalignment. EBA's Index REER regression informs a few changes to the regression. First, country and year fixed effects are added. Second, a number of EBA regressors capturing non-policy (external and demographic) factors are also introduced: terms of trade, trade openness, trading partner GDP, dependency ratio and population growth. Results available upon request.

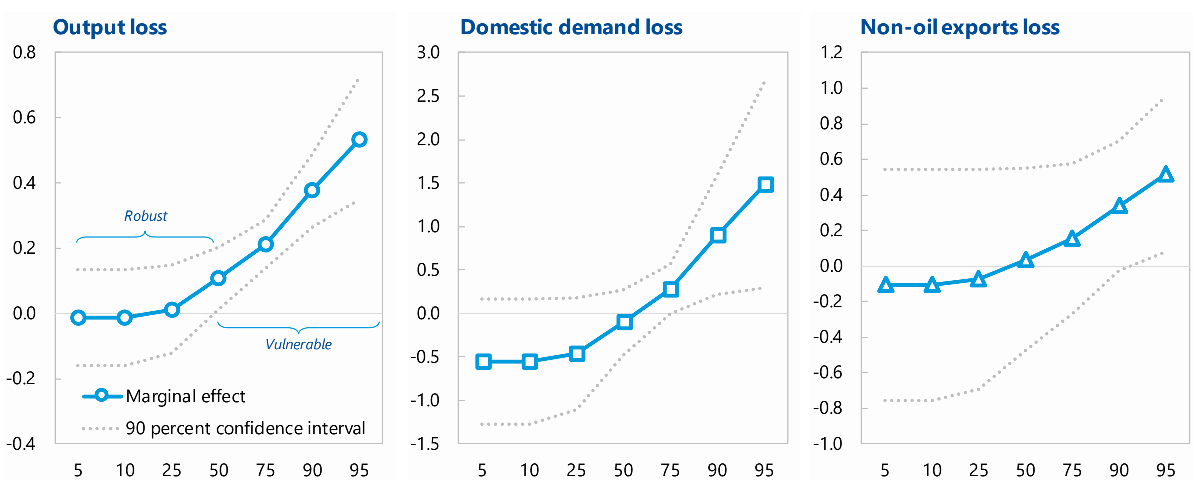
This, of course, raises the question of why estimated ex-ante misalignments are lower, on average, than ex-post equilibrium depreciations. It could be driven by an misspecified Balassa-Samuelson regression, and this will require further testing. An alternative explanation is that ex-ante misalignments may be ill-suited for assessing the required REER correction in extreme cases. As discussed earlier, the fire sale of domestic assets is a key ingredient of the balance sheet effect. To the extent these assets are bought by foreigners, the fire sale can reduce the country's net IIP. Conceptually and empirically (IMF's EBA), the NIIP is a key determinant of external balance equilibrium, hence the depreciation itself may be endogenously raising the equilibrium REER. This hypothesis is highly speculative, and requires additional testing (e.g., crises can also be associated with NIIP improvements when sustainability is achieved through debt restructurings). It nevertheless suggests a potential venue for future research linked to assessment of external sustainability in near-crisis cases.

Annex Figures and Tables

Annex Figure 1. Nominal exchange rate and interest rate spreads dynamics (Turkey 2018).

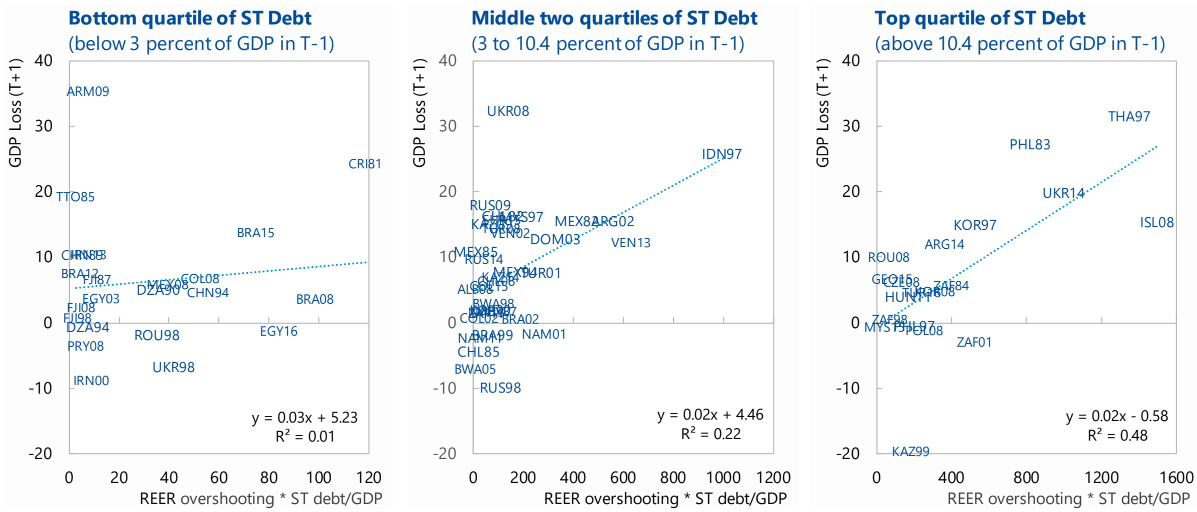


Annex Figure 2. Marginal effect of exchange rate overshooting on domestic demand and non-oil exports loss in $T + 1$ by percentile of external short-term debt (stable episodes only).



