Sudden Stops, Productivity, and the Exchange Rate*

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Abstract

Following a sudden stop, real exchange rates adjust through a nominal exchange rate depreciation, lower domestic prices, or both. This paper studies how the type of adjustment shapes the response of productivity. Using Spanish micro-data, it documents that in a currency union unproductive firms exit more than in a floating regime. A small open economy DSGE model featuring firm selection, markups and elastic labor supply rationalizes this finding. There are three mechanisms through which a sudden stop affects productivity: a pro-competitive, cost, and demand channel. While only the former operates when floating, all are active in a currency union.

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Keywords: sudden stops, currency union, productivity.

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1 Introduction

The benefits of flexible exchange rates during a balance of payment crisis have been widely discussed among generations of international macroeconomists. The arguments, however, mostly rely on an aggregate view of the economy. This contrasts with an increasing use of granular data and a stark emphasis on heterogeneity in theoretical frameworks across fields. Zooming into the micro-level response to exchange rate policy remains a pending assignment for this literature. This paper contributes towards closing the gap by pursuing an unexplored dimension of exchange rate policy: its effects on firm dynamics.

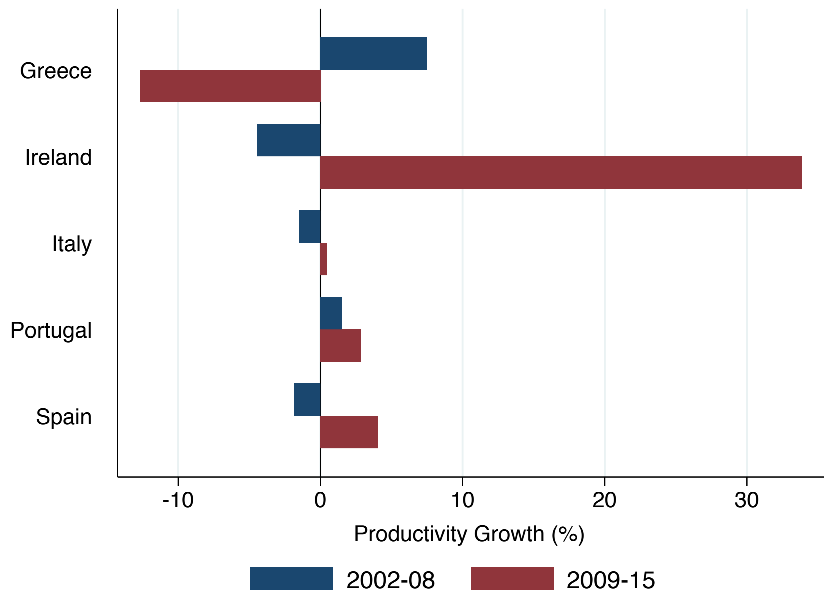
The recent European sovereign debt crisis makes for an excellent stage to rekindle this debate. As Greece admitted to have misreported the figures of its public debt in late 2009, the periphery of Europe experienced an unexpected reversal in capital flows. This phenomenon, often referred to as a sudden stop, had not yet been studied in the context of a currency union. In addition, sudden stops have been traditionally associated with declines in aggregate total factor productivity (TFP). However, with the exception of Greece, the periphery of Europe experienced a productivity improvement as shown in Figure I. It is well known that measuring TFP is particularly challenging in the aggregate and is often subject to compositional bias. Thus, in looking for explanations to this puzzling observation, firm-level heterogeneity emerges as a key element to consider when addressing the following questions: what is the relationship between sudden stops, productivity and the exchange rate regime? How does accounting for firm dynamics complement our understanding of fixed versus floating regimes?

This paper studies how the type of real exchange rate realignment shapes the response of macroeconomic variables to a sudden stop in the presence of firm heterogeneity. Using Spanish microdata during two balance of payment crises, it is the first paper to document differences in firm entry and exit across exchange rate regimes. An internal devaluation, as opposed to a nominal depreciation, is associated with greater exit of unproductive firms, contributing to TFP growth through a so-called cleansing effect. The paper rationalizes these patterns by incorporating firm dynamics to an otherwise standard small open economy model. The novel link between consumer labor income and firm profitability is crucial in explaining why firm exit is larger when wages fall. The model's predictions apply to a wider set of countries as shown by the event study discussed at the end of the paper. This exercises looks at aggregate data by binning sudden stop episodes by the prevalent exchange rate regime.

Section 2 starts by inspecting micro evidence from the Spanish manufacturing sector. More specifically, I exploit survey firm-level data during the 2010-13 European sovereign debt crisis and contrast it to an earlier sudden stop that hit Spain in 1992-93: the Exchange Rate Mechanism crisis. Parallels in the onset but divergence in the observed cyclicality of productivity make for a relevant comparison.

The joint analysis of these episodes uncovers the following empirical patterns. First, changes

FIGURE I: PRODUCTIVITY GROWTH IN PERIPHERAL EUROPE 2002-2015



Notes: This graph plots the overall change in aggregate TFP for Greece, Ireland, Italy, Portugal and Spain for the 2002-08 and the 2009-15 periods. The latter coincides with the European sovereign debt crisis and is the period of interest, while the former is depicted for comparison. The data used is collected from the AMECO database.

in productivity are concentrated on the lower tail of the firm productivity distribution in both cases. Second, while productivity declines at the firm-level during both crises, the exit of unproductive firms contributes substantially more to positive TFP growth in the 2010-13 sudden stop. Third, a formal test for cleansing shows that the negative (positive) correlation between firm-level productivity and propensity to exit (factor growth) is strengthened in 2010-13 but not during the 1992-93 sudden stop. Fourth, there is evidence that firms charge price markups which are firm-specific and time-varying. The data shows these tend to be higher among more productive firms and lower in times of higher aggregate productivity, suggesting there is a link between changes in competition and aggregate productivity.

Arguments based on disparities in the size of the construction bust, the uneven disruption of credit and opposing trends in the misallocation of (solely) capital empirically fail to fully explain these findings. There is, however, an obvious difference across episodes that cannot be ruled out: the response of exchange rate policy. While during the earlier sudden stop, the national currency, the *peseta*, depreciated on multiple occasions; during the latter, Spain was a member of a currency union and could only regain competitiveness by lowering wages. The rest of the paper is devoted to exploring this distinctness.

Based on the previous evidence, section 3 develops a small open economy model with firm heterogeneity to study the macroeconomic effects of a sudden stop. The model features a micro-structure that incorporates Melitz and Ottaviano (2008) into a firm dynamics setting. [1] The use of quasi-linear quadratic preferences generates firm selection into production and endogenous variable markups, as observed in the data. Allowing for stochastic idiosyncratic firm productivity, as opposed to the static assumption in trade models, allows for both entry and exit to happen simultaneously. I also extend the framework to include leisure in the utility function, thereby explicitly modeling the consumer's labor supply decision. This means wages are allowed to respond to shocks, which is absent in Melitz and Ottaviano (2008) but essential in studying internal devaluations. Moreover, this provides a new channel through which the wage level and individual firm profits interact.

To allow a role for policy, I introduce nominal rigidities in the wage-setting process. The central bank chooses the nominal exchange rate as its main policy tool. I focus on two extreme regimes: a currency union, characterized by a credible commitment to keep the nominal exchange rate constant; and a strict wage inflation targeting regime, where the flexible wage equilibrium is always implemented. A sudden stop is defined as a two-fold shock to the domestic economy. First, it involves an increase in the risk premium component of the interest rate that consumers pay when borrowing. By increasing the cost of borrowing abroad, the domestic economy is forced to deleverage internationally and increase net exports through a real exchange rate depreciation. Second, it simultaneously features a decline in the productivity level of all firms, which leads to a contraction of domestic output despite the reversal in the current account.

Section 4 discusses the effects of a sudden stop shock on aggregate productivity in a simpler version of the model. Under constant idiosyncratic productivity and no free entry, the model features a closed-form solution. The key insight is that aggregate productivity is proportional to a domestic productivity threshold. The threshold represents the minimum productivity level at which a firm can generate positive profits and, thus, select into the domestic market. It therefore suffices to understand how the threshold moves after a sudden stop to learn about its effect on aggregate productivity.

In equilibrium, the domestic threshold is determined by the number of active firms in the market and the wage level. Therefore, there are three endogenous mechanisms through which a shock can affect productivity. First, the threshold increases with the number of active firms, as greater competition lowers profit margins for all firms and, thus, requires a higher level of productivity to remain profitable. This is the pro-competitive channel. Second, higher wages increase the costs of production for all firms, lowering again their profit margin and calling for a higher productivity level. This is the cost channel. Third, higher wages also increase the demand for overall consumption by increasing households' labor income. This, instead, increases the firm

[1] A sudden stop is essentially a real exchange rate shock. To some extent, it is isomorphic to a specific trade policy mix: a simultaneous increase in export subsidies and import tariffs. I, thus, build on , which has long studied the effects of trade liberalization on aggregate productivity through firm selection, to understand the impact of a sudden stop.

profit margin and relaxes the productivity requirement. This is the demand channel.

The effect of a sudden stop on the domestic productivity threshold will hinge on the relative strength of these conflicting forces. This, in turn, depends on how the real exchange rate adjusts. More precisely, on whether it takes place through the depreciation of nominal exchange rates or a lower wage level. For a simplified version of the model that can be solved analytically, I show that if the nominal exchange rate bears the full brunt of the adjustment, then only the pro-competitive channel is active, as fewer firms import and productivity falls unambiguously. In contrast, when the nominal exchange rate is fixed, the wage adjusts completely and all three channels operate, resulting in a quantitatively ambiguous overall effect. The simplified model delivers conditions under which the demand channel dominates, allowing a sudden stop to generate a productivity improvement in a currency union.

I turn towards studying the quantitative properties of the full model in section 5. To do so, I first parameterize the model using a combination of values from the literature and a moment-matching exercise. Second, I solve for the transition dynamics of the model following a shock to the interest rate and the common shifter of firm productivity. Plotting the impulse response function of aggregate TFP confirms that the previous analytical results hold more generally: productivity falls under a floating arrangement and increases in a currency union following a sudden stop. In addition, the model generates the other stylized facts previously documented by the literature: a contraction in output, a reversal in the current account and a real exchange rate depreciation.

Next, I use the quantitative model to simulate the 2010-13 sudden stop in Spain by feeding in the path of the interest rate risk premium and the common productivity shifter between 2000 and 2014. The model is able to generate roughly half of the increase in aggregate productivity observed in the firm-level data. To evaluate the mechanism, I repeat the productivity growth decomposition exercise portrayed in section 2 using the simulated data. While the model falls short in predicting the contribution of exiters and overstates the reallocation effect, it overall succeeds in generating a sizable cleansing effect that overcomes the decline in productivity at the firm-level.

Section 6 explores the external validity of the paper by providing systematic evidence on the behavior of macroeconomic variables during a sudden stop for a wider set of economies during the 1990-2015 period. Using a standard criterion to identify sudden stops that captures both the episodes discussed previously in the literature as well as the recent Southern-European cases, I first confirm the established fact that TFP falls on average. Next, I show that when binning episodes by prevalent exchange rate regime, a new pattern emerges: the decline in productivity increases in the flexibility of the exchange rate as captured by the model. This is robust to alternative exchange rate classifications, detrending methods and controlling for crisis and country characteristics.

In comparing the response of other macroeconomic variables across regimes two more regularities provide additional empirical support for the working of the model. First, in a currency union there is a larger decline in employment in both absolute and relative to output terms. Second, there is also a greater decline in imports relative to the increase in exports, suggesting the increase in aggregate TFP comes at the expense of a greater domestic contraction.

Relation to the literature This paper contributes to several strands of the literature at the intersection of international finance, trade theory and firm dynamics.

First, it focuses on sudden stops, as defined by Calvo (1998), abrupt and unexpected reversals in foreign capital inflows. It follows the empirical research that documents regularities among historical sudden stop episodes including Calvo, Izquierdo and Mejía (2004), Guidotti et al. (2004), Calvo and Talvi (2005) and Kehoe and Ruhl (2009) and adds to the discussion by revisiting the established stylized facts when episodes are binned by the flexibility of the nominal exchange rate. I document the fall in productivity is increasing in the relative size of the nominal adjustment.

On the theoretical side, several articles propose amendments to the standard open economy neoclassical model in order to reconcile theoretical predictions with the observed behavior of macroeconomic variables. Among them, Neumeyer and Perri (2005) introduces advanced payments of inputs, Meza and Quintin (2007) allows for endogenous factor utilization and Mendoza (2010) features an occasionally binding borrowing constraint. As in these papers, I formalize a sudden stop as a simultaneous shock to productivity and the risk premium but generate amplification through selection into production. In a similar spirit, Ates and Saffie (2021) also accounts for firm dynamics in the study of the productivity costs of sudden stops. Their focus, however, is on the long run effects of entry distortions and how financial selection cushions the fall in endogenous productivity.

The second strand of the literature to which this paper closely relates is trade models of heterogeneous firms à la Melitz (2003).[2] My framework builds on Melitz and Ottaviano (2008) in featuring endogenous markups but departs along three dimensions. First, I explicitly model a labor supply choice, incorporating a new channel that affects firm entry decisions. Second, I allow for transition dynamics by embedding the steady-state version in a DSGE setting.[3] Third, I introduce nominal rigidities and, thus, discuss the effects of monetary policy. [4]

Finally, this paper is connected to the literature that studies the contribution of reallocation to TFP growth. In particular, I provide empirical support for Caballero and Hammour (1994)'s cleansing hypothesis and discuss the conditions under which its magnitude is likely to be relevant in the context of a current account shock.[5] Moreover, this work adds to the recent set of

[2] For a review of the literature, refer to Melitz and Redding (2014).

[3] Ghironi and Melitz (2005) are the first to consider firm dynamics in an open economy setting. To gain tractability, however, they assume that all firms that enter the market generate positive profits and, thus, firm exit is exogenous.

[4] Bilbiie, Ghironi and Melitz (2008) and Bilbiie, Fujiwara and Ghironi (2014) introduce price adjustment costs in a DSGE model with endogenous entry and product variety to study optimal monetary policy. They consider, however, a closed economy.

[5] The cleansing hypothesis is an interpretation of Schumpeter (1939)'s creative destruction argument that emphasizes the role of reallocation among new and incumbent firms at a business cycle frequency.

papers that link declining TFP and enhanced misallocation with capital inflows; see Reis (2013), Benigno and Fornaro (2014) and Gopinath et al. (2017) among others. While their focus is on an earlier period, I show that the negative relationship between productivity and flows holds when capital retrenches and propose a complementary explanation for changes in measured misallocation: variable markups.

2 Spain: A Tale of Two Sudden Stops

In unraveling what might be behind the aggregate patterns summarized by Figure I, it is useful to look at more disaggregated data. In exploring the singularity of this episode, it is convenient to set it against a comparable sudden stop that features a TFP decline. I do both by exploiting firm-level data from two sudden stops in Spanish recent economic history: the 1992-93 Exchange Rate Mechanism (ERM) crisis and the 2010-2013 European sovereign debt crisis.

There are clear parallels between the two episodes regarding the onset. Both were preceded by periods of increasing capital inflows, declining international competitiveness and widening current account deficits. Economic growth was fueled by the construction sector, with steep increases in property prices and crawling private debt. Public finances, on the other hand, were in a similar good shape.

