Sudden stops, productivity and the exchange rate*

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Abstract

Following a sudden stop, real exchange rates are forced to realign through a nominal exchange rate depreciation, lower internal prices or a combination of both. This paper makes four contributions to understand how the type of adjustment shapes the response of macroeconomic variables, in particular, productivity, to such an episode. First, it documents that TFP systematically collapses under a flexible exchange rate arrangement while it improves, albeit moderately, within a currency union. Second, using firm-level data for two sudden stops occurred in Spain, it highlights that the difference in the productivity response is largely driven by entry and exit firm dynamics. Third, it proposes a small open economy DSGE framework with firm selection into production and endogenous mark-ups that is consistent with the empirical findings. The model nests three channels through which a shock affects productivity: a pro-competitive, a cost and a demand effect. While only the former operates when the nominal exchange rate burdens the adjustment, all three are active under a currency union. The model is able to predict general conditions under which the demand effect dominates in the latter scenario. Fourth, a quantitative version of the model is used to revisit the optimality of exchange rate policy after a sudden stop.

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1 Introduction

The case for flexible exchange rates, as famously introduced by Milton Friedman, still prevails as the optimal policy prescription against current account shocks among many economists.[1] The classic reference argues that in the presence of nominal rigidities, flexible exchange rates make for a good substitute of internal price adjustments. Given the observed sluggishness in wage behavior, it then follows that currency unions are doomed to failure in the event of a balance of payment crisis. The recent European Sovereign Debt crisis calls for a renewed interest on this old discussion for two reasons. First, it provides direct empirical evidence on a special type of balance of payment crisis, a sudden stop, within a currency union. Second, the internal devaluation that followed the initial shock was accompanied by a moderate, but still puzzling, productivity improvement. This clashes with the standard practice of taking TFP declines as given in this literature and raises the following questions: What is the relationship between sudden stops, productivity and the exchange rate regime? How does accounting for this change, if anything, the fixed vs floating debate?

In this paper I study how the type of real exchange rate realignment shapes the response of macroeconomic variables, in particular productivity, to a sudden stop. I put forth a new narrative whereby internal devaluations, as opposed to nominal depreciations, lead to greater cleansing effects of the shock through a larger contraction of labor income and, thus, domestic demand. I then call for a welfare evaluation of policy options that accounts for this new positive side-effect of currency unions.

In doing so, I first provide systematic evidence on the behavior of macroeconomic variables during a sudden stop for both developed and developing economies during the 1990-2015 period. To this end, a new criterion for sudden stop identification is developed such that it captures both the episodes that had been previously discussed by the literature as well as the recent Southern-European cases. Sudden stops are classified based on the prevalent exchange rate regime and the response of macroeconomic variables is evaluated for each regime using an event study approach. Results show that while TFP systematically collapses under flexible exchange rate arrangements, it improves, albeit moderately, within a currency union. Moreover, there is also a larger decline in employment and a greater contraction in consumption as a share of GDP. In other words, the increase in TFP is associated with a greater domestic contraction.

To better understand the drivers of aggregate TFP performance, I next resort to micro evidence in the form of firm-level data. In particular, two sudden stop episodes occurred in Spain, the 1992-93 Exchange Rate Mechanism crisis and the 2009-13 European Sovereign Crisis, are compared using survey data from the manufacturing sector. During the former the national currency, the *peseta*, was devalued in multiple occasions and TFP fell over 10%; whereas during the latter, the country could only regain competitiveness lowering wages as a member of a

[1] See Friedman (1953) for the full argument.

currency union and TFP increased 10%.

My findings are four. First, changes in productivity are concentrated on the lower tail of the firm productivity distribution in both episodes. Second, while the productivity was declining at the firm level during both crises, unproductive exiting firms contributed substantially more to TFP growth in the 2009-2013 sudden stop. Third, the 2009-13 sudden stop had a cleansing effect on productivity while the 1992-93 did not. Finally, there is suggestive evidence that links heterogeneity in price mark-ups with changes in allocative efficiency throughout the sample.

Based on the evidence above, I then propose a structural DSGE model with elements from the trade literature to study the behavior of macroeconomic variables, in particular productivity, during a sudden stop. The model features a small open economy with quasi-linear quadratic preferences and firm heterogeneity in productivity which gives rise to firm selection into production and endogenous variable markups. I model the labor supply decision explicitly by including leisure in the representative agent's utility function. This provides a key new channel through which the wage level and individual firm profits interact.