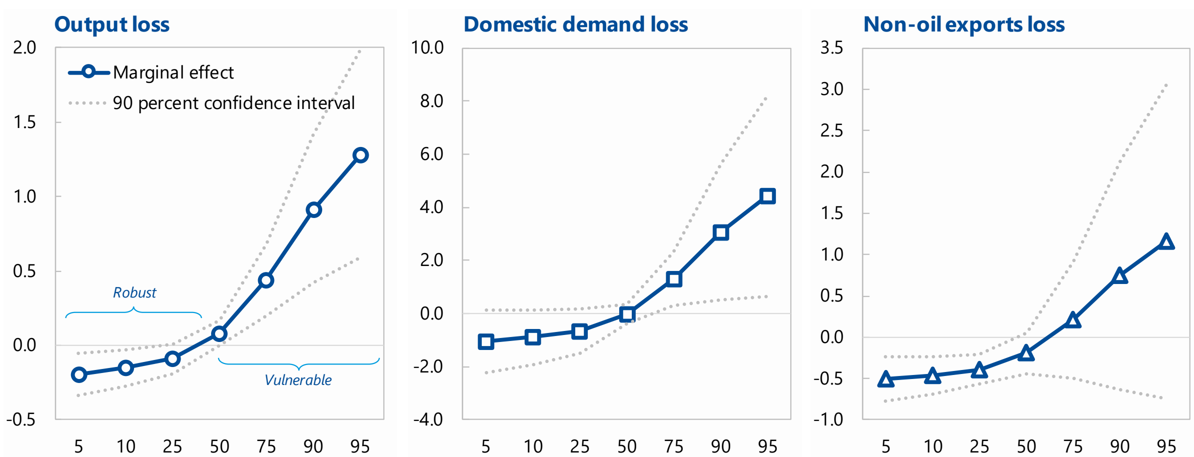
Note: Marginal effects are computed from specifications 4, 5 and 6 in Annex Table 3. The horizontal axis plots the percentiles of external short-term debt a year prior to the onset of large depreciations. Larger values indicate larger *negative* deviation from pre-crisis domestic demand/non-oil exports trends.

Annex Figure 3. The overshooting-based balance sheet effect vs. output loss in $T + 1$ by quartiles of external short-term debt



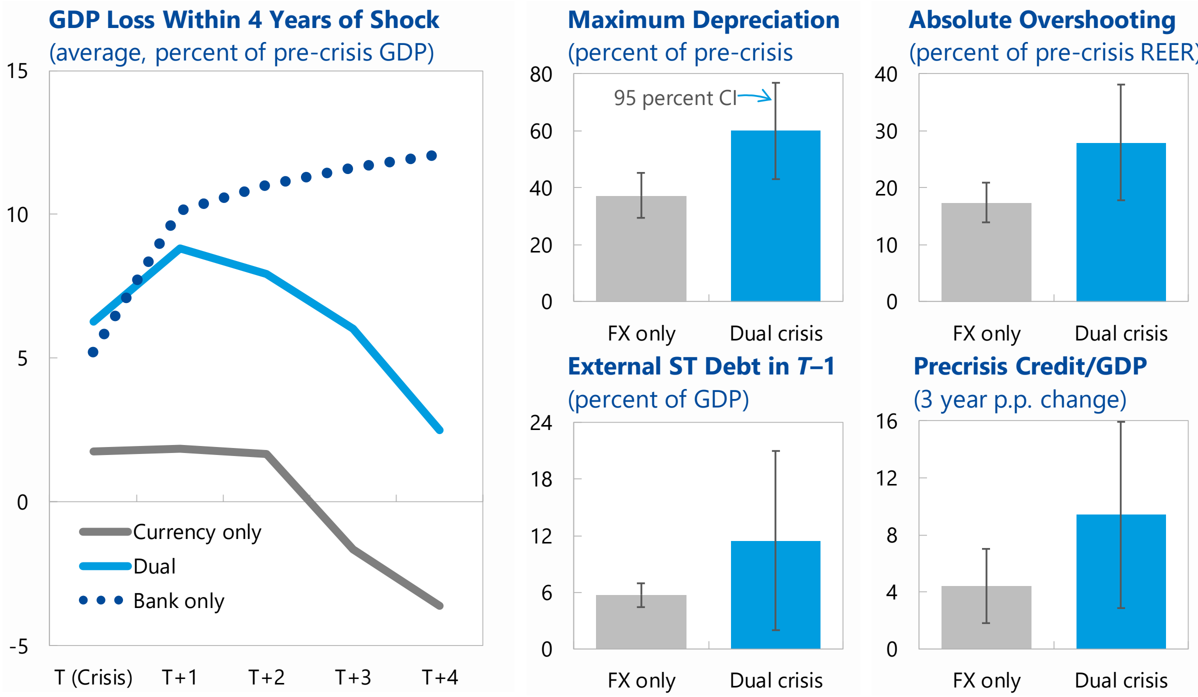
Note: Plots includes 84 large depreciation episodes with non-zero external ST debt. Individual episodes are identified by the 3-letter ISO code and the 2-digit year in which the episode had occurred.

Annex Figure 4. Marginal effect of pre-depreciation external short-term debt on output loss, domestic demand loss and non-oil exports loss in $T + 1$ by percentile of overshooting (stable episodes only).