Foreign capital inflows abruptly reverted following a confidence crisis affecting the European integration project: the negative outcome of the Danish referendum on the Maastricht Treaty in the first case, and the Greek announcement of substantial upward revisions in the government budget deficit more recently. The flight of international investment led to an urgent correction of misaligned real exchange rates in order to expand net exports. As growth stalled and unemployment rose, austerity measures were put in place in order to curb the rising public deficits generated by automatic stabilizers. In addition, structural reforms aimed at increasing the flexibility of the labor market were passed during both episodes.[6,7]

The response of exchange rate policy to these events, however, diverged significantly. While the *peseta* was devalued in three occasions during the 1992-93 crisis, Spain already shared a common currency with its largest trading partners since 2002 and underwent a process of internal devaluation.[8] I take these episodes as examples of sudden stops under floating arrangements

[6]There are two stark differences regarding these two sudden stops. First is the magnitude of the shock: Spain's current account surplus as a share of GDP moved from -3.5% to -1.2% between 1991 and 1994 versus -4.3% to 1.0% between 2009 and 2014. However, the duration was longer in the second episode, such that, per year, the reduction was around 1.1% during both episodes. Second, the latter is an example of a twin crisis, defined as a simultaneous crisis in banking and currency, while the former is not. I partially address this concern by looking at the level of leverage of firms at the end of the section.

[7]For a more detailed discussion on the comparability of these two sudden stops see Online Appendix A.1.

[8]In 1992, the *peseta* was first devalued by 5% on September 17th, known as Black Wednesday, when the pound and the lira abandoned the ERM altogether. A further 6% was devalued on November 23rd, with a third devaluation taking place in May 1993.

and currency unions, respectively, and use firm-level data to explore what is driving the observed aggregate TFP pattern.[9,10]

2.1 Data

I use firm-level data from the Survey on Business Strategies (Encuesta sobre Estrategias Empresariales, ESEE, in Spanish) managed by the SEPI Foundation, a public entity linked to the Spanish Ministry of Finance and Public Administrations. The ESEE surveys all manufacturing firms operating in Spain with more than 200 workers and a sample of firms between 10 and 200 workers, providing a rich panel dataset with over 1,800 firms for the period 1990-2014. It covers around 20 percent of output in Spanish manufacturing and provides information on each firm's balance sheet together with its profit and loss statement.

The main advantage of ESEE, especially over the ORBIS dataset compiled by Bureau van Dijk Electronic Publishing (BvD), is that it closely captures the extensive margin of production.[11] This is particularly true for the exit of firms as the dataset clearly differentiates between firms that decide not to collaborate in a given year, firms that exit the market and firms that are affected by a split-up, a merger or an acquisition process. In addition, firms that resume production or collaboration with the survey are re-included in the sample and properly recorded. As for entry, new firms are incorporated every year in order to minimize the deterioration of the initial sample. These include all entrants with more than 200 workers and a random selection representing 5% of those with 10 to 200 workers.[12]

There are other advantages of the ESEE dataset that are also worth highlighting. It is the only dataset with reliable financial information going back as early as the beginning of the 1990s, allowing me to study the 1992-93 episode. It also provides firm-level records of the value of exports which is most often subject to stringent confidentiality rules in Spain. Finally, the ESEE dataset is intended for research purposes, with effort devoted to ensure consistency and accuracy during the data collection process.

[9] It can be argued that Spain does not strictly classify as a floating exchange rate regime in 1992-93 as it remains a member of the ERM, a multilateral party grid of exchange rates established in 1979. However, the repeated realignments of its central rate against the *deutsche mark* and the substantial widening of the exchange rate fluctuation bands meant that the overall devaluation of its currency was even larger than that of floating currencies such as the pound. In order words, despite the formal membership of the ERM, the exchange rate effectively behaved as flexible.

[10] Figure A.1 revisits the evolution of aggregate TFP in Spain using all popular sources available. While depending on the source one might conclude that since 2009 TFP clearly increased, remained flat or declined slightly in absolute terms, TFP performance improved by all metrics when compared to its previous trend. As this paper focuses on business cycle fluctuations as opposed to long-term trends, the latter is the relevant measure to consider.

[11] The other existing firm-level dataset, as used in García-Santana et al. (2020), is the Central Balance Sheet Data (Central de Balances Integrada, CBI, in Spanish) owned by the Bank of Spain and only accessible to in-house economists. This alternative dataset, however, is put together using the same source of data that constitutes the Spanish input for ORBIS, annual financial statements that firms are obliged to submit to the Commercial Registry, and, thus, is subjected to the same limitations. Almunia, López-Rodríguez and Moral-Benito (2018) provide extensive details.

[12] Therefore, for the rest of the analysis entrants are defined as firms trespassing the 10 worker threshold for the first time.

Representativeness A well-known shortcoming of the ESEE dataset is its over-representation of large firms. I address this concern by exploiting dynamic sampling weights based on the Census, as provided by the SEPI Foundation. Figure A.4 shows that the weighted sample does a much better job at matching the firm size distribution than the raw (unweighted) data.

Despite this improvement, it is still the case that the ESEE dataset provides no information on micro firms, i.e., firms with nine employees or less. According to administrative data, over 80% of all firms in the Spanish manufacturing sector are micro firms; yet, they account for only 9% of production and 11% of the wage bill.[13]. Given the latter, the empirical disregard for micro firms is generally not a concern in macroeconomic analyses that emphasize the intensive margin. However, this paper also examines the role of the extensive margin, making it crucial to understand the type of bias that truncation by firm size may introduce.

In this regard, I implement two strategies —one empirical, the other theoretical. In Online Appendix A.7, I use data from ORBIS to complement the baseline analysis. On one hand, this improves coverage by capturing not only micro firms but also a larger share of total manufacturing activity. On the other hand, the data only dates back to the early 2000s, restricting the analysis to the 2010-13 sudden stop.[14] In Section 5, I use the quantitative model to show that by focusing on larger firms, the empirical analysis underestimates, albeit slightly, the role of the extensive margin.

Details on the cleaning procedure and the deflating of nominal variables are relegated to Online Appendix A.2. I estimate industry output elasticities for capital and labor using Ackerberg, Caves and Frazer (2015)'s algorithm and then compute firm-level productivity as a Solow residual.[15]

2.2 Results

Aggregate TFP, defined as the employment-weighted average of firm-level TFP, decreased by 14.56% during the 1992-1993 episode while increased by 4.36% in the 2010-2013 period.[16] The granularity of the data allows for a more detailed investigation regarding the drivers of productivity.

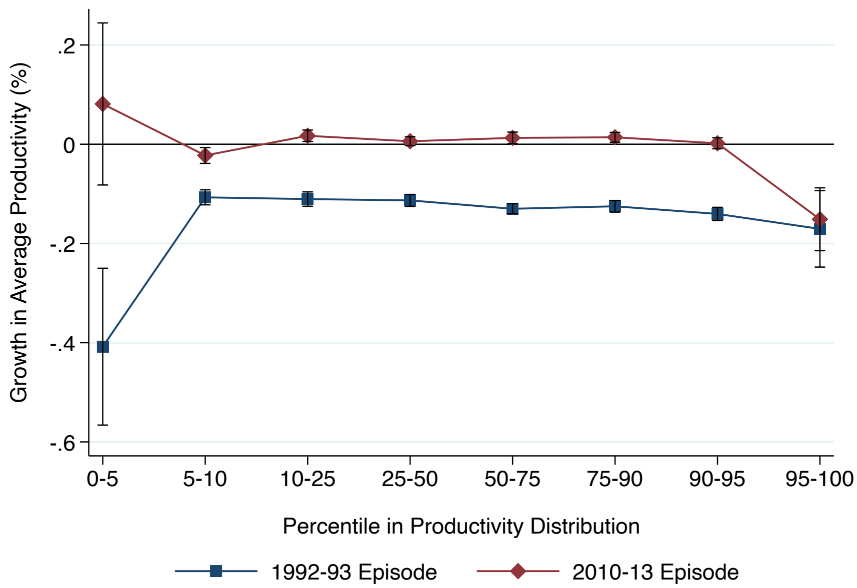
[13]Data corresponds to the Structural Business Statistics for years 2005-2020 as reported by Eurostat

[14]I refer the reader to Online Appendix for a more detailed description of analysis and results using the ORBIS dataset.

[15]See Online Appendix A.4 for a more detailed review of production function estimation techniques.

[16]I consider employment, as opposed to value added, weights when aggregating TFP for two reasons. First, I will be presenting a theoretical model with labor as the only factor of production where employment shares are the appropriate weight. Second, large firms in terms of employment are overstated in my sample, as explained above, and, thus, employment weights are consistent with the interpretation of my results as a lower bound. Results using value added weights, however, are reported in Online Appendix A.7.

FIGURE II: PRODUCTIVITY GROWTH ACROSS THE PRODUCTIVITY DISTRIBUTION



Notes: This graph plots the growth in average TFP by percentile of the productivity distribution. It compares the average TFP of firms in a given percentile before and after each of the two sudden stops. As this is an unbalanced panel, firms are allowed to change percentiles and even exit the sample during the transition. The corresponding base and end years are 1991 and 1993 for the first episode; 2009 and 2013 for the second episode. To account for variability, the vertical lines represent error bands. The data used is collected from the ESEE dataset.

The Lower Tail

I first document changes in the distribution of firm-level productivity before and after each of the crises. A visual inspection of the kernel probability distribution estimate of log TFP before and after each of the two sudden stops confirms there is ample heterogeneity in TFP levels among firms in any given year as already highlighted by the literature. More surprisingly, the shape of the distribution is similar and remains unchanged throughout both crisis periods, with no major shifts. In fact, the lower tail concentrates most, if not all, of the action: it lengthens as TFP decreases in the former crisis while shortens as TFP increases in the latter case.

To see this graphically, Figure II presents the percentage change in average productivity for each percentile of the productivity distribution during the two sudden stops. On average, the difference in the change in productivity across episodes, the gap between the red and blue lines, is roughly constant across the entire distribution, with the notable exception of the 5% percentile where TFP decreases by 41% during 1991-1993 while increases by 8% during 2009-2013. Although the error bands are admittedly wide in both cases, the difference relative to other percentiles is large enough to remain relevant - the gap is three times the average.

TABLE I: DECOMPOSITION OF PRODUCTIVITY GROWTH

	Sudden Stops	
	1992-1993	2010-2013
Productivity Growth (%)	-14.56	4.36
Contribution to Productivity Growth		
Incumbents' Contribution	**-14.81**	**-5.51**
Within-firm Contribution	-12.20	-6.77
Between-firm Contribution	-2.53	0.84
Cross-term Contribution	-0.08	0.42
Net Entry Contribution	**0.26**	**9.87**
Entrants' Contribution	-2.29	-0.06
Exiters' Contribution	2.54	9.93

Notes: Productivity growth refers to accumulated TFP growth for the stated period. Base and final years are 1991 and 1993 for the first episode; 2009 and 2013 for the second episode. Contribution of incumbents and net entrants add up to productivity growth. Contribution of within-firm, between-firm and cross-term components add up to incumbents' contribution. Contribution of entrants and exiters add up to net entry contribution. The formal decomposition is given by:

$$\Delta Z_t = \sum_{i \in C} s^C_{i,t-1} \Delta Z_{i,t} + \sum_{i \in C} Z_{i,t-1} \Delta s^C_{i,t} + \sum_{i \in C} \Delta s^C_{i,t} \Delta Z_{i,t} + s^N_t \left(Z^N_t - Z^C_t \right) - s^X_{t-1} \left(Z^X_{t-1} - Z^C_{t-1} \right),$$

where $s^C_{i,t} = \frac{s_{i,t}}{s^C_t}$, $s_{i,t}$ is the employment share and $Z_{i,t}$ is the productivity level of firm i in period t and C, N, X denote incumbents, entrants and exiters respectively. More details can be found in Online Appendix A.5. The data used is collected from the ESEE dataset.

Estimated moments of the distribution support the predominant role of the lower tail with higher-order moments experiencing the largest swings.[17] During the 1992-93 crisis firms display lower productivity on average and the dispersion of log TFP increases. The increase in dispersion, however, is asymmetric. The distribution of unproductive firms expands while that of productive firms changes little with the coefficient of skewness declining from -0.40 to -1.24. Moreover, increasing kurtosis, 7.04 versus 10.42, is associated with fatter tails as the probability mass moves away from the shoulders of the distribution. Although the behavior of TFP exactly reverses during the 2010-2013 crisis - productivity increases while dispersion drops - it is still the tails, and especially, the lower tail, that changes the most. In this case, skewness increases from -2.37 to -0.89 while kurtosis shrinks from 27.92 to 7.13.

Decomposing Productivity Growth

While the above findings support a narrative of shifting productivity cutoffs, it is often the case that firms at the lower end of the productivity scale are small in size and, thus, have negligible effects on the aggregate. A more formal test of growth patterns requires considering weighted

[17] Refer to Table A.1 for further details.

measures. Moreover, it should aim at disentangling the role of incumbent, entering and exiting firms in shaping TFP changes.

I study this by performing a TFP growth decomposition exercise using the formulation proposed by Dias and Marques (2021), which I derive in Online Appendix A.5. Results for the two sudden stops are summarized in Table I. The decline in TFP in the 1992-1993 crisis is entirely driven by incumbents. In fact, net entry contributes to positive growth, although the magnitude is small as the positive contribution of exiters almost cancels out the negative contribution of entrants. Among incumbents, there is some reallocation towards less productive firms, but it's mostly the pronounced fall in within-firm productivity that explains the overall large negative effect.

In contrast, the increase in TFP experienced during 2010-2013 is fully driven by net entry, in particular, by unproductive firms exiting the sample. The size of the effect is remarkable, especially given that small and medium firms are underrepresented in the sample. Delving deeper into the characteristics of exiting firms shows that during the 2010-2013 episode, firms that exit the market were, on average, bigger in terms of market share (7.46% versus 6.26%) and 60% more unproductive relative to incumbents (32.28% versus 20.20%) than their 1992-1993 counterparts. Moreover, the annualized exit rate more than doubled from 4.63% to 9.82%.[18] To alleviate potential industry composition concerns, Figure A.6 shows this holds broadly at the three-digit industry level too. In sum, there is more and better exit.

Back to Table I, the contribution of incumbents remains negative for the 2010-13 sudden stop. It is still the case that, on average, the productivity of incumbents is procyclical. There is a positive yet small effect of the between and cross terms that cushions the negative effect of the within-firm component. The increase in market share reallocation and a stronger correlation between productivity and market share changes at the individual firm, together with the positive contribution of exiting firms, is consistent with a cleansing effect of the 2010-13 sudden stop which is absent in the 1992-93 episode. The cleansing hypothesis, as discussed by Caballero and Hammour (1994), argues that crises are periods of accelerated productivity-enhancing reallocations, especially as resources are freed by the exit of unproductive firms. I turn to formally testing the firm-level implications of this interpretation in what follows.[19]

The Cleansing Hypothesis: A Formal Test

According to the literature, there is a tight connection between firm exit, input growth and productivity: models of firm dynamics predict that exit is more likely among low productivity firms

[18]The corresponding averages for the entire sample are the following: the annualized exit rate is 7.87%, the employment share of exiting firms is 6.89% and the difference in TFP between exiting firms and incumbents is 16.81%.