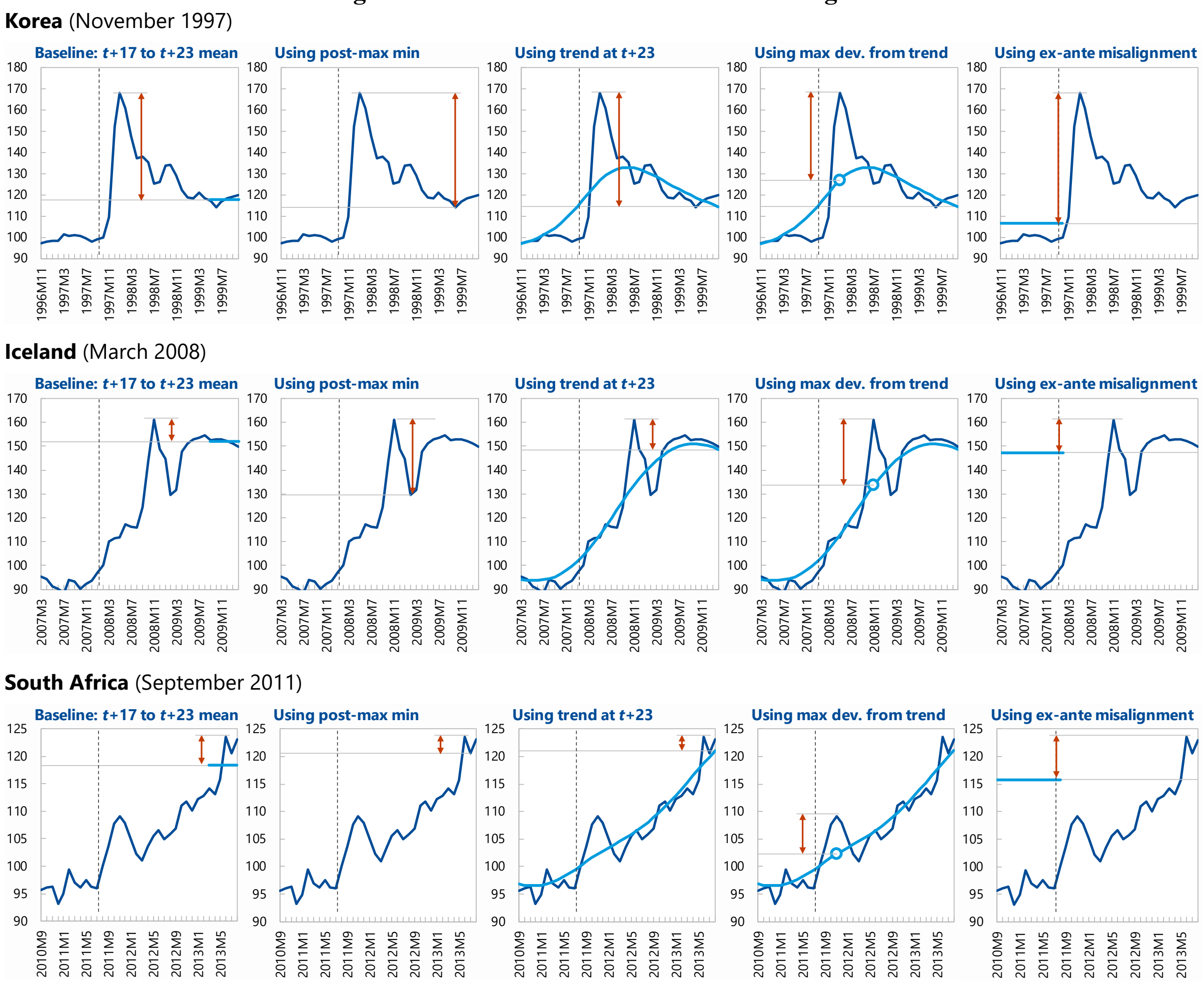
Note: Marginal effects are computed from specifications 1, 2 and 3 in Annex Table 3. The horizontal axis plots the percentiles of overshooting in large depreciations. Larger values indicate larger *negative* deviations from pre-crisis trends.

Annex Figure 5. Summary statistics for large depreciations and dual banking-currency crises



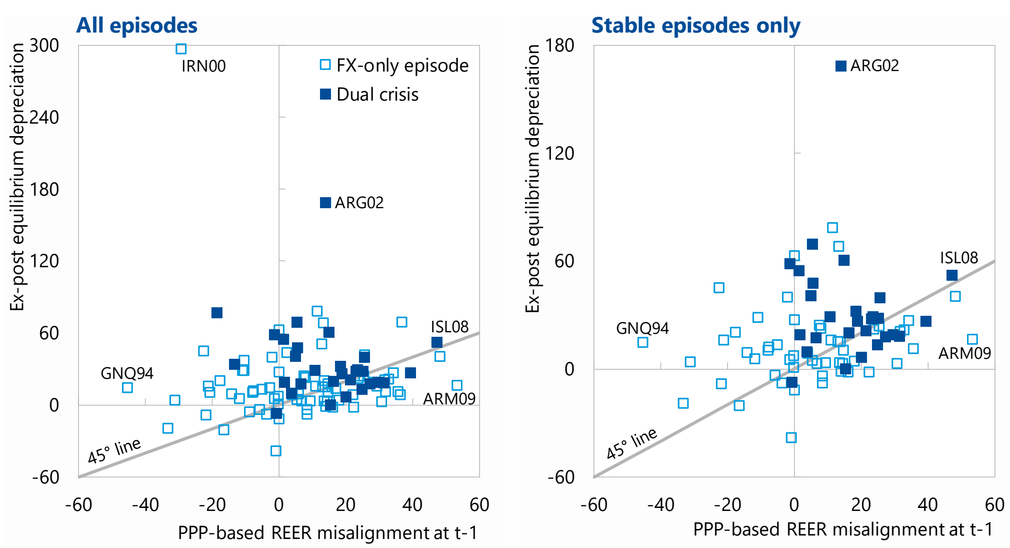
Note: Banking crisis data from Laeven and Valencia (2018). Output loss for "bank only" episodes is computed using the methodology described in section III.

Annex Figure 6. Various definitions of overshooting illustrated



Note: Red arrows mark the overshooting under each definition. The REER is normalized to 100 at $t-1$ (dotted line).

Annex Figure 7. Ex-ante REER misalignment vs. ex-post equilibrium depreciation



Note: Ex-post equilibrium depreciation uses baseline definition (average REER in months $t+18$ through $t+23$). Key outliers identified by the ISO3 country code and the 2-digit year of the episode.

Annex Table 1. Key summary statistics of large depreciation episodes

Episode	LCU/USD Rate		REER					External debt and private credit in T-1			GDP Loss	Laeven and Valencia sample	2015 WEO Ch. 3 sample
	Peak month	Max Dep	Peak month	Max Dep =	Eq Dep +	Overshooting	Stable	ST Debt, percent GDP	STRM Debt, percent GDP	Credit/GDP 3-yr change	(T+1)		
Advanced Economies													
Australia 02/1985	17	36.3	18	51.2	43.9	7.3	0			2.4	-3.7	0	1
Australia 08/2008	5	46.5	3	28.9	-1.2	30.0	1			17.9	2.6	1	0
Australia 05/2013	22	35.1	21	18.6	15.7	2.9	0			-0.8	0.8	0	0
Belgium 02/1982	23	46.2	23	11.4	10.2	1.2	0			2.4	7.1	0	0
Finland 09/1992	10	53.3	6	28.1	18.5	9.6	1			13.6	14.9	0	1
France 06/1982	19	40.9	19	12.4	11.0	1.4	0			0.2	4.6	0	0
Greece 01/1983	23	82.1	0	17.1	12.1	5.0	1			1.2	11.3	1	1
Greece 06/1988	11	23.5	10	0.5	-3.5	3.9	1			-2.7	-6.3	0	0
Greece 03/1991	23	36.1	2	2.0	-3.8	5.8	1			-2.8	-2.4	0	0
Iceland 01/1982	23	250.8	17	33.1	20.3	12.7	1			4.8	12.6	1	1
Iceland 11/1984	14	25.3	1	12.8	4.3	8.5	1			10.2	-1.6	0	0
Iceland 05/1988	18	61.7	18	15.6	14.3	1.3	0			-3.9	8.6	0	0
Iceland 03/2008	8	116.1	8	61.1	52.3	8.8	1	53.2		91.6	15.5	1	1
Italy 09/1992	15	58.1	15	29.9	27.0	2.9	1			4.7	5.9	0	0
Japan 01/1982	9	26.1	9	17.3	0.9	16.4	1			6.3	3.2	0	1
Japan 12/2012	23	43.4	23	38.6	29.0	9.6	0			-5.2	-1.9	0	1
Korea, Republic of 11/1997	1	75.6	2	68.0	17.7	50.3	1	9.6		7.7	15.1	1	1
Korea, Republic of 11/2000	4	16.5	5	13.3	4.5	8.8	1	6.6	11.7	16.0	2.1	0	0
Korea, Republic of 08/2008	6	51.6	6	28.5	7.3	21.1	1	14.9	17.6	25.1	4.9	1	1
Luxembourg 02/1982	23	46.2	2	6.9	4.6	2.3	1			16.7	5.9	0	0
New Zealand 07/1984	10	41.8	1	22.7	5.6	17.1	1			0.7	-5.9	1	0
Norway 09/2008	5	30.4	3	15.7	1.1	14.6	1			2.2	6.2	0	0
Portugal 06/1982	23	95.1	13	23.6	16.2	7.4	1			10.9	6.3	1	0
Spain 09/1992	10	57.5	11	23.2	21.1	2.1	1			4.2	6.3	0	0
Sweden 10/1982	23	36.5	4	17.4	9.3	8.0	1			0.6	-2.3	0	1
Sweden 10/1992	13	60.1	14	32.7	28.5	4.2	1			-2.9	4.1	0	1
Sweden 08/2008	6	49.4	7	19.9	9.9	10.0	1			19.4	11.5	0	0
Switzerland 03/1991	3	18.5	13	10.3	3.4	6.9	1			14.1	5.5	0	0
United Kingdom 09/1992	5	39.0	5	20.3	15.3	4.9	1			10.8	6.3	0	0
United Kingdom 08/2008	6	39.5	5	18.3	13.4	4.9	1			32.9	11.0	1	1
Emerging Markets													
Albania 01/1997	5	73.4	5	27.2	-11.4	38.6	1	0.0	0.5		-12.7	1	1
Albania 10/2008	19	29.2	20	9.9	8.6	1.3	0	2.1	6.4	20.2	5.2	0	0
Algeria 11/1990	11	133.5	11	75.9	48.0	28.0	1	2.7		-11.4	5.2	1	1
Algeria 04/1994	21	107.3	15	66.1	60.6	5.5	1	1.5		-49.5	-0.5	1	1
Argentina 01/2002	5	275.2	5	265.4	168.6	96.8	1	10.8	16.6	-3.3	15.7	1	1
Argentina 01/2014	23	101.5	1	12.5	-20.3	32.8	1	10.3	22.9	3.1	12.1	1	1
Armenia 03/2009	12	31.0	8	37.7	16.4	21.3	1	0.5	0.7	11.3	35.4	0	0
Azerbaijan, Rep. of 02/2015	23	144.3	18	73.2	69.2	4.0	0			13.4	31.5	1	0
Botswana 06/1998	23	31.0	3	17.1	4.9	12.3	1	5.9	9.0	-4.3	3.0	0	0
Botswana 05/2005	16	41.4	22	21.9	20.4	1.5	0	6.2	5.1	5.4	-7.0	0	0
Brazil 01/1999	1	70.8	1	53.4	28.0	25.4	1	4.4	8.1	-13.1	-1.8	1	1
Brazil 05/2002	4	64.9	5	60.9	22.8	38.1	1	4.6	9.6	-0.5	0.7	1	1
Brazil 09/2008	5	45.5	3	33.7	-1.5	35.2	1	2.2	5.5	11.3	3.7	1	0
Brazil 03/2012	22	42.3	17	26.9	24.1	2.8	1	1.3	3.4	12.3	7.6	0	1
Brazil 02/2015	7	58.6	7	35.3	3.6	31.7	1	2.8	6.3	9.0	13.9	1	1
Chile 06/1982	23	95.1	8	53.5	39.8	13.8	1	12.3	12.3	24.2	16.4	1	1
Chile 07/1985	23	118.7	23	37.8	34.4	3.4	0	12.2	18.2	29.3	-4.3	1	1
Chile 06/2008	4	38.6	6	18.4	3.3	15.1	1	8.3	12.0	8.3	6.5	0	0
China,P.R.: Mainland 12/198	23	44.7	23	58.9	53.3	5.6	0	1.7	1.8	1.2	10.4	1	1
China,P.R.: Mainland 01/199	2	50.1	0	44.2	18.6	25.6	1	1.8	3.3	10.7	4.7	1	1
Colombia 07/2002	8	23.4	8	23.9	16.2	7.7	1	3.6	10.4	-11.0	0.8	0	0
Colombia 08/2008	7	42.9	6	19.6	-1.5	21.0	1	2.3	5.0	10.4	6.9	0	0
Colombia 05/2015	9	38.4	9	21.7	4.8	16.9	1	5.0	6.3	7.9	5.7	0	1
Costa Rica 01/1981	23	369.7	10	187.7	68.3	119.4	1	1.2	7.6	1.3	24.3	1	1
Czech Republic 08/2008	6	45.0	6	20.0	11.6	8.4	1	17.1		13.1	6.3	0	0
Dominican Republic 03/198	15	136.6	15	38.6	19.1	19.5	1			-3.4	-5.9	1	1
Dominican Republic 04/199	14	105.0	10	17.6	6.5	11.1	1			-0.2	12.2	1	0
Dominican Republic 02/200	11	184.1	11	86.6	20.1	66.6	1	6.7	7.1	7.2	12.9	1	1
Ecuador 09/1998	15	269.1	14	76.9	17.9	59.0	1	0.0		3.4	7.1	1	0
Egypt 01/2003	21	38.5	12	46.8	39.8	7.0	1	1.6	3.6	2.7	3.8	1	1
Egypt 11/2016	2	111.4	1	84.9	45.2	39.7	1	5.2	2.9	7.9	-1.1	1	1
Equatorial Guinea 01/1994	0	100.7	0	59.1	14.8	44.2	1	0.0	9.0	-20.6	-56.8	1	1
Fiji 06/1987	4	42.7	5	36.4	28.9	7.5	1	1.7		1.1	6.7	1	1
Fiji 01/1998	7	35.6	4	22.8	18.7	4.1	1	1.0		-6.9	0.8	0	1
Fiji 10/2008	6	34.0	7	23.0	16.9	6.1	1	4.7		17.3	2.4	0	1