[19]A valid concern is that if firms are forward-looking, they might backload the decision to exit, and, thus, the duration of a crisis might be an important driver of results. I refer the reader to Online Appendix A.7, where I show that exit in the 2010-13 episode is not concentrated on the later years.

whereas high productivity firms are expected to grow by more every period. The cleansing hypothesis suggests that recessions accelerate these dynamics. One should therefore observe a stronger correlation between survival, labor growth and productivity levels during crises. To test whether this is the case for the two sudden stop episodes considered, I adjust the empirical specification proposed by Foster, Grim and Haltiwanger (2016) and run the following set of regressions:

$$y_{i,t+1} = \beta\, TFP_{it} + \gamma\, ss^1_{t+1} * TFP_{it} + \theta\, ss^2_{t+1} * TFP_{it} + X'_{i,t}\,\omega + \epsilon_{i,t+1}\,,$$

where $y_{i,t+1}$ stands for a set of dependent variables. It is a dummy variable with value one when a firm reports activity in period t and no activity in period $t+1$ in the exit specification. It is a quantitative variable measuring labor growth between t and $t+1$ in the regressions for input growth. The regressor ss^1_{t+1} is a dummy variable for the 1992-93 sudden stop, ss^2_{t+1} is a dummy variable for the 2010-13 sudden stop and TFP_{it} captures the log of firm-level productivity. To abstract from underlying sector-specific trends, the above specification includes industry-year fixed effects at the three-digit level. In addition, $X_{i,t}$ controls for firm characteristics. For the baseline specification, I follow Foster, Grim and Haltiwanger (2016) in accounting for firm size and age effects.[20] However, the role of other firm characteristics is also explored in the section that follows.

For the exit specification, the relationship between survival probability and productivity is expected to be positive and, thus, $\beta < 0$. Under the cleansing hypothesis, this correlation should strengthen during a sudden stop episode and one would anticipate $\gamma < 0$ and $\theta < 0$. For the input growth specification, the exact opposite applies.

Results of these regressions are summarized in Table II. The first column shows the relationship between productivity and the probability of exit. Consistent with earlier findings, firms that exit the market tend to feature lower productivity levels. Focusing on the interaction terms, there is evidence of a cleansing effect only during the second episode. In terms of quantitative significance, the predicted difference in probability of exit between a firm one standard deviation below and a firm one standard deviation above average is about 5 percentage points in normal times but almost 12 percentage points during the latter sudden stop.

The second and third columns support further the predictions of the cleansing hypothesis for the 2010-13 episode. First, note that there is a positive impact of productivity on labor growth as predicted by the literature. Of greater interest, this correlation is even higher during the second sudden stop. In fact, the predicted difference in labor growth between a firm one standard deviation above and a firm one standard deviation below average increases from 4.8 (4.3) percentage points in normal times to 7.8 (6.4) percentage points in 2010-2013 according to coefficients reported in the second (third) column.

[20] For firm size effects, I use a categorical variable: firm size class =1 if firm employment < 20; =2 if $20 \leq$ firm employment ≤ 50; =3 if $50 \leq$ firm employment ≤ 200; =4 if firm employment > 200. To control for the life cycle of the firm, I use a dummy variable $Young_{it}$ that equals one if the firms is five years old or younger.

TABLE II: REALLOCATION AND PRODUCTIVITY

	Exit	Labor Growth (Incumbent & Exiters)	Labor Growth (Incumbents Only)
	(1)	(2)	(3)
TFP_{it}	-0.038***	0.037***	0.033***
	(0.004)	(0.004)	(0.004)
$ss^1_{t+1} * TFP_{it}$	0.007	-0.004	-0.004
	(0.013)	(0.013)	(0.013)
$ss^2_{t+1} * TFP_{it}$	-0.052***	0.023***	0.016***
	(0.009)	(0.008)	(0.008)
Observations	36,252	32,262	29,679
Industry-Year FE	Yes	Yes	Yes
Firm Controls	Yes	Yes	Yes

Notes: Regression for exit is a linear probability model where exit=1 if the firm reports positive activity in period t and no activity in period $t+1$. Labor growth is measured from period t to period $t+1$. TFP_{it} is the log firm-level TFP at time t, ss^1_{t+1} is a dummy equal to one for years 1992-1993 and ss^2_{t+1} is a dummy equal to one for years 2010-2013. Firm controls in period t account for age and size effects. Standard errors (in parentheses) are calculated using bootstrapping methods; $^{***}p < 0.01$, $^{**}p < 0.05$, and $^{*}p < 0.10$.

2.3 Alternative Explanations

Though so far the focus has been on the marked divergence in the exchange rate policies implemented during the two sudden stops, there are a number of additional dimensions along which the Spanish economy differed in 1992 versus 2010 that could also explain the contrast in firm dynamics documented in the previous section. While it is unfeasible to fully rule out all alternative explanations, this section explores to what extent they might be driving the results. More specifically, I investigate the role of the banking crisis, expenditure switching effects of a real depreciation and resource misallocation trends. [21]

Table III augments the above empirical model for exit by adding relevant firm-level controls and interactions to test whether the coefficients of interest, especially θ, remain significant and stable when considering alternative explanations. To ease comparison, the first column of Table III reiterates results for the baseline specification.

The most important difference across the two sudden stops, besides the exchange rate, is that Spain simultaneously experienced a banking crisis only during the latter. While intuition works in the opposite direction: highly leveraged firms, with a higher propensity to exit during a credit

[21] The burst of the 2000s property bubble in 2008 might appeal to the reader as an alternative explanation too. Note that my analysis takes care of this in two ways. First, the ESEE dataset abstracts from construction sector altogether. Second, the industry-year fixed effects address the concern that manufacturing firms might be differentially exposed to construction through input-output linkages.

TABLE III: FIRM EXIT AND PRODUCTIVITY WITH ADDITIONAL CONTROLS

	(1)	(2)	(3)	(4)	(5)
TFP_{it}	-0.038***	-0.033***	-0.037***	-0.038***	-0.032***
	(0.005)	-0.005	(0.005)	(0.005)	(0.005)
$ss^1_{t+1} * TFP_{it}$	0.007	-0.002	0.007	0.007	-0.003
	(0.012)	(0.013	(0.012	(0.012	(0.013)
$ss^2_{t+1} * TFP_{it}$	-0.052***	-0.040***	-0.051***	-0.050***	-0.038***
	(0.011)	(0.011)	(0.011)	(0.011)	(0.011)
$leverage_{it}$		0.052***			0.052***
		(0.013)			(0.013)
$ss^1_{t+1} * leverage_{it}$		-0.008			-0.006
		(0.036)			(0.036)
$ss^2_{t+1} * leverage_{it}$		0.054*			0.055*
		(0.031)			(0.031)
$importer_{it}$			-0.012***		-0.012**
			(0.003)		(0.004)
$ss^1_{t+1} * importer_{it}$			0.002		0.012
			(0.012)		(0.014)
$ss^2_{t+1} * importer_{it}$			-0.010		0.005
			(0.009)		(0.010)
$exporter_{it}$				-0.001	0.002
				(0.003)	(0.003)
$ss^1_{t+1} * exporter_{it}$				-0.020**	-0.025*
				(0.009)	(0.012)
$ss^2_{t+1} * exporter_{it}$				-0.020**	-0.016*
				(0.007)	(0.009)
Observations	36,252	34,279	36,252	36,252	34,279
Industry-Year FE	Yes	Yes	Yes	Yes	Yes
Firm Controls	Yes	Yes	Yes	Yes	Yes

Notes: All regressions are linear probability models where exit=1 if the firm reports positive activity in period t and no activity in period $t+1$. TFP_{it} is the log firm-level TFP at time t, ss^1_{t+1} is a dummy equal to one for years 1992-1993 and ss^2_{t+1} is a dummy equal to one for years 2010-2013. $leverage_{it}$ is captured by the bank debt-to-assets ratio. $importer_{it}$ is a dummy equal to one if the firm reports imports above 50,000€ in value. $exporter_{it}$ is a dummy equal to one if the firm reports exports above 50,000€ in value. Firm size classes in period t are used to control for firm size effects. Standard errors (in parentheses) are calculated using bootstrapping methods; $^{***}p < 0.01$, $^{**}p < 0.05$, and $^{*}p < 0.10$.

crunch, feature higher productivity levels on average; the second column of Table III considers the role of leverage explicitly. In particular, the empirical model is augmented to account for the bank debt to assets ratio and the corresponding interactions. As expected, leverage is positively correlated with exit and this correlation is strengthened during the banking crisis, in line with findings in Bornstein and Castillo-Martinez (2023) for other European countries. However, the productivity results remain mostly unchanged. While the 2010-13 disruption of credit contributed to the overall increase in firm exit, it cannot fully explain the extend of the cleansing effect that followed.

Other well-known effects of a real exchange rate depreciation include (i) an expenditure switching effect on imported intermediate inputs and (ii) balance sheet effects resulting from liability currency mismatches. While in the absence of a model it is ex-ante unclear whether these effects

TABLE IV: MARKUPS AND PRODUCTIVITY

	(1)	(2)	(3)	(4)
Firm-level TFP	0.994***	0.992***	0.964***	0.960***
	(0.003)	(0.003)	(0.008)	(0.008)
Aggregate TFP	0.022	-0.000		
	(0.020)	(0.016)		
Industry TFP			-0.882***	-0.879***
			(0.048)	(0.049)
Observations	36,261	36,261	36,261	36,261
R-squared	0.933	0.937	0.856	0.859
Industry FE	Yes	Yes	No	No
Export status	No	Yes	No	Yes

Notes: This table reports the results of a cross-section regression of firm-level markups on different measures of productivity: at the firm level, at the industry level and at the economy level. All variables are measured in logs. Export status is a dummy equal to one whenever a firm reports a positive exporting revenue. Standard errors (in parentheses) are clustered by industry; $^{***}p < 0.01$, $^{**}p < 0.05$, and $^{*}p < 0.10$. The data used is collected from the ESEE dataset.

should be different across episodes, most economists tend to expect a greater impact whenever the currency depreciates. This would involve more exit in the first episode, which does not hold in the data. Although the ESEE dataset does not provide information on debt denomination, the third column of Table III provides some evidence on the role of imported intermediate inputs by featuring the import status of the firm. As theory predicts importers have a lower propensity to exit. Interestingly, this correlation remains unchanged during both sudden stops. As in the previous column, the productivity coefficients remain significant and stable.

For completeness, I also explore the role of exporters. [22] According to the fifth column of Table III, exporters are less likely to exit. This correlation, however, is only statistically significant during each of the sudden stops. It's important to highlight that the correlation is already conditional on the firm's productivity level. Thus, the interaction terms are mostly likely capturing that foreign demand is relatively stronger (vis-à-vis domestic demand) during sudden stops and exporters are better able to substitute between the two, in line with results by Almunia et al. (2021). In any case, accounting for firms' exporting status does not alter the cleansing results.

Finally, I evaluate a popular complementary channel through which reallocation contributes to productivity growth - increased allocative efficiency. Following Hsieh and Klenow (2009), the

[22] As it has been well documented in the literature, exporters are, on average, (138.15%) more productive and, thus, (19.05%) less likely to exit than non-exporters. During both episodes, the firm-level data shows an increase in the propensity to export (9.51% increase in the first episode; 17.65% increase in the second episode) and a decline in the average productivity of exporters (23.31% in the first episode; 4.45% in the second episode). This falls in line with a decline in the productivity threshold for exporting as predicted by the model that I later present.

degree of dispersion of firm-specific distortions is informative of the degree of misallocation in the economy. As distortions are unobservable in practice, I use marginal revenues products as proxies. Periods of higher TFP should be associated with periods of lower marginal revenue product dispersion and differences in the results for capital and labor can be interpreted as evidence of the different types of wedges that might prevail.[23]

In this spirit, I estimate the within-sector standard deviations of marginal revenue products of capital (MRPK) and labor (MRPL) before and after each sudden stop for each three-digit industry. In most sectors, dispersion increases during the first episode and decreases by the end of the latter.[24] Importantly, this pattern holds for both capital and labor, suggesting that while there are changes in the distortions over time, such distortions affect both factors of production simultaneously or, in Hsieh and Klenow (2009) lingo, it is changes in the output (and not the capital to labor ratio) wedge that are driving TFP movements.[25]

An alternative interpretation of this result, which implies moving away from the CES assumption, suggests the presence of firm-specific markups that are time-varying. I explore this possibility by computing markups at the firm level as the ratio of the output elasticity of labor to the labor share following De Loecker and Warzynski (2012)'s cost minimization approach. I find that the dispersion of firm-specific markups is substantial; the standard deviation is 0.47 and changes over time.[26]

To study its relationship with productivity, I regress firm-specific markups on firm-level and aggregate TFP measures. Results are presented in Table IV. Columns (1) and (2) focus on a economy-wide measure of aggregate productivity while columns (3) and (4) restrict attention to productivity aggregated at the industry level. More productive firms set higher markups on average. This is consistent with most models of variable markups. In addition, lower markups are associated with higher levels of aggregate productivity at the industry level although the effect vanishes at a higher level.

As a brief summary, the above findings call for a theory of sudden stops that features heterogeneously productive firms, selection into production and variable firm-specific markups. All of these elements, together with the exchange rate dimension, are featured in the theoretical frame-

[23] See Online Appendix A.6 for a review of the argument and further details on how to construct these measures.

[24] Take the biggest industry in the dataset, "Vehicles", as an example. For the 1992-93 sudden stop the standard deviation for capital (labor) was 0.947 (0.342) the year before the crisis; it increased to 1.037 (0.439) by the end of the crisis. For the 2010-13 sudden stop the standard deviation for capital (labor) was 1.098 (0.704) the year before the crisis; it however decreased to 0.977 (0.368) by the end of the crisis. To derive an economy-wide measure of the standard deviation, I then aggregate standard deviations at the industry level using time-invariant employment weights. Results, which are similar to those for "Vehicles", are summarized in Table A.6.

[25] While Gopinath et al. (2017) and García-Santana et al. (2020) have shown that increasing capital misallocation is responsible for the slowdown of productivity growth prior to the 2010-2013 crisis, these results rule out the possibility that it is the undoing of this phenomenon what drives the most recent improvement.

[26] To calculate these numbers, I estimate standard deviation at the industry level and then compute an employment weighted average across industries.

work that I develop next.

3 A Small Open Economy with Firm Dynamics

Consider an infinite-horizon small open economy. Time is discrete and indexed by t. The economy is populated by a continuum of households, $i \in (0,1)$, that consume goods, provide specialized individual labor types and engage in financial transactions with foreign investors. A large number of differentiated firms, indexed by j, produce consumption goods using labor and a monetary authority sets the nominal exchange rate as the policy instrument.

3.1 Consumers

Households derive utility from leisure and the consumption of a set of differentiated varieties, indexed by ω. Labor decisions are outsourced to type-specific labor unions as discussed below. Under the assumption of complete contingent claims markets for consumption, consumption and saving decisions are identical across households. Thus, I drop the household specific index i and, thus, consider a representative consumer for the rest of this section.[27] Its lifetime utility is given by

$$\mathbb{E}_0 \left[\sum_{t=0}^{\infty} \beta^t U \left(q_t \left(\omega \right) L_t \right) \right] , \tag{1}$$

where $\mathbb{E}_t$ is the expectation operator conditional on the information set available at time t, β is the discount factor and $q_t(\omega)$ is the consumption level of variety ω.

The period utility function is based on Melitz and Ottaviano (2008):

$$U \left(q_t \left(\omega \right), L_t \right) = \alpha \int_0^{N_t} q_t \left(\omega \right) \, d\omega - \frac{1}{2} \gamma \int_0^{N_t} q_t \left(\omega \right)^2 d\omega - \frac{1}{2} \eta \left(\int_0^{N_t} q_t \left(\omega \right) d\omega \right)^2 - L_t \, ,$$

where N_t is the measure of available consumption varieties, α determines the level of product differentiation and γ and η measure the substitutability between the consumption of differentiated goods and leisure. All three demand parameters are strictly positive. [28,29]

[27]Note that this is a slight abuse of notation. There is technically not a representative household in this model due to labor specialization. However, all households have the same consumption budget, choose the same consumption and, thus, have the same marginal utility of income.

[28]Melitz and Ottaviano (2008) preferences are appealing for three reasons. First, they capture love of variety. As γ increases, consumers place higher weight on the distribution of consumption across varieties. Second, the quadratic form gives rise to a linear demand function which ensures the existence of a choke price and an extensive margin of production even in the absence of fixed costs of production. Third, they generate endogenous variable markups, which capture the effect of market competition on firm sales (the so-called pro-competitive effect) as opposed to standard CES preferences.

[29]Melitz and Ottaviano (2008) preferences also depict a second consumption good, which is homogeneous and assumed to be the numeraire, with a linear production technology that pins down the wage in the economy. As endogenous fluctuations in the wage level are relevant in this analysis, this feature of the original functional form is

The budget constraint is given by:

$$\int_0^{N_t} p_t(\omega)\, q_t(\omega)\, d\omega + e_t B_t = W_t L_t + \Pi_t + e_t R_{t-1} B_{t-1}\,, \tag{2}$$

where $W_t L_t$ is labor income, Π_t is profit received from firms and e_t denotes the nominal exchange rate, defined as units of domestic currency per unit of foreign currency.

Households can only engage in financial transactions with foreign investors by trading in risk-free foreign denominated bonds B_t, which pay a debt elastic rate of return:

$$R_t = R^* + \phi\left(e^{\bar{B}-B_t} - 1\right) + \xi_t\,, \tag{3}$$

where R_t^* is the world interest rate, $\bar{B}$ is the steady state level of debt and ξ_t is as a country risk premium shock.[30]

Each period, the representative housheold maximizes (1) by choice of $q_t(\omega)$ and B_t, subject to (2). Given quadratic preferences, consumption is governed by the existence of a choke price, p_t^{max}, i.e., the maximum relative price consumers are willing to pay. If $p(\omega) > p_t^{max}$, optimal consumption of variety ω falls to zero. If instead $p(\omega) \leq p_t^{max}$, optimal consumption of variety ω is given by the corresponding first order condition:

$$\alpha - \gamma q_t(\omega) - \eta \int_0^{N_t} q_t(\omega)\, d\omega = \lambda_t p_t(\omega)\ ,$$

where λ_t is the time t Lagrange multiplier on the budget constraint. The inverse demand can be written compactly as

$$q_t(\omega) = \max\left\{\frac{\lambda_t}{\gamma}\left[p_t^{max} - p_t(\omega)\right], 0\right\}\ , \tag{4}$$

where $p_t^{max} \equiv \frac{\frac{\alpha\gamma}{\lambda_t} + \eta \int_0^{N_t} p_t(\omega) d\omega}{\gamma + \eta N_t}$. As in Melitz and Ottaviano (2008), a larger number of competing varieties, induce a decrease in the choke price. In addition, higher income, lower λ_t, increases the choke price.

The optimal decision for the purchase of the foreign asset, B_t, delivers a standard Euler equation:

$$\lambda_t = \beta R_t E_t\left[\frac{e_{t+1}}{e_t}\lambda_{t+1}\right]\ . \tag{5}$$

A higher interest rate and expectations of nominal exchange rate depreciation both increase the

inconvenient. Moreover, in the context of an internal devaluation, it is also interesting to capture any changes in demand patterns that may arise from movements in wages. My approach is to explicitly model the labor supply decision by assuming preferences that are linear in leisure. Given the quasi-linear functional form, there is no income effect for differentiated varieties. However, changes in wages will affect demand through the substitution effect.

[30] Households are not allowed to trade in domestic bonds in the baseline model for the sake of simplicity. However, extending the model to include domestic bonds would be trivial as these would be in zero net supply.

cost of borrowing internationally and, thus, encourage consumer savings.

3.2 Labor Market

As is standard in sticky wage New Keynesian models, a central authority competitively aggregates units of differentiated labor input, L_t^i, into aggregate employment services, which firms can purchase at a rate W_t, using a CES technology, $L_t = \left(\int L_t^{i\,\frac{\varepsilon_w-1}{\varepsilon_w}} di\right)^{\frac{\varepsilon_w}{\varepsilon_w-1}}$, where ε_w is the elasticity of substitution across labor types. In addition, wages are set by unions, each of which represents households specialized in a given type of labor. Wage setting is staggered à la Calvo (1983), i.e. , a union is able to reset its wage with a probability $1-\theta$ every period. [31]

All unions that reset their wage in a given period choose the same wage since they face an identical problem. In particular they choose W_t^* to maximize $\mathbb{E}_t\left[\sum_{k=0}^{\infty}(\beta\theta)^k U\left(q_{t+k|t}(\omega), L_{t+k|t}\right)\right]$, where $q_{t+k|t}$ and $L_{t+k|t}$ denote consumption and labor at time $t+k$ for a household that last updated the wage at time t. This is subject to the sequence of household budget constraints that are effective while W_t^* remains in place, as well as the corresponding labor demand schedules, as given by: $L_{t+k|t} = \left(\frac{W_t^*}{W_{t+k}}\right)^{-\varepsilon_w} L_{t+k}$.

The optimality condition associated with the above problem can be written as

$$\sum_{k=0}^{\infty}(\beta\theta)^k \mathbb{E}_t\left[L_{t+k}\left(\frac{W_t^*}{W_{t+k}}\right)^{-\varepsilon_w}\left(W_t^* - \frac{\varepsilon_w}{\varepsilon_w-1}\frac{1}{\lambda_{t+k}}\right)\right] = 0\,. \tag{6}$$

In the limiting case of full wage flexibility, $\theta = 0$, $W_t = W_t^* = \frac{\varepsilon_w}{\varepsilon_w-1}\frac{1}{\lambda_t}$. Higher wages increase household income all else equal. Given diminishing marginal utility, the Lagrange multiplier, i.e. , the increase in utility of an extra dollar of income, falls. With staggered wages, the goal is to close the discounted sum of expected wedges between actual and desired (flexible) wages.

Following this wage setting structure, the evolution of the aggregate wage is given by

$$W_t = \left[\theta W_{t-1}^{1-\varepsilon_w} + (1-\theta)(W_t^*)^{1-\varepsilon_w}\right]^{\frac{1}{1-\varepsilon_w}}\ . \tag{7}$$

3.3 Domestic Firms

There is an endogenous measure, M_t, of domestic firms, indexed by j, producing differentiated goods. Labor is the only factor of production and the unit cost is a concave function in the factor price, i.e., $\frac{W_t^\sigma}{Z_{jt}}$ where $0 < \sigma \leq 1$ is the labor income share.[32] Firm productivity $Z_{jt} = Z_t^A z_j^P z_{jt}^T$

[31] The model could alternatively feature Rotemberg wage adjustment costs, sticky information à la Mankiw and Reis (2002) or downward wage rigidities, as long as the latter are incorporated in the form of a constraint on the wage setting problem of the worker (or of the union that represents them).

[32] To rationalize this functional form, suppose there is a second factor of production, which is inelastically supplied by households and the production function is Cobb-Douglas. If the price of this second input, κ, is assumed to be

is the product of an aggregate shifter, Z_t^A, an idiosyncratic permanent component, z_j^P, and an idiosyncratic transitory effect, z_{jt}^T. Permanent idiosyncratic productivity is drawn from a distribution $F(z^P)$ while transitory idiosyncratic effects, z_t^T, follow a Markov process with transition function $H(z_{t+1}^T|z_t^T)$. Firms with the same level of productivity make the same decisions and, thus, in what follows I index firms by their idiosyncratic productivity, $z_t = z^P z_t^T$, rather than by their index j.

The timing of events for an incumbent firm at period t is as follows. At the start of the period, aggregate uncertainty is resolved. The firm observes its idiosyncratic productivity as well as its stochastic value of exiting, x_{jt}, which is positive and drawn from a common time-invariant distribution $\xi(x_t)$. If it exits, it receives the exit value. If it decides to stay, it sets prices and chooses labor. Production takes place and the period concludes.

Every period there is an endogenous mass of potential entrants, M_t^q. Entry is a two-step procedure and takes place once aggregate uncertainty is realized. First, a potential entrant comes up with an idea, which involves paying a fixed cost $c_q > 0$. The quality of the idea, measured by $q_j \sim Q(q)$, is informative of the entrant's productivity. Conditional on entry, the distribution of the idiosyncratic shocks in the first period of operation is $H^q(z_t|q_t)$, strictly decreasing in q. Potential entrants that decide to implement their idea must pay an additional cost $c_e > 0$ to enter. The measure of actual entrants is denoted by $\mathcal{E}_t$.

Incumbents' static problem Domestic firms can sell their varieties in both the domestic and the export market. Markets are segmented and selling abroad requires incurring a per-unit trade cost $\tau > 1$. While domestic demand for a differentiated good, $q_t^H(z)$, is given by equation (4), I assume the foreign demand for a domestic variety is: $q^X(z) = A - Bp^X(z)$, where A and B are exogenous given a small-open economy setting. [33] Conditional on operating, flow profits are given by

$$\pi(z) = \max_{p^H, p^X} p^H(z)\, q^H(z) + e\, p^X(z)\, q^X(z) - \frac{W^\sigma}{Zz}\left(q^H(z) + \tau q^X(z)\right)$$

$$\text{s. t.} \quad q^H(z) = \frac{\lambda}{\gamma}\left[p^{max} - p^H(z)\right] \geq 0\,,$$

$$q^X(z) = A - Bp^X(z) \geq 0\,.$$

constant, the marginal cost is given by $\left(\frac{W_t}{\sigma}\right)^\sigma \left(\frac{\kappa}{1-\sigma}\right)^{1-\sigma}$.

[33]In the spirit of Demidova and Rodriguez-Clare (2009), I show in Online Appendix B.1 that this small open economy is a special case of the two economy framework where the share of potentially active firms in Home, $n = \frac{M}{M+M^*}$ approaches zero. In the limit z^{*F} is unaffected by changes in Home, the term A includes the price index, the number of consumed varieties and the marginal utility of wealth in Foreign while the term B is proportional to the marginal utility of wealth in Foreign.

The above optimization delivers expressions for prices and output

$$p^H(z) = \min\left\{\frac{1}{2}\left[p^{max} + \frac{W^\sigma}{Zz}\right], p^{max}\right\},\ q^H(z) = \max\left\{\frac{\lambda}{2\gamma}\left[p^{max} - \frac{W^\sigma}{Zz}\right], 0\right\},$$
$$p^X(z) = \min\left\{\frac{1}{2}\left[\frac{A}{B} + \frac{\tau}{e}\frac{W^\sigma}{Zz}\right], \frac{A}{B}\right\},\ q^X(z) = \max\left\{\frac{B}{2}\left[\frac{A}{B} - \frac{\tau}{e}\frac{W^\sigma}{Zz}\right] 0\right\}.$$

Incumbents' recursive problem At all $t \geq 0$, the distribution of operating firms is denoted by $\Gamma_t(z_t)$, such that $\int d\Gamma_t(z_t) = M_t$. Let $\mu_t \in \mu$ denote the set of aggregate state variables and $J(\mu_{t+1}|\mu_t)$ its transition operator. Note that $\mu_t = \{w_{t-1}, e_t, \Gamma_t, R_t, Z_t\}$. The start-of-period value of an incumbent firm is given by $W(\mu, z^P, z^T)$ which solves

$$W(\mu, z^P, z^T) = \int \max\left\{V^c(\mu, z^P, z^T), x\right\} d\xi(x).$$

where the value of a continuing firm is

$$V^c(\mu, z^P, z^T) = \begin{cases} \pi(z^P, z^T) + \beta \int_\mu \int_{\mathbb{R}} W(\mu', z^P, z^{T\prime})\ dH\left(z^{T\prime}|z^T\right)\ dJ\left(\mu'|\mu\right) & \text{if } \pi(z) > 0 \\ 0 & \text{otherwise} \end{cases}$$

In other words, the firm will choose to exit if its price exceeds the market choke price or if the exit value is high enough.

Entry decision For an aggregate state μ, the value of a new firm with permanent idiosyncratic component z^P that enters after receiving signal q is

$$V^e(\mu, z^P, q) = \int V^c(\mu, z^P, z^T)\ dH^q\ \left(z^T|q\right).$$

It follows that only potential entrants with sufficiently high values of $q(z^P) \geq q^*(z^P)$ find it profitable to enter, where $q^*(z^P)$ is determined by $V^e(\mu, z^P, q^*(z^P)) = c_e(z^P)$. Finally, the free-entry condition ensures that potential gains from entry are exhausted. Potential entrants keep generating ideas right until $V^p(\mu) = c_q$, where the value function of a potential entrant is given by

$$V^p(\mu) = \int\int \max\left\{V^e(\mu, z^P, q) - c_e,\ 0\right\} dF(z^P)\, dQ(q).$$

3.4 Foreign Importers

Foreign firms might choose to serve the domestic market. While the distribution of operating foreign firms, $\Gamma^*(z)$, is exogenous given the small open economy assumption, the mass of importers, N_t^M, is endogenous. Similarly to the domestic pricing problem above, flow profits for a foreign firm are given by

$$\pi^M(z) = \max_{p^M} \; p^M(z)\, q^M(z) - \frac{e\tau}{z} q^M(z)$$
$$\text{s. t.} \quad q^M(z) = \frac{\lambda}{\gamma}\left[p^{max} - p^M(z)\right] \geq 0\,.$$

which delivers

$$p^M(z) = \min\left\{\frac{1}{2}\left[p^{max} + \frac{e\tau}{z}\right], p^{max}\right\},\; q^M(z) = \max\left\{\frac{\lambda}{2\gamma}\left[p^{max} - \frac{e\tau}{z}\right], 0\right\}\,.$$

A foreign firm will select into importing provided that $\pi^M(z) > 0$.

3.5 Exchange Rate Policy

To pin down the nominal variables of the model, I need to determine exchange rate policy. Suppose the central bank implements monetary policy by setting the nominal exchange rate according to the following rule:

$$\left(\Pi_t^w\right)^{\phi_W} (e_t)^{1-\phi_W} = 1\,, \tag{8}$$

where $\Pi_t^w = \frac{W_t}{W_{t-1}}$ is wage inflation and $0 \leq \phi_w \leq 1$ is the weight that the central banks puts on wage stabilization. I explore two extreme versions of this rule. Under a currency union, the central bank perfectly commits to a currency peg in which $e_t = 1$ at every period t, i.e. , $\phi_W = 0$. Under a flexible exchange rate arrangement, the central bank offsets all the distortions that originate from nominal rigidities by implementing the flexible wage equilibrium, i.e. , $\phi_W = 1$.