(continued)

Episode	LCU/USD Rate		REER					External debt and private credit in T-1			GDP Loss (T+1)	Laeven and Valencia sample	2015 WEO Ch. 3 sample
	Peak month	Max Dep	Peak month	Max Dep	= Eq Dep	+ Overshooting	Stable	ST Debt, percent GDP	STRM Debt, percent GDP	Credit/GDP 3-yr change			
Gabon 01/1994	0	100.7	0	82.5	29.3	53.2	1	0.0	6.1	-2.6	-5.8	1	1
Georgia 11/1998	3	67.4	3	32.1	5.3	26.8	1	0.0	2.9	0.0	-42.8	1	1
Georgia 01/2015	23	42.0	23	16.1	9.5	6.6	0	18.5	18.2	12.6	6.8	0	0
Hungary 09/2011	8	28.9	2	13.7	6.7	6.9	1	22.9	46.5	7.5	4.1	0	0
Indonesia 08/1997	10	473.3	10	215.2	54.9	160.3	1	3.7	13.4	6.5	25.9	1	1
Indonesia 08/2013	23	31.2	4	19.9	8.7	11.2	1	4.7	5.9	5.8	1.8	0	0
Iran, I.R. of 12/2000	23	357.3	19	305.5	296.8	8.8	0	0.8	1.5	9.6	-8.7	1	0
Iran, I.R. of 07/2013	23	139.1	1	95.6	63.0	32.5	1	0.2	0.8	3.4	10.5	1	0
Kazakhstan 04/1999	23	66.2	6	45.7	28.8	16.9	1	5.5	12.4	-0.8	-19.5	1	1
Kazakhstan 02/2009	1	24.5	8	29.8	19.4	10.4	1	6.1	11.0	14.0	15.1	0	0
Kazakhstan 02/2014	23	134.6	23	51.2	24.2	27.0	0	4.4	7.1	-4.4	7.1	0	0
Libya 06/2001	7	135.9	23	185.1	178.8	6.3	0			-1.6	2.8	1	0
Macedonia, FYR 07/1997	23	26.9	23	23.5	19.3	4.2	0	0.0	1.1	-32.8	-7.3	1	1
Malaysia 08/1997	5	73.6	5	50.5	29.3	21.2	1	10.4	11.9	35.2	16.3	1	0
Malaysia 08/2015	16	17.5	16	12.0	10.5	1.4	1	27.6	43.8	12.2	-0.5	0	0
Mexico 02/1982	23	455.9	7	107.6	58.7	48.9	1	12.3	10.6	0.1	15.6	1	1
Mexico 07/1985	23	493.7	20	80.6	76.7	3.9	0	2.5	5.3	-5.4	10.9	1	0
Mexico 12/1987	23	48.2	0	6.7	-19.1	25.8	1	3.9	7.6	-1.2	1.8	0	0
Mexico 12/1994	22	129.5	3	75.1	29.1	46.0	1	6.1	8.1	10.0	7.8	1	1
Mexico 10/2008	4	38.3	5	27.7	10.5	17.2	1	3.0	6.0	4.6	5.9	0	0
Namibia 09/2001	3	44.3	4	30.7	-7.8	38.5	1	7.5		-2.3	-1.6	1	0
Namibia 09/2011	23	46.6	21	18.6	14.0	4.6	0	4.4		0.8	-2.2	0	0
Paraguay 03/1989	23	140.5	10	52.1	24.3	27.8	1	0.0	2.5	-0.1	-1.3	1	1
Paraguay 05/2002	7	47.4	8	25.1	13.4	11.7	1	0.0	6.0	1.6	4.7	1	0
Paraguay 10/2008	5	27.9	13	21.1	15.5	5.5	1	1.5	4.2	9.9	-3.4	0	0
Philippines 10/1983	12	81.7	0	25.2	-7.0	32.2	1	27.2	29.2	5.5	27.4	1	1
Philippines 07/1997	13	66.3	6	38.1	19.1	19.0	1	12.2	13.9	22.6	-0.3	1	0
Poland 08/2008	6	79.2	6	39.7	21.8	17.9	1	12.3	21.2	10.8	-1.1	0	0
Romania 12/1998	23	151.6	3	16.7	-1.5	18.2	1	1.1	5.5		-1.7	1	1
Romania 09/2008	21	48.6	21	14.9	11.0	3.9	0	13.1	24.6		10.2	0	0
Russian Federation 08/1998	18	359.4	5	92.9	69.5	23.4	1	3.4		-1.4	-9.8	1	1
Russian Federation 01/2009	1	21.6	1	17.3	0.1	17.1	1	4.0	6.5	15.6	18.1	0	0
Russian Federation 07/2014	18	123.5	19	55.0	42.2	12.8	0	2.8	8.8	6.5	9.8	1	0
South Africa 07/1984	13	104.7	17	82.8	56.1	26.8	1	18.6	17.7	11.2	5.8	1	1
South Africa 06/1998	23	34.9	1	17.6	11.6	6.1	1	13.9	13.1	2.4	0.6	0	0
South Africa 09/2001	3	44.3	3	36.4	-7.6	44.0	1	10.0	14.2	17.0	-2.8	1	0
South Africa 09/2011	23	46.6	21	23.6	17.6	6.0	0	7.0	9.3	-11.2	1.5	0	0
Suriname 01/1999	23	443.3	20	6.1	-5.6	11.7	0	0.0		14.8	17.0	1	1
Suriname 11/2015	10	132.2	7	35.4	22.1	13.3	1	9.7		9.4	15.9	1	1
Swaziland 06/1998	23	34.9	1	12.0	2.5	9.6	1	0.0		-4.1	4.4	0	1
Swaziland 09/2001	3	44.3	3	20.4	-8.0	28.4	1	0.0		-2.8	0.5	1	1
Swaziland 09/2011	23	46.6	21	12.3	8.7	3.6	0	0.0		-3.1	0.1	0	1
Thailand 07/1997	6	113.0	6	73.0	21.2	51.8	1	25.5	29.4	38.3	31.6	1	1
Trinidad and Tobago 12/19	23	50.0	23	56.2	51.1	5.1	0	2.7	3.0	16.2	19.4	1	1
Trinidad and Tobago 04/19	13	40.6	1	31.1	27.3	3.8	1	0.0	4.3	1.8	-5.2	1	1
Turkey 02/2001	17	148.6	8	52.7	26.5	26.2	1	8.2	16.8	-8.6	7.8	1	1
Turkey 10/2008	4	37.0	5	19.5	3.1	16.4	1	7.6	13.1	13.0	14.4	0	0
Turkey 11/2016	21	106.7	22	58.0	37.4	20.6	0	13.9	19.1	13.6	4.7	0	0
Ukraine 09/1998	17	144.3	16	54.8	40.8	14.0	1	4.5	6.2	-2.2	-6.6	1	0
Ukraine 10/2008	11	64.8	12	40.4	26.7	13.7	1	13.7	24.3	56.2	32.5	1	1
Ukraine 02/2014	12	247.3	12	92.8	32.4	60.3	1	15.3	33.5	-5.2	20.0	1	1
Uruguay 12/1984	23	156.0	3	13.2	8.3	4.9	1			12.4	-7.3	1	0
Uruguay 04/2002	23	89.7	22	65.4	60.9	4.5	0			13.3	15.2	1	1
Venezuela, Rep. Bol. 02/198	23	74.4	1	74.0	49.8	24.2	1			7.7	7.3	1	1
Venezuela, Rep. Bol. 03/198	23	273.1	0	104.5	78.6	25.8	1			-4.0	10.4	1	1
Venezuela, Rep. Bol. 02/200	11	142.4	11	63.8	40.6	23.3	1	7.5		-1.9	13.8	1	1
Venezuela, Rep. Bol. 02/201	23	46.5	1	36.8	-37.8	74.7	1	12.7		1.7	12.3	1	0
Mean (or share in percent)	14	95.1	9	45.1	25.0	20.1	78.7%	7.0	11.2	6.2	5.2	57.4%	50.8%
Median	14	52.4	7	30.3	17.6	12.8		4.5	8.1	4.7	5.3		
25th percentile	6	39.1	3	18.4	6.5	5.7		1.6	5.3	-1.3	-0.5		
75th percentile	23	112.6	16	55.9	29.3	26.1		10.3	13.9	12.2	11.2		
Standard deviation	8.1	98.4	7.4	46.7	37.9	23.2		8.2	9.4	14.7	11.8		