3.6 Stationary Competitive Equilibrium

I now define the recursive stationary competitive equilibrium of this economy. The law of motion for the measure of operating (domestic) firms $\Gamma(z^P, z^T)$ is defined as follows. For all Borel sets $\mathcal{Z}^P \times \mathcal{Z}^T \in \Re^+ \times \Re^+$,

$$\Gamma'(\mathcal{Z}^P \times \mathcal{Z}^T) = \int \int_{\mathcal{Z}^T} \int_{B(\mu',x)} d\xi(x)\, dH(z^{T'}|z^T)\, d\Gamma(z^P, z^T) + \mathcal{E}'(\mathcal{Z}^P \times \mathcal{Z}^T)\,,$$

where $B(\mu', x) = \{x \text{ s.t. } V^c(\mu', z^P, z^{T'}) \geq x\}$ and $\mathcal{E}(z^P, z^T)$ is the measure of actual entrants, such that, for all Borel sets $\mathcal{Z} \in \Re^+$,

$$\mathcal{E}(\mathcal{Z}^P \times \mathcal{Z}^T) = M^q \int_{q^*}^{\infty} \int_{B_p(\mu, z^P, z^T)} F(z^P)\, dH^q(z^T|q)\, dQ(q)\,,$$

where $B_p(\mu, z^P, z^T) = \{z^T \in \mathcal{Z}^T \text{ s.t. } V^c(\mu, z^P, z^T) > 0\}$.

Clearing in the goods market requires:

$$e\,(1-R)\,B = e\int p^X(\mu,z)\,q^X(\mu,z)\;d\Gamma(z) - \int p^M(\mu,z)\,q^M(\mu,z)\;d\Gamma^*(z) - \left(M^q c_q + M^e c_e - X\right)\,, \tag{9}$$

where $M^e = \int d\mathcal{E}$ is the number of actual entrants and $X = \int\int \mathcal{I}(V^c(\mu,z) < x)\,x\,d\Gamma(z)\,d\xi(x)$ is the total value of exiting. The left-hand side is the net foreign asset position of the economy while the right-hand side is the trade balance after accounting for net entry costs.

Finally, note that the exchange rate rule above, equation (8), implies that $e = 1$ in the stationary equilibrium. The definition of the recursive stationary competitive equilibrium is as follows.

Definition 1. *A **Recursive Stationary Competitive Equilibrium** consists of value functions $V(\mu,z)$, $V^c(\mu,z)$, $V^e(\mu,q)$, and $V^p(\mu)$; policy functions $\pi^i(\mu,z)$, $p^i(\mu,z)$, and $q^i(\mu,z)$ for $i = \{H,X,M\}$; a vector of aggregate prices $\{p^{max},W,R\}$; foreign bonds B; the Lagrange multiplier λ; the number of varieties N; the number of potential entrants M_q and the distribution of operating (domestic) firms, $\Gamma(z)$ such that:*

1. *$V(\mu,z)$, $V^c(\mu,z)$, $\pi^H(\mu,z)$, $\pi^X(\mu,z)$, $p^H(\mu,z)$, $p^X(\mu,z)$, $q^H(\mu,z)$, and $q^X(\mu,z)$ solve the incumbent's problem*
2. *$V^e(\mu,q)$, and $V^p(\mu)$ solve the entrant's problem*
3. *$\pi^M(\mu,z)$, $p^M(\mu,z)$ and $q^M(\mu,z)$ solve the importer's problem*
4. *p^{max} and B solve the household's problem*
5. $W = \frac{\varepsilon_w}{\varepsilon_w - 1}\frac{1}{\lambda}$
6. *R follows equation* (3)
7. $N = \int \mathcal{I}(\pi^H(\mu,z) > 0)\;d\Gamma(z) + \int \mathcal{I}(\pi^M(\mu z) > 0)\;d\Gamma^*(z)$
8. *Free entry condition holds: $V^p(\mu) = c_q$*
9. *Goods market clears - i.e., equation 9 holds*
10. *The distribution of operating (domestic) firms is stationary*

4 Sudden Stops and Productivity in a Simple Example

Before proceeding to the full characterization of the model's solution, it is useful to build intuition of the mechanism by providing some analytical results. In order to do this, I focus on a simpler version of the model with (i) constant idiosyncratic firm productivity, (ii) no free entry of firms and (iii) zero exit value at all times. There is an exogenous number of potentially active firms at home, M, and abroad, M^*, with productivity z that follows a Pareto distribution $1-\Gamma(z)=\left(\frac{1}{z}\right)^k$ with shape parameter k and minimum level equal to one.

In the following, I define aggregate productivity and discuss the channels through which shocks can potentially affect it. I then show how the effects of a sudden stop on productivity depend on the exchange rate regime.

4.1 Aggregate Productivity

Given the new set of assumptions above, the domestic firm's optimization problem is static. Firms' decision to operate can be written in terms of a productivity threshold: a firm will choose to serve market i provided that $z \geq z_t^i$ where $i \sim \{H, X, M\}$. Thus, the variable of interest, domestic aggregate productivity, is given by:

$$Z_t^H = M \int_{z_t^H}^{\infty} \Omega(z)\, z\, Z_t \, \frac{\gamma(z)}{1-\Gamma(z_t^H)}\; dz\,,$$

where $\Omega(z)$ is the weight used in the aggregation and $\gamma(z)$ is the probability distribution function of the Pareto distribution. It must satisfy:

$$M \int_{z_t^H}^{\infty} \Omega(z)\; \frac{\gamma(z)}{1-\Gamma(z_t^H)}\; dz = 1\,.$$

Aggregate productivity is often computed as: (i) the unweighted average, $\Omega(z)=\frac{1}{M}$; (ii) the output-weighted average, $\Omega(z)=\frac{q(z)}{Q_t^H}$; or (iii) the revenue-weighted average, $\Omega(z)=\frac{r(z)}{R_t^H}$. [34] The following Lemma establishes that $z_t^H Z_t$ is the key statistic for measuring aggregate productivity independent of the weights used in the aggregation.

Lemma 1. *Domestic aggregate productivity, Z_t^H, is an increasing function of the domestic productivity threshold, z_t^H and the common shifter, Z_t.*

Proof. See Appendix □

In other words, changes in productivity in this model are partly governed by firms' extensive margin decisions. This is in contrast to alternatives in the literature that either model productiv-

[34] Q_t^H is total domestic output given by:

$$Q_t^H = M \int_{z_t^H}^{\infty} q_t^H(z)\; \frac{\gamma(z)}{1-\Gamma(z_t^H)}\; dz\,,$$

and R_t^H is total domestic revenue given by:

$$R_t^H = M \int_{z_t^H}^{\infty} p_t^H(z) q_t^H(z)\; \frac{\gamma(z)}{1-\Gamma(z_t^H)}\; dz\,.$$

ity exclusively as an exogenous shock to the economy, allow for variable capacity utilization or consider R&D decisions.

4.2 Pro-competitive, Cost and Demand Channels

In the absence of shocks to the common shifter, $Z_t = 1$, the productivity threshold is determined by the number of firms in the market, the cost of production and the level of consumer demand; all three are potentially subject to change during a sudden stop episode.

Proposition 1. *In the stationary equilibrium, i.e. , $Z_t = 1$:*

$$dz_t^H = \underbrace{F_N\, dN_t}_{\text{Pro-competitive}} + \underbrace{F_W\, dW_t}_{\text{Cost}} + \underbrace{F_\lambda\, d\lambda_t}_{\text{Demand}},$$

where $F_N > 0$, $F_W > 0$ and $F_\lambda > 0$.

Proof. See Appendix □

The intuition follows next. In the first place, a larger number of active firms in the market, $dN_t > 0$, implies greater competition. Given the preferences considered, enhanced competition lowers individual firm demand. This forces less productive firms out of the market as profit margins are reduced at every level of productivity. This *pro-competitive effect* was first introduced by Melitz and Ottaviano (2008), which focuses on competition in the goods market.

Second, a higher wage, $dW_t > 0$, lowers the firm's profit margin by increasing the cost of producing.[35] Once again, a higher productivity level is then required for firms to remain profitable and select into production, therefore, aggregate productivity increases. This is what I denote the *cost effect*, which is the underlying mechanism in the canonical Melitz (2003) model, which focuses on competition in the labor market.

Finally, higher aggregate demand from consumers, $d\lambda_t < 0$, raises individual firm demand at all productivity levels and loosens the minimum productivity requirement. Less productive firms have a higher chance of entering or surviving in the market. This final channel, a novelty of this model, is referred to as the *demand effect*.[36] It results from featuring leisure in the consumer's utility function.

[35]Note that the focus here is on nominal instead of real wages and costs. The underlying reason is that Melitz and Ottaviano (2008) preferences do not give rise to an ideal price index that provides a clear mapping from nominal to real variables.

[36]There is an implicit demand effect in the baseline Melitz (2003) model too. However, the assumption of fixed production costs introduces an additional fixed cost channel (on top of the variable cost channel here considered) that exactly offsets the demand effect.

4.3 Effects of a Sudden Stop

I simplify the dynamics of the sudden stop in the following way. First, suppose the common productivity shifter remains constant, i.e., $Z_t = 1$ for all t. Second, wages are sticky for one period only. Third, consumers are no longer allowed to issue bonds but are instead required to pay a lump-sum tax to foreigners. To ease the algebra, suppose the lump-sum tax is a fraction, Δ_t, of total import revenues such that the goods market clearing condition, equation 9, now reads:

$$\frac{e_t M \int p^X(z) q^X(z) g(z) dz}{M^* \int p^M(z) q^M(z) g(z) dz} = (1 + \Delta_t)\,, \tag{10}$$

For now, let's assume a sudden stop is simply a positive realization of Δ_t This will force an expansion of net exports and an improvement in international competitiveness. The following proposition considers its effect on productivity under the two alternative exchange rate regimes.

Proposition 2. *Given a sudden stop,*

1. *In a floating arrangement, only the pro-competitive channel operates and productivity falls:*

$$dN_t < 0,\ dW_t = 0 \ \text{ and } \ d\lambda_t = 0 \ \text{ so that } \ dz_t^H < 0\,.$$

2. *In a currency union, all three channel operate and the effect on productivity is ambiguous:*

$$dN_t < 0,\ dW_t < 0 \ \text{ and } \ d\lambda_t > 0 \ \text{ so that } \ dz_t^H \gtrless 0\,.$$

Proof. See Appendix □

First, suppose that the nominal exchange rate depreciates one-to-one with the real exchange rate, i.e., e_t increases. Under this assumption, the cost and the demand effect are muted as the wage level remains unchanged. There is a fall, however, in the active number of firms in the domestic economy as the number of importers declines due to the loss of competitiveness by foreign firms and consumers switching expenditure towards domestic varieties. There is an unambiguous fall in productivity as a result of this negative pro-competitive force.

Suppose instead that the aggregate wage adjusts completely: W_t falls while the nominal exchange rate remains unchanged. Under this alternative scenario, the negative pro-competitive effect prevails as there is still a decline in importing firms. The change in wages, in addition, leads to a negative cost effect, production of goods is cheaper, and a negative demand effect, households consume less.[37] In other words, all three channels are operating.

[37] Recall that a negative demand effect is represented by a positive change in λ_t.

In sum, the change in productivity after a sudden stop is ambiguous in the currency union and depends on parameter values. It is possible, nonetheless, to show under which parameterization, the demand effect dominates and productivity increases.

Corollary 1. *Following a sudden stop in a currency union, a sufficient condition for $z_t^H > 0$ is that*

$$\frac{1}{2} < \theta(1-\beta(1-\theta))\sigma(1+k) < 1\,.$$

Proof. See Appendix □

There are three key parameters for this condition to hold: the share of labor income, σ, the degree of wage rigidities, θ, and the shape parameter of the productivity distribution, k. The share of labor income governs the mapping between the wage level and the unit cost. As σ increases, labor represents a greater share of the optimal input bundle and falling wages cheapen production costs by more. This reinforces the cost effect of a sudden stop. In the Melitz (2003) model, the cost channel is at its strongest featuring a production function which is linear in labor, $\sigma = 1$.

The degree of wage rigidities determines the size of the demand effect. A sudden stop here is simply an improvement in the domestic economy's competitiveness through a decline in the wage level. As the level of wage stickiness increases and fewer labor-types are allowed to adjust, the decline in the optimal wage, W_t^*, that is required to achieve the desired overall wage adjustment is larger. This leads to a larger decrease in today's consumer wealth and, thus, a stronger demand effect of a sudden stop.

The shape parameter measures the concentration of firms at the lower end of the productivity distribution. This represents the inverse of dispersion in firm-level productivity. As firms only differ in their productivity levels, if k increases, they become more homogeneous and, thus, more reliant on their relative cost advantage to survive. This implies that changes in the economy's international competitiveness will lead to larger swings in the number of importers, thus, increasing the size of the pro-competitive effect.

Two questions remain unanswered. First, is the above requirement satisfied under a reasonable parameterization? Second, do results hold in the fully-fledged version? While the following section discusses how to calibrate and numerically solve for the general model, I first explore how far can the current modeling of a sudden stop takes us in generating the micro-patterns observed in the two Spanish episodes.

A Qualitative Decomposition of Productivity

Table V reports the model predictions regarding the TFP growth decomposition exercise described in section 2.2. The previous results show that under the above parameter restriction, a positive

TABLE V: MODEL GENERATED QUALITATIVE DECOMPOSITION OF PRODUCTIVITY GROWTH

	Exchange Rate Regime	
	Floating Arrangement	Currency Union
Productivity Growth (%)	↓	↑
Contribution to Productivity Growth		
Incumbents' Contribution	**↓**	**↑**
Within-firm Contribution	-	-
Between-firm Contribution	↓	↑
Cross-term Contribution	-	-
Net Entry Contribution	**↓**	**↑**
Entrants' Contribution	↓	-
Exiters' Contribution	-	↑

Notes: This table reproduces the productivity growth decomposition exercise in section 2 but through the lens of the model described in section 3. It builds on the analytical results discussed in section 4.3, which are qualitative. Online Appendix B.4 provides more details on the model derivations.

shock to Δ_t leads to an increase (decrease) in productivity in a currency union (floating arrangement), which is summarized in the first row of Table V. The subsequent rows show that the overall pattern is driven by both net entrants and incumbents.

Regarding the extensive margin, the model matches the positive contribution of net entry in a currency union while it predicts a counterfactual negative contribution in a floating arrangement. Decomposing net entry further shows that this is driven by a particular feature of the model that prevents entry and exit occurring at the same time. While the model generates a negative contribution of entrants in the floating arrangement in line with the data; it fails to fully offset it with a positive contribution of exiters. This caveat is not as important in the currency union regime because empirically it is exit, which the model is able to capture, that quantitatively dominates the overall contribution of net entry.

Regarding the intensive margin, the contribution of incumbent firms is exclusively driven by the reallocation of market shares. The exit of unproductive firms in a currency union frees up resources which are, at least partly, reallocated towards more productive survivors. The exact opposite holds in a floating arrangement. The model is silent about the within-firm and cross-term contribution because, so far, there is no firm-level productivity growth.

In sum, the current framework provides a fair representation of productivity patterns in a currency union but does not in a floating arrangement. This is not surprising as the empirical evidence concluded that the 2010-2013 increase in TFP was driven by a composition effect, which the model embraces, while the 1992-93 decline in TFP responded to a level adjustment, which is absent by construction. To improve performance, in what follows I will augment the definition of a sudden stop to allow for changes in firm-level productivity.

5 Quantitative Analysis

This section begins with a discussion of the model parameterization. I then solve for the transition dynamics following an aggregate shock. Finally, I discuss how I use the model to simulate the 2010-13 sudden stop in Spain and evaluate its quantitative performance.