Annex Table 2. Data sources

Variables	Source	Time coverage
Large depreciation year Maximum REER depreciation Equilibrium REER depreciation REER overshooting Depreciation episode stability	Culiuc and Deb (2020)	1980-2018
Real GDP Real GDP/Capita in PPP USD External short-term debt External short-term debt on remaining maturity basis External bank debt Non-FDI liabilities Non-oil exports volume Real domestic demand International reserves Terms-of-trade Trade openness	World Economic Outlook	1980-2018
Domestic credit to private sector	Financial Stability Indicators	1980-2018
Exchange rate regime	Klein and Shambaugh (2010)	1980-2018 (extrapolated)
Banking crisis year	Laeven and Valencia (2018)	1980-2017
Trading partner GDP growth	Cubeddu et al. (2014)	1980-2018 (updated)
PPP price factor	Penn World Tables 9.1	1980-2017
Old age dependency ratio Population growth	World Development Indicators	1980-2018

Annex Table 3. OLS regressions on $T + 1$ output loss, domestic demand loss and non-oil exports loss.

	All episodes			Stable episodes only		
	GDP	Dom. Demand	Exports (excl. oil)	GDP	Dom. Demand	Exports (excl. oil)
	(1)	(2)	(3)	(4)	(5)	(6)
Equilibrium depreciation (percent)	-0.005	0.006	-0.193***	0.037	0.140	-0.152
	(0.030)	(0.088)	(0.068)	(0.040)	(0.133)	(0.236)
Overshooting (percent)	-0.012	-0.592	-0.105	-0.014	-0.557	-0.104
	(0.089)	(0.490)	(0.251)	(0.089)	(0.432)	(0.388)
External ST Debt (percent GDP, T-1)	-0.220**	-1.116	-0.522***	-0.252**	-1.263	-0.573***
	(0.102)	(0.788)	(0.165)	(0.102)	(0.813)	(0.204)
Overshooting * External ST Debt/GDP (T-1)	0.025***	0.096*	0.027	0.026***	0.098*	0.030
	(0.009)	(0.055)	(0.020)	(0.009)	(0.052)	(0.023)
PPP GDP/capita (Log, T-1)	0.079*	0.432	0.202**	0.100**	0.564	0.202*
	(0.042)	(0.326)	(0.095)	(0.045)	(0.387)	(0.110)
Constant	-70.442*	-390.658	-181.023*	-90.810**	-516.509	-183.234
	(39.072)	(301.394)	(96.330)	(42.556)	(360.850)	(114.140)
Observations	88	76	70	71	62	57
R^2	0.297	0.284	0.055	0.363	0.355	0.042

Note: Robust standard errors in parentheses. *, **, *** indicate significance at 10, 5 and 1 percent levels respectively.

Annex Table 4. OLS regressions on output loss in T through $T + 4$.

	All devaluation episodes					Excluding dual banking-currency crises				
	T	T+1	T+2	T+3	T+4	T	T+1	T+2	T+3	T+4
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
Equilibrium depreciation (percent)	0.017	-0.006	-0.044	-0.126**	-0.174*	0.004	-0.018	-0.041	-0.151*	-0.189*
	(0.022)	(0.029)	(0.032)	(0.061)	(0.092)	(0.021)	(0.036)	(0.051)	(0.084)	(0.109)
Overshooting * External ST Debt/GDP (T-1)	0.011***	0.024***	0.035***	0.058**	0.070**	0.003	0.006	0.006	0.019	0.021
	(0.003)	(0.004)	(0.008)	(0.027)	(0.034)	(0.004)	(0.006)	(0.014)	(0.044)	(0.055)
External ST Debt (percent GDP, T-1)	-0.149***	-0.209***	-0.315**	-0.833	-1.076	-0.350***	-0.428*	-0.672	-2.395	-2.948
	(0.041)	(0.056)	(0.138)	(0.548)	(0.738)	(0.110)	(0.226)	(0.483)	(1.744)	(2.258)
PPP GDP/capita (Log, T-1)	0.045*	0.080*	0.167*	0.590	0.778	0.058*	0.107*	0.214*	0.780	0.996
	(0.024)	(0.042)	(0.096)	(0.396)	(0.533)	(0.031)	(0.054)	(0.122)	(0.501)	(0.653)
Constant	-39.744*	-70.823*	-153.458*	-547.870	-723.992	-50.504*	-94.649*	-193.159*	-714.933	-914.581
	(22.616)	(39.790)	(90.445)	(370.637)	(497.306)	(28.979)	(50.418)	(112.904)	(462.607)	(602.557)
Observations	97	88	78	73	70	67	60	57	53	53
R^2	0.170	0.296	0.311	0.300	0.300	0.158	0.238	0.294	0.356	0.349

Note: Robust standard errors in parentheses. *, **, *** indicate significance at 10, 5 and 1 percent levels respectively.

Annex Table 5. OLS regressions on output loss in $T + 1$: Extended specifications (stable episodes only)

GDP Loss (T+1)	(1)	(2)	(3)	(4)	(5)	(6)	(7)
Equilibrium depreciation (percent)	0.007	-0.007	-0.001	0.007	0.026	0.098***	0.060
	(0.044)	(0.043)	(0.044)	(0.043)	(0.045)	(0.037)	(0.047)
Overshooting * External ST Debt/GDP (T-1)	0.022***	0.032***	0.025***	0.020***	0.020***		
	(0.004)	(0.005)	(0.004)	(0.004)	(0.004)		
External ST Debt (percent GDP, T-1)	-0.234***	-1.065**	-0.256***	-0.308***	-0.403***		
	(0.059)	(0.463)	(0.053)	(0.082)	(0.082)		
PPP GDP/capita (Log, T-1)	0.101**	0.141***	0.075*	0.096**	0.087**	0.046*	0.030
	(0.045)	(0.045)	(0.042)	(0.043)	(0.042)	(0.027)	(0.028)
Dual Banking/currency crisis	5.346*	4.537	2.719	6.215**	5.578**		2.548
	(2.968)	(3.581)	(3.567)	(3.007)	(2.598)		(3.096)
Non-FDI Capital inflows (% GDP, cumulated T-3 to T-1)		0.298*					
		(0.174)					
Trading partner GDP (% change, T-1 to T+1)			-1.023				-0.754
			(0.789)				(0.640)
ToT (% change, T-1 to T)			-0.344*				-0.342***
			(0.181)				(0.116)
Domestic credit to private sector (% GDP, T-1)				0.068			
				(0.044)			
Domestic credit to private sector (p.p. GDP change, T-3 to T-1)					0.357***	-0.021	-0.042
					(0.103)	(0.103)	(0.103)
Overshooting * Dom. credit to priv. sect. (p.p. GDP change, T-3 to T-1)						0.019***	0.017***
						(0.006)	(0.004)
Constant	-93.07**	-129.17***	-65.47	-90.36**	-80.38**	-42.53	-24.74
	(42.45)	(42.61)	(41.21)	(40.98)	(39.70)	(26.80)	(28.57)
Observations	71	64	64	70	69	94	82
R^2	0.389	0.496	0.523	0.413	0.478	0.358	0.494

Note: Robust standard errors in parentheses. *, **, *** indicate significance at 10, 5 and 1 percent levels respectively.