5.1 Parameterization

I start by discussing how I parameterize firm technology and choose the parameters of the model. I divide the parameters into two groups. For the first group, I use commonly used values in the literature. For the second group, I implement a moment-matching exercise to assign values. To do so, I use the steady state of the model with constant $Z_t^A = 1$ and no country risk premium shock, $\xi_t = 0$. Details on the algorithm that solves the stationary competitive equilibrium are relegated to Online Appendix B.2.

Functional Forms I assume a discrete process for transitory idiosyncratic firm productivity shocks that approximates the autoregressive process

$$\log z_t^T = -\frac{\sigma_z^2}{2(1+\rho_z)} + \rho_z \log z_{t-1}^T + \sigma_z u_{it}^z \quad \text{with} \quad u_{it}^z \sim N(0,1)\,,$$

where ρ_z captures persistence and σ_z denotes the standard deviation of innovations u_{it}^z. The constant term normalizes the unconditional mean of transitory idiosyncratic productivity to one for any choice of ρ_z and σ_z. The permanent component of productivity, z_i^P is drawn from the following distribution:

$$z_i^P = \begin{cases} z^H\,, & \text{with probability } \pi \\ z^L\,, & \text{with probability } 1-\pi \end{cases}$$

The exit value is assumed to be zero with probability e_0. With probability $(1-e_0)$, the exit value is uniformly distributed between $[0, \bar{e}]$. The entry transition function is assumed to be identical to that of incumbents: $H^q(z|q) = H(z'|z)$. The distribution of ideas follows $Q(q) = Bexp(-q)$ over the lower part of the transitory productivity distribution where B is a scale parameter to ensure $Q(q)$ adds up to one. Γ^* is assumed to be equal to the stationary distribution of the domestic operating firms.

Externally Calibrated Parameters Table VI provides a summary of the model parameters that are externally calibrated, their baseline values and the source or the empirical target. This first set

TABLE VI: EXTERNALLY CALIBRATED PARAMETERS

	Parameter	Value	Calibration target/source
β	Discount factor	0.99	Annual real return on bonds is 4%
σ	Labor share	0.64	National Accounts Spain
ε_w	Elasticity of substitution (labor)	4.3	Galí and Monacelli (2016)
θ	Index of wage rigidity	0.2	Galí and Monacelli (2016)
τ	Iceberg trade cost	1.3	Ghironi and Melitz (2005)
ϕ	Risk premium parameter	0.001	Schmitt-Grohé and Uribe (2003)
ρ_z	Transitory productivity - persistence	0.59	Gopinath et al. (2017)
σ_z	Transitory productivity - st dev of innovations	0.13	Gopinath et al. (2017)
π	Permanent productivity parameter	0.80	Gopinath et al. (2017)
z_L	Permanent productivity parameter	0.785	Gopinath et al. (2017)
z_H	Permanent productivity parameter	1.86	Gopinath et al. (2017)

of parameters are standard and, thus, values are chosen in line with the literature and, when possible, consistent with Spanish statistics taking the 2002-08 period as a reference. The time period of the model is a quarter. Accordingly, the discount factor β is chosen to be 0.99. The output elasticity parameter σ is set to 0.64, roughly the average labor share and within the range that is common in the literature. For the elasticity of substitution for labor types, ϵ_w, and the index of wage rigidities, θ, values are taken from Galí and Monacelli (2016) which are based on empirical studies on European countries conducted by the OECD. In terms of trade costs, τ is equal to 1.3 following Ghironi and Melitz (2005) and many others. The risk premium parameter, ϕ, is a theoretical shortcut to ensure stationarity in small open economy framework. It measures the sensitivity of the country interest-rate premium to debt. I follow Schmitt-Grohé and Uribe (2003) in choosing a very small value. Finally, for the parameters that govern the evolution of firm productivity, I borrow from Gopinath et al. (2017) that exploit ORBIS data for Spanish manufacturing firms. In particular, ρ_z and σ_z, are estimated by fitting a firm fixed-effects model on firm idiosyncratic productivity to be 0.59 and 0.13 respectively. The average z_t^P is normalized to one and values $\pi = 0.80$, $z_L = 0.785$, and $z_H = 1.86$ are chosen such that, together with the previous estimates, the standard deviation of $\log(Z_j)$ equals 0.38 as in the data.

Internally Calibrated Parameters I calibrate the rest of the parameters to match informative moments of the data. I target a total of eight moments. The first three moments are the average size of incumbents, the average size of entrants and the average size of exiters, as reported by the Structural Business Statistics from Eurostat. The following two are the share of exporting firms and the exports-to-sales ratio. To calculate these, I use the 5th vintage of the CompNet dataset and restrict attention to manufacturing firms between 1998 and 2008. [38] Next, I target the average

[38]The CompNet Dataset is an initiative by the Competitiveness Research Network, established by the ECB, to collect detailed firm-level data across several European countries.

TABLE VII: INTERNALLY CALIBRATED PARAMETERS

Parameter	Description	Value	Target	Data	Model
α	Preference parameter	.64	Exit rate among micro firms	0.10	0.16
γ	Preference parameter	12	Average firm size	15	17.18
A	Foreign demand parameter	4.25	Export share	0.16	0.18
B	Foreign demand parameter	3.11	Export to sales ratio	0.27	0.25
e_0	Prob. of zero exit value	0.85	Exit rate	0.08	0.08
$\bar{e}$	Max exit value	7	Average size of exiters	4.87	2.36
c_e	Fixed cost of entry	0.24	Average size of entrants	5.21	3.68
c_q	Fixed cost of ideas	0.13	W/W^*	0.73	0.73

exit rate and the exit rate among micro-firms, as documented by the Spanish Business Registry (Directorio Central de Empresas, DIRCE). The final moment is the relative wage level, computed as the ratio of labor costs in Spain versus the Euro area according to Eurostat.

The model is highly nonlinear, and all parameters affect all moments. However, some parameters are more determinant for certain statistics. The relative wage level is pinned down by the free entry condition and, thus, largely driven by the fixed cost of ideas. Selection in entry, as reflected by the average size of entrants , is mostly governed by the fixed cost of entry. Exit in the model is due to the choke price or the arrival of the exit shock. As the choke price is largely determined by the preference parameter α, there is a close relationship between this parameter and the exit rate of micro firms. Holding this constant, the overall exit rate is then determined by the probability of a non-zero exit value. The average of exiters is controlled by the maximum exit value. The export share and the export to sales ratio are affected by the foreign demand parameters A and B. Finally, the average firm size is predominantly influenced by the preference parameter γ.

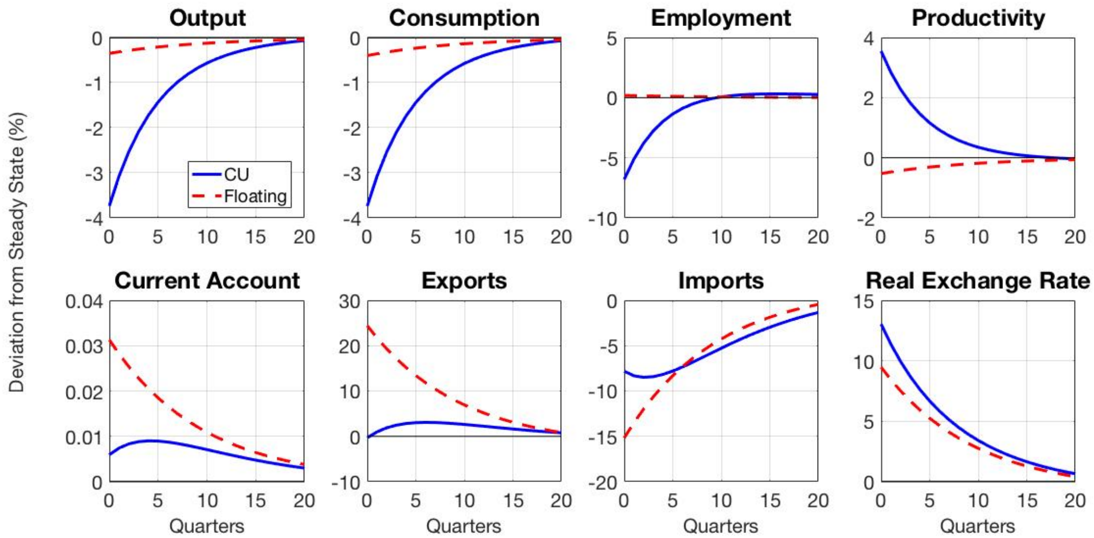
Table VII reports the estimated parameter values as well as the target moments in the data and the model. In addition, note that the preference parameter η is normalized to one without loss of generality and the steady state value of debt, $\bar{B}$, is set to zero to ensure that trade is balanced in steady state.

5.2 Adding Aggregate Dynamics

Before I turn towards studying the quantitative relevance of the mechanism, I explore the dynamic properties of the quantitative model. The goal is to show that the analytical results in 4.3 hold more broadly.

When the economy is out of steady state, the value functions, the distribution of operating firms, and all aggregate variables change over time. Hence, I solve for the sequences $\{V_t, V_t^c, V_t^e, V_t^P\}_{t=0}^T$, $\{\Gamma_t\}_{t=0}^T$ and $\{W_t, W_t^*, \lambda_t, p_t^{\max}, R_t, B_t, N_t, M_t^q\}_{t=0}^T$ consistent with (i) household, labor union and firm (incumbent, entrant and importer) optimization, (ii) aggregate wage and interest rate dynamics, (iii) law of motion for the distribution of operating firms and (iv) goods market clearing,

FIGURE III: MACROECONOMIC EFFECTS OF A SUDDEN STOP



Notes. These figures plot the impulse response functions of key macroeconomic variables to a one percentage point increase to the country-specific risk premium and a one percentage point decrease to the common TFP shifter as predicted by the model described in section 3. All variables but the current account are expressed in log deviations from steady state. The current account, assumed to be zero in steady state, is expressed in levels. The current account, exports and imports are denominated in domestic currency; all other variables are expressed in real terms.

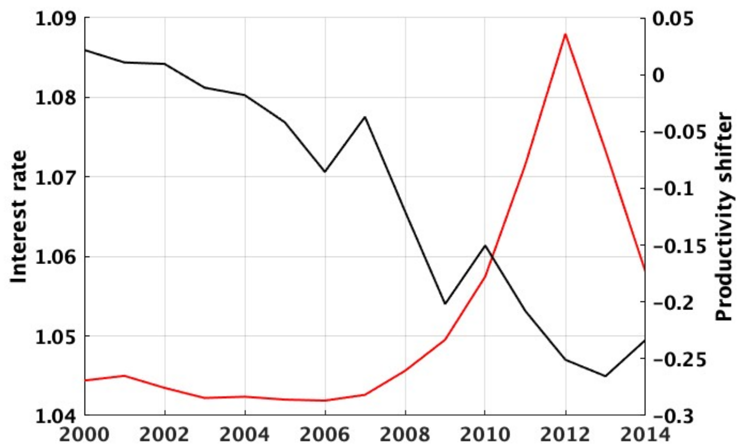
where $t = 0$ is the period in which shocks hit and agents learn about them, and T is the period in which the economy reaches its new steady state. Online Appendix B.3 describes the numerical algorithm.

Figure III summarizes the model response of key macroeconomic variables to a simultaneous one percentage point increase in the risk-premium and a one percentage point decrease in the TFP shifter. All variables, but the current account, are expressed in log deviations from steady state. The current account is expressed in levels as trade balance is assumed to hold before the realization of the shock.

As expected, a sudden stop is characterized by a depreciation of the real exchange rate and a current account surplus. The model predicts a slight delay in the adjustment within a currency union. This is entirely driven by nominal rigidities as the model disregards additional policy instruments available under a currency union, such as public capital inflows, that might directly cushion the adjustment in the data.

The path of TFP clearly diverges across regimes. On the one hand, under the baseline calibration, the positive effect of a lower aggregate demand offsets the negative effect of lower production costs and fewer competing firms on the domestic productivity cutoff and, thus, TFP improves in the currency union. On the other hand, productivity falls unambiguously in the floating regime. I study the sensitivity of these results to alternative parameter values next.

FIGURE IV: EVOLUTION OF SHOCKS



Notes. This figures plots the paths of the two aggregate shocks that I use to simulate the 2010-13 sudden stop. The red line represents the interest rate, R_t, at which domestically households borrow internationally resulting from the risk premium measured as the spread between the 10-year Spanish government bond and its German counterpart. The black line represents the common productivity shifter, Z_t^A, in logs calculated using the within-contribution of incumbents to aggregate annual productivity growth measures usind the firm-level data from Section 2.

Output and consumption are measured in real terms. The model predicts a fall in the two variables under both regimes although the decline is more pronounced in a currency union. Similarly, the decline in employment is only evident when productivity rises.

The current account surplus, denominated in domestic currency, is generated through an increase in export and a decline in import revenues.[39] However, regimes differ in the relative magnitude of these simultaneous effects: in a floating regime the expansion of exports dominates while in a currency union the main driving force is the retrench of import revenues. This highlights the importance of the demand mechanism in the model as it is the larger domestic contraction generated by the adjustment of wages that additionally reduces imports in a currency union.

5.3 Simulating the 2010-13 Sudden Stop

With the calibrated model in hand, I now use it to simulate the 2010-13 sudden stop in Spain. I proceed by feeding in the path of the interest rate risk premium, ξ_t, and the aggregate productivity shifter, Z_t^A, between 2000 and 2014. I start with the economy in stationary equilibrium in 1999, that is, when the euro was first introduced. The assumption is that agents have perfect foresight but are continuously surprised by these aggregate shocks which they perceive as AR(1) processes.

I measure the Spanish risk premium as the spread between the 10-year Spanish government bond and its German counterpart. The common productivity shifter, however, requires more

[39]The current account, imports and exports are denominated in terms of the domestic currency to ease comparison with the empirical counterparts in Figures V and VI.

careful thought. Aggregate productivity is not well suited because it is driven by entry and exit dynamics as well as changing market shares. However, through the lens of the model, annual changes in a common shifter exactly map into the within-contribution of incumbents to aggregate annual productivity growth, which I can measure using the firm-level data.

Figure IV plots the evolution of the resulting interest rate (in red) and the common productivity shifter in logs (in black). The former remains stable right up to 2009, when the risk premium starts escalating dramatically until it peaks in 2012. The latter shows a clear negative trend over time. This suggests that the productivity slowdown that had been documented by the literature during pre-crisis year, extends to the crisis too.

5.3.1 TFP Decomposition

Having simulated the 2010-13 sudden stop, I return to the aggregate productivity decomposition exercise to evaluate the quantitative performance of the model. For convenience, the first column of Table VIII reports once more the results for the 2010-13 productivity growth decomposition exercise using the ESEE data while the second column summarizes the model generated results. Focusing on the incumbents first, by construction the within-firm contribution exactly matches the data. Also, by construction, the contribution of the cross-term is zero in the model. However, this is more than offset by the fact that, absent reallocation frictions, the model overstates the between-firm contribution.

In terms of the net entry, the model matches pretty well the contribution of entrants. It also generates a sizable contribution of exiters, although only slightly above one half of what is documented in the data. This is the main reason behind the model underpredicting the decline in productivity growth.

6 Other Sudden Stops

This section explores whether the model's aggregate predictions apply beyond the Spanish experience. To systematically analyze a wider set of countries, I establish a criterion to identify sudden stops and use an event study approach to study the path of macroeconomic variables. Both these steps are standard in the literature. The novelty of the exercise relies on binning the episodes by exchange rate regime.