Annex Table 6. OLS regressions on output loss in $T + 1$: restricted samples

	All episodes						Stable episodes					
GDP Loss (T+1)	**Excl. top decile**		**Laeven & Valencia**		**2015 WEO Ch. 3**		**Excl. top decile**		**Laeven & Valencia**		**2015 WEO Ch. 3**	
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)
Equilibrium depreciation (percent)	-0.015	0.023	-0.002	0.014	0.027	0.100**	0.059	0.104**	0.042	0.096**	0.001	0.090*
	(0.033)	(0.041)	(0.033)	(0.041)	(0.056)	(0.047)	(0.064)	(0.042)	(0.047)	(0.043)	(0.049)	(0.047)
Overshooting * External ST Debt/GDP (T-1)	0.020**		0.025***		0.027***		0.023***		0.027***		0.030***	
	(0.008)		(0.004)		(0.004)		(0.008)		(0.005)		(0.005)	
External ST debt (percent GDP, T-1)	-0.362*		-0.212***		-0.236***		-0.468**		-0.242***		-0.272***	
	(0.195)		(0.062)		(0.070)		(0.224)		(0.065)		(0.074)	
PPP GDP/Capita (T-1)	0.095**	0.032	0.091*	0.059*	0.091	0.047	0.124**	0.044*	0.111**	0.068*	0.117*	0.070*
	(0.047)	(0.020)	(0.052)	(0.034)	(0.060)	(0.033)	(0.050)	(0.023)	(0.054)	(0.037)	(0.061)	(0.038)
Dom. credit to private sector (p.p. GDP change, T-3 to T-1)		-0.007		0.006		0.010		-0.114		-0.054		-0.051
		(0.112)		(0.101)		(0.108)		(0.103)		(0.116)		(0.124)
Overshooting * Dom. credit to priv. sect. (p.p. GDP change, T-3 to T-1)		0.031**		0.016***		0.020***		0.038***		0.019***		0.021***
		(0.013)		(0.006)		(0.006)		(0.012)		(0.005)		(0.006)
Constant	-83.96*	-27.12	-82.14*	-51.39	-82.64	-43.24	-112.11**	-40.46*	-102.74**	-62.93*	-107.14*	-64.62*
	(43.18)	(19.47)	(48.25)	(32.85)	(55.22)	(32.29)	(46.06)	(23.02)	(49.95)	(35.30)	(56.30)	(37.03)
Observations	79	108	56	68	49	60	62	82	48	57	43	51
R^2	0.217	0.269	0.357	0.317	0.381	0.407	0.305	0.376	0.447	0.407	0.459	0.452

Note: Robust standard errors in parentheses. *, **, *** indicate significance at 10, 5 and 1 percent levels respectively. Episodes excluded in specification 1 are: Argentina 2002, Indonesia 1997, Iceland 2008, Korea 1997, Philippines 1983, Thailand 1997, Ukraine 2014, Venezuela 2013, South Africa 2001. Episodes excluded in specification 2 are: Australia 2008, Brazil 2008, Dominican Rep. 2003, Indonesia 1997, Iceland 2008, Korea 2008, Mexico 1994, Malaysia 1997, Philippines 1997, Thailand 1997, Ukraine 2008, South Africa 2001. Episodes included in specifications 3–6 and 9–12 are identified in Annex 3 (last two columns).

Annex Table 7. OLS regressions on output loss in $T+1$: alternative measures of REER equilibrium and overshooting

Definition of equilibrium depreciation and overshoting	**All episodes**								**Stable episodes only**							
	Using t+17 - t+23 REER average **(baseline)**	Using REER at t=23	Using post-max minimum REER	Using HP trend REER at t=23	Using CF trend REER at t=23	Using max deviation from HP trend	Using max deviation from CF trend	Using t-1 PPP misalignment	Using t+17 - t+23 REER average **(baseline)**	Using REER at t=23	Using post-max minimum REER	Using HP trend REER at t=23	Using CF trend REER at t=23	Using max deviation from HP trend	Using max deviation from CF trend	Using t-1 PPP misalignment
GDP Loss (T+1)	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Equilibrium depreciation	-0.006	-0.005	-0.027	-0.002	-0.007	0.007	0.004	0.360***	0.034	0.036	0.024	0.044	0.040	0.048	0.043	0.418***
	(0.029)	(0.030)	(0.024)	(0.033)	(0.028)	(0.072)	(0.074)	(0.088)	(0.041)	(0.036)	(0.041)	(0.041)	(0.045)	(0.080)	(0.074)	(0.103)
Overshooting * External ST Debt/GDP (T-1)	0.024***	0.023***	0.022***	0.024***	0.023***	0.022**	0.025**	0.016***	0.025***	0.025***	0.022***	0.025***	0.024***	0.023**	0.026**	0.017***
	(0.004)	(0.004)	(0.005)	(0.004)	(0.004)	(0.010)	(0.012)	(0.004)	(0.004)	(0.004)	(0.005)	(0.005)	(0.004)	(0.011)	(0.013)	(0.004)
External ST Debt (percent GDP, T-1)	-0.209***	-0.255***	-0.680***	-0.280***	-0.315***	-0.556*	-0.569*	-0.286***	-0.241***	-0.296***	-0.686***	-0.313***	-0.351***	-0.619*	-0.636*	-0.318***
	(0.056)	(0.064)	(0.170)	(0.071)	(0.073)	(0.298)	(0.306)	(0.084)	(0.062)	(0.070)	(0.176)	(0.079)	(0.083)	(0.342)	(0.340)	(0.092)
PPP GDP/capita (Log, T-1)	0.080*	0.082*	0.108**	0.078*	0.079*	0.086*	0.085*	0.087**	0.100**	0.103**	0.109**	0.099**	0.099**	0.109**	0.108**	0.087**
	(0.042)	(0.043)	(0.047)	(0.043)	(0.043)	(0.046)	(0.046)	(0.036)	(0.046)	(0.046)	(0.049)	(0.047)	(0.047)	(0.053)	(0.053)	(0.039)
Constant	-70.82*	-72.86*	-94.81**	-69.08*	-69.45*	-73.80*	-72.94*	-80.74**	-91.40**	-92.97**	-96.74**	-89.37**	-89.61**	-96.03*	-95.51*	-81.03**
	(39.79)	(40.03)	(43.77)	(40.35)	(40.43)	(42.95)	(42.65)	(34.21)	(43.22)	(43.34)	(45.92)	(44.45)	(44.34)	(48.95)	(48.79)	(37.00)
Observations	88	88	82	88	88	88	88	77	71	71	71	71	71	71	71	61
R^2	0.296	0.293	0.296	0.270	0.275	0.210	0.215	0.453	0.363	0.361	0.308	0.334	0.337	0.282	0.290	0.519

Note: Robust standard errors in parentheses. *, **, *** indicate significance at 10, 5 and 1 percent levels respectively.