6.1 Data and Methodology

Following Cavallo and Frankel (2008), I define a sudden stop as an episode in which there is a substantial decline in the capital account surplus together with a recession.[40] In particular, I clas-

[40] The practice of conditioning on output contraction goes back as far as the canonical Calvo, Izquierdo and Mejía (2004) methodology. While I confine myself to what is standard in the literature, it is fair to acknowledge this is not

TABLE VIII: MODEL GENERATED QUANTITATIVE DECOMPOSITION OF PRODUCTIVITY GROWTH

	2010-2013	
	Data	Model
Productivity Growth (%)	4.36	2.02
Contribution to Productivity Growth		
Net Entry Contribution	**9.87**	**5.68**
Entrants' Contribution	-0.06	-0.05
Exiters' Contribution	9.93	5.73
Incumbents' Contribution	**-5.51**	**-3.66**
Within-firm Contribution	-6.77	-6.77
Between-firm Contribution	0.84	3.11
Cross-term Contribution	0.42	0.00

Notes: The first column of the table repeats the results for the 2010-13 productivity growth decomposition exercise using the ESEE data as summarized in Table I. The second column shows the results from the same exercise using simulated data from the quantitative model. Online Appendix B.4 provides more details on the required derivations.

sify as a sudden stop a period that contains at least one year during which (i) the financial account surplus has fallen at least one standard deviation below its rolling average and (ii) GDP per capita contracts.[41] The start and end of each episode is marked by the first and last year within the period in which the financial account surplus is half a standard deviation below the rolling average.[42] The latter requirement ensures that the capital flow reversals captured by the algorithm strictly qualify as sudden stops; first, by requiring that the financing disruption is accompanied by an appropriate macroeconomic adjustment, and second, by ruling out booming episodes that display similar characteristics, for example a positive trade shock. All data is collected from standard sources and, thus, its description is relegated to Online Appendix D.1

The total number of episodes is 78, representing 5.2% of total available country/year observations in the sample.The full list of episodes per country, plus exchange rate classification, is given by Table A.13. The criterion successfully captures all traditional sudden stop episodes previously discussed by the literature - mostly occurring around the 1994/5 Tequila crisis, the 1997 Asian Financial Crisis, the 1998 Russian default - as well as the most recent balance of payment crisis in the peripheral economies of the European Union.[43,44]

strictly consistent with the model's definition of a sudden stop.

[41]This contrasts with Cavallo and Frankel (2008), who also require an improvement in the current account deficit (or an equivalent decline in foreign reserves). As this is conceptually equivalent to the first condition, I drop it.

[42]Refer to Online Appendix D.2 for further details.

[43]The methodology does not account for changes in TARGET2 balances in the Eurozone and, thus, prevents me from measuring private capital flows accurately. However, this is not problematic for my purposes as the algorithm already identifies the GIIPS episodes.

[44]Note that the algorithm dates the start of the two Spanish sudden stops differently than Section 2, which is instead

I build on Ilzetzki, Reinhart and Rogoff (2019) updated *de facto* coding system in order to bin episodes by exchange rate flexibility. In my baseline results, I consider as prevalent the exchange rate regime that is in place during the last year of the sudden stop. There are four different cases: a currency union, a hard peg, a soft peg and a floating arrangement.[45] Out of the 78 episodes identified, 11 occur within a currency union (8 in the Euro Area and 3 in the West African Economic and Monetary Union), 14 in a hard peg system, 26 in a soft peg regime and 25 in a floating arrangement.

Figure V and VI show the mean and median path of each of these aggregate variables during the episodes conditional on their exchange rate classification together with standard error bands. In order to capture the buildup and end phase of each episode, the plot depicts six-year windows that begin two years before the start of each reversal and marks the start and the average duration of a sudden stop with vertical lines. As is standard in this literature, I focus on the cyclical component of most of the variables by looking at its percentage deviation from an extrapolated pre-crisis linear trend.[46]

6.2 Results

Figure V illustrates how domestic variables respond to an unexpected reversal of capital flows when the exchange rate is allowed to adjust freely. First, a sudden stop is associated with a contraction in output and consumption, with most of the decline occurring on impact or shortly after. There is also a small decline in employment levels, measured as the total number of hours worked, and a significant collapse in total factor productivity. The last four graphs capture the response of the external sector: capital outflows coincide with a depreciation of the real exchange rate, represented by a decline in the index. The current account deficit is reduced sharply, almost reaching trade balance as soon as one year after the start of the episode. Finally, the average duration is slightly less than two years.

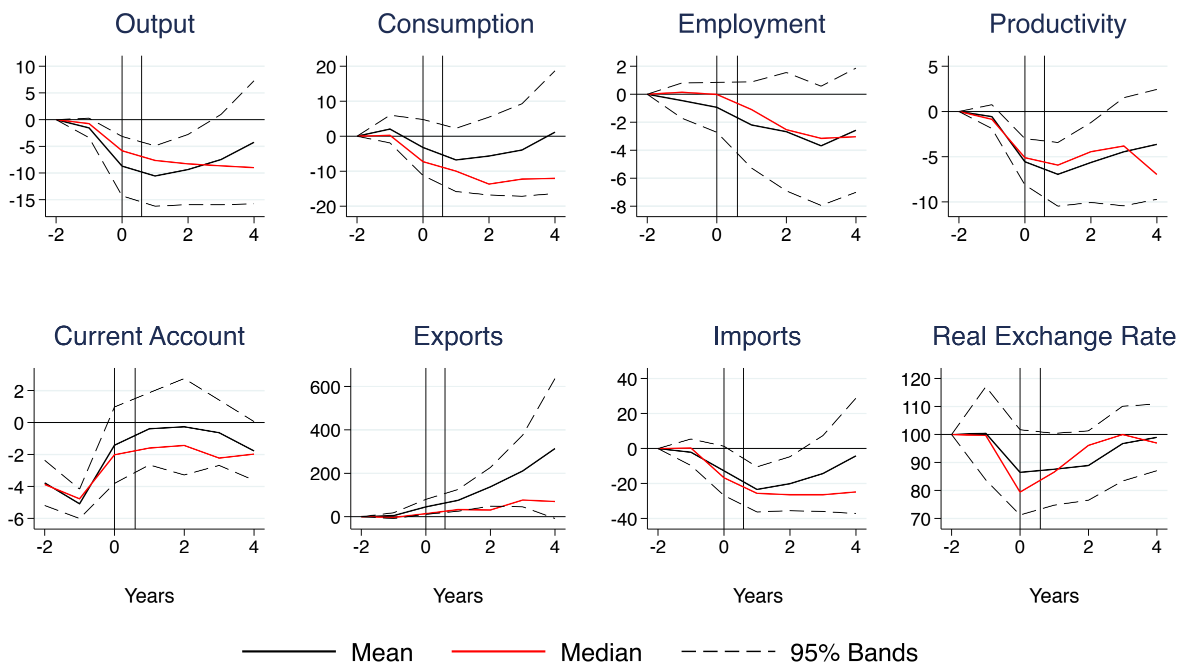
The results for a currency union are summarized by Figure VI. The response of all variables but TFP is similar, in qualitative terms, to that depicted in the flexible exchange rate case. The unexpected reversal of flows is associated with a decline in output, consumption and employment. There is a gradual reduction in the current account deficit that yet persists four years after the onset of the crisis. In line with this result, the real depreciation is more gentle than in the previous case and the episodes last longer; on average, two and a half years.

based on common narrative. The peseta was depreciated twice already in 1992 and the improvement in the Spanish current account in 2009 is driven by the collapse of global trade in 2008 rather than by country-specific developments. In any case, the empirical results are robust to the assumption that the sudden stops start in 1993 and 2009 respectively.

[45] In terms of the Ilzetzki, Reinhart and Rogoff (2019) fine classification, I deviate as follows: (1) I manually divide code 1 into currency union and no separate legal tender, (2) I group codes 2 to 4 under the hard peg category, (3) I group codes 5 to 11 under the soft peg category, (4) I group codes 12 to 14 under the floating arrangement and (5) I rename group 15 as 5, i.e., other categories.

[46] The current account deficit, expressed as a share of GDP, and the real exchange rate index, with base t-2, are the

Figure V: A Sudden Stop in a Floating Arrangement



Notes: This figure plots the response of macroeconomic variables to a sudden stop under a floating arrangement. The black and red solid lines depict the mean and median path of the corresponding variables while the black dashed lines represent standard error bands. The two vertical lines show the start and end of an average episode. Output, consumption, employment, productivity, exports and imports are expressed in terms of percentage deviations from an extrapolated linear trend calculated from periods $t-5$ to $t-2$. Current account is expressed as a share of GDP and the real exchange rate (RER), calculated as an index, is expressed in levels. The data used is collected from IFS, WDI and the Total Economy Database.

The most notable difference across the plots is the behavior of TFP: whereas productivity clearly falls in the first case, it remains unchanged or, if anything, improves slightly within currency unions.[47,48] The positive relationship between the size of the decline in TFP and the degree of exchange rate flexibility is in line with the model's predictions.

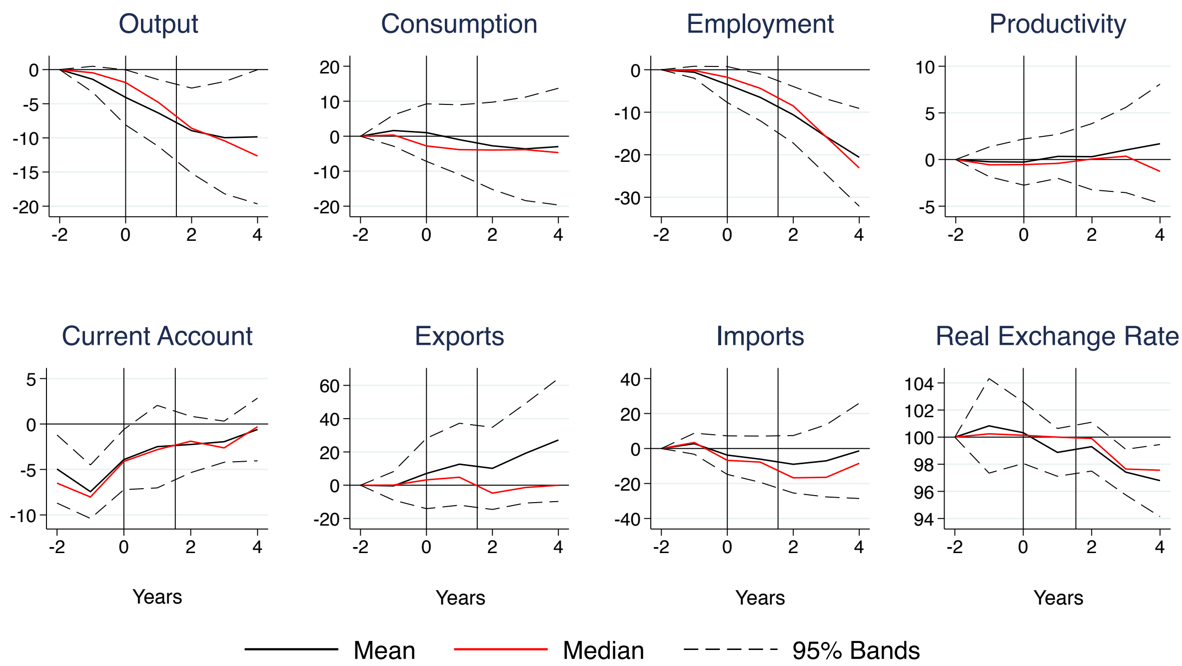
Moreover, there are additional, although arguably minor, differences in responses across regimes that are worth highlighting. Although a quantitative comparison is beyond the scope of this exercise, the decline in employment is more pronounced in Figure VI. This holds in both absolute and relative to output terms and is consistent with the predictions of the model. In addition, a closer look at the external sector shows that in floating arrangements the current account reversal

exception.

[47]Given the reduced sample size, standard error bands are admittedly large to be able to conclude that TFP increases significantly.

[48]For completeness, I present the results for the hard and soft pegs in Figures A.7 and A.8. It is still the case that the decline in productivity is increasing in the degree of flexibility: under a hard peg, there is an increase in productivity, although bands are much wider than within a currency union, and under a soft peg, there is some significant decline, especially on impact.

FIGURE VI: A SUDDEN STOP IN A CURRENCY UNION



Notes: This figure plots the response of macroeconomic variables to a sudden stop under a currency union. The black and red solid lines depict the mean and median path of the corresponding variables while the black dashed lines represent standard error bands. The two vertical lines show the start and end of an average episode. Output, consumption, employment, productivity, exports and imports are expressed in terms of percentage deviations from an extrapolated linear trend calculated from periods $t-5$ to $t-2$. Current account is expressed as a share of GDP and the real exchange rate (RER), calculated as an index, is expressed in levels. The data used is collected from IFS, WDI and the Total Economy Database.

is mostly driven by the increase in exports. In a currency union, however, the decline in imports almost matches in magnitude the increase in exports suggesting there is a larger contraction of domestic demand in line with the mechanisms at play in the model.

Finally, I conduct a battery of robustness checks to evaluate the consistency of the TFP finding including different approaches to exchange rate classification and removing the trend, alternative data sources and controlling for crisis and country characteristics. Results are available in Online Appendix D.3.

7 Conclusion

This paper revisits a classical question in international macroeconomics: how does exchange rate policy affect macroeconomic performance after a shock? While the literature provides many attempts at answering this issue, it has mostly overlooked the effect on firm dynamics. I study the question anew in the context of a sudden stop, emphasizing the divergence in TFP patterns that emerges across exchange rate regimes in the aggregate data and relating them to observed differences in firm exit at the micro level.

Taking the firm-level analysis of two sudden stops in Spain as a starting point, the paper argues that documented differences in the reallocation of resources from unproductive exiting firms to productive survivors might be related to the degree of currency appreciation vis-à-vis wage devaluation. A small open economy DSGE model featuring firm selection, variable markups and elastic labor supply formalizes the mechanism. Productivity is determined by the number of firms (pro-competitive channel), the marginal utility of wealth (demand channel) and the unit cost of production (cost mechanism). The relative magnitude of these forces depends on the exchange rate policy with a currency union generating quantitatively more cleansing because of a larger demand effect. Systematic analysis of the behavior of macroeconomic variables during sudden stops under different exchange rate regimes confirms that the model's implications hold for a wide set of economies.

This paper provides a positive account of the effect of exchange rate policy on short-term productivity growth. However, it raises a new important question: how does productivity translate into welfare gains? Evaluating the trade-off between improving resource reallocation and undoing nominal rigidities seems key in understanding the normative implications of this type of model. In particular, what is the optimal weight policy should put on each of these remains an open question for future research.

References

Ackerberg, Daniel A, Kevin Caves, and Garth Frazer. 2015. "Identification Properties of Recent Production Function Estimators." *Econometrica*, 83(6): 2411–2451.

Almunia, Miguel, David López-Rodríguez, and Enrique Moral-Benito. 2018. "Evaluating the Macro-Representativeness of a Firm-Level Database: an Application for the Spanish Economy." Banco de España Ocassional Paper 1802.

Almunia, Miguel, Pol Antràs, David Lopez-Rodriguez, and Eduardo Morales. 2021. "Venting Out: Exports during a Domestic Slump." *American Economic Review*, 111(11): 3611–3662.

Ates, Sina T, and Felipe E Saffie. 2021. "Fewer but Better:Sudden Stops, Firm Entry, and Financial Selection." *American Economic Journal: Macroeconomics*, 13(3): 304–356.

Baily, Martin Neil, Charles Hulten, David Campbell, Timothy Bresnahan, and Richard E Caves. 1992. "Productivity Dynamics in Manufacturing Plants." *Brookings Papers on Economic Activity: Microeconomics*, 1992: 187–267.

Benigno, Gianluca, and Luca Fornaro. 2014. "The Financial Resource Curse." *The Scandinavian Journal of Economics*, 116(1): 58–86.

Bilbiie, Florin O., Fabio Ghironi, and Marc J. Melitz. 2008. "Monetary Policy and Business Cycles with Endogenous Entry and Product Variety." *NBER Macroeconomics Annual*, 22: 299–353.

Bilbiie, Florin O., Ippei Fujiwara, and Fabio Ghironi. 2014. "Optimal Monetary Policy with Endogenous Entry and Product Variety." *Journal of Monetary Economics*, 64: 1–20.

Bornstein, Gideon, and Laura Castillo-Martinez. 2023. "Firm Exit and Financial Frictions."

Caballero, Ricardo J., and Mohamad L. Hammour. 1994. "The Cleansing Effect of Recessions." *American Economic Review*, 84(5): 1350–1368.

Calvo, Guillermo A. 1983. "Staggered Prices in a Utility-Maximizing Framework." *Journal of Monetary Economics*, 12(3): 383–398.

Calvo, Guillermo A. 1998. "Capital Flows and Capital-Market Crises: the Simple Economics of Sudden Stops." *Journal of Applied Economics*, 1(1): 35–54.

Calvo, Guillermo A., Alejandro Izquierdo, and Luis-Fernando Mejía. 2004. "On the Empirics of Sudden Stops: the Relevance of Balance-Sheet Effects." NBER Working Paper 10520.

Calvo, Guillermo A., and Ernesto Talvi. 2005. "Sudden Stop, Financial Factors and Economic Collapse in Latin America: Learning from Argentina and Chile." NBER Working Paper 11153.

Cavallo, Eduardo A, and Jeffrey A Frankel. 2008. "Does Openness to Trade Make Countries More Vulnerable to Sudden Stops, or Less? Using Gravity to Establish Causality." *Journal of International Money and Finance*, 27(8): 1430–1452.

De Loecker, Jan, and Frederic Warzynski. 2012. "Markups and Firm-Level Export Status." *American Economic Review*, 102(6): 2437–71.

Demidova, Svetlana, and Andres Rodriguez-Clare. 2009. "Trade Policy under Firm-Level Heterogeneity in a Small Economy." *Journal of International Economics*, 78(1): 100–112.

Dias, Daniel A., and Carlos Robalo Marques. 2021. "Every Cloud Has a Silver Lining: Micro-Level Evidence on the Cleansing Effects of the Portuguese Financial Crisis." *Oxford Bulletin of Economics and Statistics*, 83(2): 352–376.

Foster, Lucia, Cheryl Grim, and John Haltiwanger. 2016. "Reallocation in the Great Recession: Cleansing or Not?" *Journal of Labor Economics*, 34(S1): S293–S331.

Foster, Lucia, John C Haltiwanger, and Cornell John Krizan. 2001. "Aggregate Productivity Growth: Lessons from Microeconomic Evidence." In *New Developments in Productivity Analysis*. 303–372. University of Chicago Press.

Fu, Chenxu, and Enrique Moral-Benito. 2018. "The Evolution of Spanish Total Factor Productivity since the Global Financial Crisis." Banco de España Ocassional Paper 1808.

Galí, Jordi, and Tommaso Monacelli. 2016. "Understanding the Gains from Wage Flexibility: the Exchange Rate Connection." *American Economic Review*, 106(12): 3829–3868.

García-Santana, Manuel, Enrique Moral-Benito, Josep Pijoan-Mas, and Roberto Ramos. 2020. "Growing like Spain: 1995-2007." *International Economic Review*, 61(1): 383–416.

Ghironi, Fabio, and Marc J. Melitz. 2005. "International Trade and Macroeconomic Dynamics with Heterogeneous Firms." *The Quarterly Journal of Economics*, 120(3): 865–915.

Gopinath, Gita, Şebnem Kalemli-Özcan, Loukas Karabarbounis, and Carolina Villegas-Sanchez. 2017. "Capital Allocation and Productivity in South Europe." *The Quarterly Journal of Economics*, 132(4): 1915–1967.

Griliches, Zvi, and Haim Regev. 1995. "Firm Productivity in Israeli Industry 1979–1988." *Journal of Econometrics*, 65(1): 175–203.

Guidotti, Pablo E., Federico Sturzenegger, Agustin Villar, José de Gregorio, and Ilan Goldfajn. 2004. "On the Consequences of Sudden Stops." *Economia*, 4(2): 171–214.

Hsieh, Chang-Tai, and Peter J. Klenow. 2009. "Misallocation and Manufacturing TFP in China and India." *The Quarterly Journal of Economics*, 124(4): 1403–1448.

Ilzetzki, Ethan, Carmen M. Reinhart, and Kenneth S. Rogoff. 2019. "Exchange Arrangements Entering the 21st Century: Which Anchor Will Hold?" *The Quarterly Journal of Economics*, 134(2): 599–646.

Kehoe, Timothy J., and Kim J. Ruhl. 2009. "Sudden Stops, Sectoral Reallocations, and the Real Exchange Rate." *Journal of Development Economics*, 89(2): 235–249.

Mankiw, N. Gregory, and Ricardo Reis. 2002. "Sticky Information versus Sticky Prices: a Proposal to Replace the New Keynesian Phillips Curve." *The Quarterly Journal of Economics*, 117(4): 1295–1328.

Melitz, Marc J. 2003. "The Impact of Trade on Intra-Industry Reallocations and Aggregate Industry Productivity." *Econometrica*, 71(6): 1695–1725.

Melitz, Marc J., and Gianmarco I.P. Ottaviano. 2008. "Market Size, Trade, and Productivity." *The Review of Economic Studies*, 75(1): 295–316.

Melitz, Marc J., and Sašo Polanec. 2015. "Dynamic Olley-Pakes Productivity Decomposition with Entry and Exit." *The Rand Journal of Economics*, 46(2): 362–375.

Melitz, Marc J., and Stephen J. Redding. 2014. "Heterogeneous Firms and Trade." *Handbook of International Economics*, 4: 1–54.

Mendoza, Enrique G. 2010. "Sudden Stops, Financial Crises, and Leverage." *American Economic Review*, 100(5): 1941–66.

Meza, Felipe, and Erwan Quintin. 2007. "Factor Utilization and the Real Impact of Financial Crises." *The BE Journal of Macroeconomics*, 7(1): 1–41.

Neumeyer, Pablo A., and Fabrizio Perri. 2005. "Business Cycles in Emerging Economies: the Role of Interest Rates." *Journal of Monetary Economics*, 52(2): 345–380.

Olley, G Steven, and Ariel Pakes. 1996. "The Dynamics of Productivity in the Telecommunications Equipment Industry." *Econometrica*, 64(6): 1263–1297.

Reis, Ricardo. 2013. "The Portuguese Slump and Crash and the Euro Crisis." *Brookings Papers on Economic Activity*, 2013(1): 143–210.

Schmitt-Grohé, Stephanie, and Martın Uribe. 2003. "Closing Small Open Economy Models." *Journal of international Economics*, 61(1): 163–185.

Schumpeter, Joseph A. 1939. *Business Cycles.* McGraw-Hill New York.

Appendix

Proof of Lemma 1

Proof. Unweighted average productivity is given by

$$\tilde{Z}_t^H = \int_{z_t^H}^{\infty} z\, Z_t\, \frac{\gamma(z)}{1-\Gamma(z_t^H)}\, dz = \frac{k}{k-1} z_t^H\, Z_t\,.$$

Average productivity weighted by output is given by

$$\hat{Z}_t^H = M \int_{z_t^H}^{\infty} \frac{q(z)}{Q_t^H}\, z\, Z_t\, \frac{\gamma(z)}{1-\Gamma(z_t^H)}\, dz\,.$$

First, solve for the choke price by exploiting the optimization condition for the marginal firm serving the domestic market, i.e. , the firm with productivity level equal to the threshold:

$$q_t^H(z_t^H) = \frac{\lambda_t}{2\gamma}\left[p_t^{max} - \frac{W_t^\sigma}{Z_t z_t^H}\right] = 0 \quad \Rightarrow \quad p_t^{max} = \frac{W_t^\sigma}{Z_t z_t^H}\,,$$

Thus,

$$q_t^H(z) = \frac{\lambda_t}{2\gamma}\frac{W_t^\sigma}{Z_t}\left[\frac{1}{z_t^H} - \frac{1}{z}\right]\,.$$

Noting that $Q_t^H = M \frac{1}{k+1} \frac{\lambda_t}{2\gamma} \frac{W_t^\sigma}{Z_t} \left(z_t^H\right)^{-1}$, the above expression simplifies to $\hat{Z}_t^H = \frac{k}{k+1} \tilde{Z}_t^H$.

Average productivity weighted by revenue is given by

$$\bar{Z}_t^H = M \int_{z_t^H}^{\infty} z\, Z_t \, \frac{p_t^H(z) q_t^H(z)}{R_t^H} \, \frac{\gamma(z)}{1-\Gamma(z_t^H)} \; dz \,.$$

Rewrite the policy function for domestic prices by substituting for the choke price above

$$p_t^H(z) = \frac{1}{2} \frac{W_t^\sigma}{Z_t} \left[\frac{1}{z_t^H} + \frac{1}{z} \right] .$$

It then follows that

$$p_t^H(z) q_t^H(z) = \frac{\lambda_t}{\gamma} \left(\frac{W_t^\sigma}{2Z_t} \right)^2 \left[\left(\frac{1}{z_t^H} \right)^2 + \left(\frac{1}{z} \right)^2 \right] .$$

Noting that $R_t^H = M \frac{2}{k+2} \left(\frac{W_t^\sigma}{2Z_t} \right)^2 (z_t^H)^{-2(k+1)}$, the above expression simplifies to $\bar{Z}_t^H = \frac{k+2}{k+1} \tilde{Z}_t^H$.

□

Proof of Proposition 1

Proof. Recall the definition of choke price

$$p_t^{max} = \frac{\frac{\alpha\gamma}{\lambda_t} + P_t}{\gamma + \eta N_t} \,.$$

where $P_t = M \int_{z_t^H} p_t^H(z) dz + M^* \int_{z_t^M} p_t^M(z) dz$ and $N_t = M (z_t^H)^{-k} + M^* (z_t^M)^{-k}$.

As derived above, the choke price can be expressed as a function of the domestic productivity threshold. In particular, $p_t^{max} = \frac{W_t^\sigma}{Z_t z_t^H}$, which allows for rewriting the domestic optimal price as:

$$p_t^H(z) = \frac{1}{2} \frac{W_t^\sigma}{Z_t} \left[\frac{1}{z_t^H} + \frac{1}{z} \right] .$$

The same argument goes through with the import productivity threshold. More specifically, $p_t^{max} = \frac{e_t \tau}{z_t^M}$, such that:

$$p_t^M(z) = \frac{1}{2} e_t \tau \left[\frac{1}{z_t^M} + \frac{1}{z} \right] .$$

The aggregate price level then reads:

$$P_t = \frac{2k+1}{2k+2} \frac{W_t^\sigma N_t}{Z_t z_t^H} \,,$$

which makes use of the relationship between the domestic and import productivity thresholds given by the choke price, i.e. , $z_t^M = \frac{e_t \tau}{W_t^\sigma} Z_t z_t^H$.

It then follows that the definition of the choke price can be rewritten as:

$$Z_t z_t^H = \frac{\lambda_t W_t^\sigma}{\alpha\gamma}\left[\gamma + \frac{\eta}{2k+2} N_t\right]$$

Finally, set $Z_t = 1$ and take the total differential of z_t^H. □

Proof of Proposition 2

Proof. To see this formally, plug in the relationship between domestic and import productivity thresholds with $Z_t = 1$ into the equilibrium number of active firms in the domestic market:

$$N_t = \left(\frac{1}{z_t^H}\right)^k \left[M + M^* \left(\frac{W_t^\sigma}{\tau\left(W_t^*\right)^\sigma e_t}\right)^k\right], \tag{11}$$

and combine with the expression for z_t^H above to get

$$z_t^H - \frac{\eta}{2k+2}\frac{\lambda_t W_t^\sigma}{\alpha\gamma}\left(\frac{1}{z_t^H}\right)^k \left[M + M^* \left(\frac{W_t^\sigma}{\tau\left(W_t^*\right)^\sigma e_t}\right)^k\right] = \frac{\lambda_t W_t^\sigma}{\alpha}. \tag{12}$$

Next, substitute the expressions for productivity thresholds, prices and quantities into the good market condition, which gives

$$\gamma \frac{M}{M^*}\frac{A^{k+2}}{B^{k+1}}\frac{e_t^{2k+1}}{\lambda_t W_t^{2\sigma(k+1)}}(z_t^H)^{k+2} = 1 + \Delta_t. \tag{13}$$

We are now ready to summarize the model's equilibrium in a single equation by combining (12) and (13) as

$$\left[\frac{M^*}{M}\frac{B^{k+1}}{A^{k+2}}\frac{\lambda_t W_t^{2\sigma(k+1)}}{e_t^{2k+1}}\frac{1+\Delta_t}{\gamma}\right]^{\frac{1}{k+2}} - \frac{\eta}{2k+2}\frac{\lambda_t W_t^\sigma}{\alpha\gamma} b^k \left[\frac{M}{M^*}\frac{A^{k+2}}{B^{k+1}}\frac{e_t^{2k+1}}{\lambda_t W_t^{2\sigma(k+1)}}\frac{\gamma}{1+\Delta_t}\right]^{\frac{k}{k+2}} \left[M + M^* \left(\frac{W_t^\sigma}{\tau\left(W_t^*\right)^\sigma e_t}\right)^k\right] = \frac{\lambda_t W_t^\sigma}{\alpha}. \tag{14}$$

From here it is straightforward to see that there is a positive relationship between e_t and Δ_t as $k > 1$. It then follows that because there is a negative relationship between e_t and z_t^H given by (12), an increase in Δ_t, lowers z_t^H unambiguously if wages remain unchanged.

The relationship between W_t and Δ_t is less obvious. The right-hand side of equation (14) is decreasing in wages as shown in Lemma 2. The left-hand side, however, depends on parameter values. Similarly the relationship between W_t and z_t^H given by (12) is also ambiguous. □

Lemma 2. *There is a negative relationship between the marginal utility of income and the wage level.*

Proof. Given the nature of the shock, $W_t^* = \frac{\varepsilon_w}{\varepsilon_w - 1}\frac{1}{\lambda_t}$. It then follows from rewriting equation (7) that

$$1 = \left[\theta\left(\frac{W_{t-1}}{W_t}\right)^{1-\varepsilon_w} + (1-\theta)\left(\frac{\varepsilon_w}{\varepsilon_w - 1}\frac{1}{\lambda_t W_t}\right)^{1-\varepsilon_w}\right]^{\frac{1}{1-\varepsilon_w}}.$$

From here it's straightforward to see that there is a negative relationship between W_t and λ_t.

□