To ensure a role for policy, nominal rigidities are introduced in the form of sticky information in the wage setting process. The central bank is then assumed to set the nominal exchange rate as its main policy tool and two extreme regimes are discussed: a currency union, characterized by a credible commitment to keep the nominal exchange rate equal to one at all times; and a strict wage inflation targeting regime, where the flexible wage equilibrium is always implemented.

I model a sudden stop as an exogenous shock to the risk premium component of the interest rate that domestic consumers pay for international borrowing. By increasing the return on foreign denominated bonds, the domestic economy is forced to save internationally and increase net exports through a real exchange rate depreciation.

My model is able to generate the observed TFP patterns under different exchange rate regimes following a sudden stop. I first show that average productivity is proportional to the domestic productivity threshold. This variable simply measures the minimum productivity level a firm is required to have in order to generate positive profits and, thus, select into the domestic market. In other words, firms with productivity levels lower than the threshold will choose not to produce. It is thus enough to understand how the threshold moves after a sudden stop to inform about overall productivity.

In order to provide intuition, it is useful to first restrict attention to partial equilibrium. In such case, I show that the domestic threshold is entirely determined by the number of active firms in the market and the wage level. The first relationship is positive as greater competition lowers profit margins for all firms and then requires a higher level of productivity to remain profitable. I call this channel the pro-competitive effect. The relationship between wages and the threshold is less obvious. On the one hand, it increases the demand for overall consumption by increasing the labor income of households (the demand effect), but, on the other, it also increases the costs of producing (the cost e ect).

The e ect of a sudden stop on the domestic productivity threshold will therefore rely on the relative strength of these con icting forces. This, in turn, depends on how the real exchange rate adjustment is conducted; via higher nominal exchange rates vs. a lower wage level. I next consider the two polar cases. Say the nominal exchange rate entirely burdens the adjustment: only the pro-competitive channel is working, less rms import, and productivity unambiguously falls. Suppose instead that the wage adjusts completely while keeping the nominal exchange rate unchanged. All three channel operate and the overall e ect is ambiguous. I then argue that the parametrization restriction that ensures that the demand e ect dominates is reasonable under a standard model calibration. Therefore, it is possible (and likely) that a sudden stop generates a productivity improvement in a currency union.

I extend the results to general equilibrium by providing the full characterization of the model's solution. The model is calibrated using Spanish macroeconomic data as well as the rm-level evidence presented at the start of the paper and simulate the response of the economy to an unexpected increase in the country risk premium component of the interest rate. The two alternative exchange rate policy rules are considered. The model mimics a sudden stop episode: the economy runs a current account surplus and the real exchange rate depreciates.

The reponse of macroeconomic variables matches the empirics in many dimensions. GDP and consumption fall with a more pronounced although much transient drop of the latter within the currency union. Moreover, relative employment dynamics are correctly captured by the generated impulse response functions with the currency union experiencing greater volatility. The model misses however, the absolute decline in employment under a oating exchange rate policy. In addition, under the baseline calibration, the documented TFP fact emerges: productivity falls when the real exchange rate depreciation tranlates one-to-one into a nominal depreciaiton, while it increases as the devaluation takes place through wages instead. I consider further how sensitive this result is to alternative parameterizations.

Finally, to evaluate the overall performance of exchange rate regimes, I study how TFP improvements translate into welfare gains by numerically solving for utility-based welfare and other welfare-relevant variables and evaluating policy rules accordingly. According to the welfare measure, a currency union ranks highest when a sudden stop has the largest impact on rm entry. According to output loss, nonetheless, a currency union always performs worst on impact but best on cumulative terms. This is due to nominal wage rigidities which are fully overcome with strict wage in ation targeting.

The rest of the paper is organized as follows. The remainder of this section reviews related literature. Section 2 and 3 present aggregate and rm-level evidence of sudden stops respectively. Section 4 introduces the model and de nes the equilibrium. Section 5 explains the intuition by restricting attention to partial equilibrium. Section 6 discusses how the model is calibrated, performs simulations and discusses optimal exchange rate policy. Section 7 presents several extensions to the baseline model and section 8 concludes.

1.1 Relation to the literature

This paper combines several strands of the literature at the intersection of international nance, trade theory and rm dynamics.

First, it contributes to the sub eld that studies the e ect of international capital movements on macroeconomic variables. In particular, the main focus is on sudden stops, as rst de ned by Calvo (1998), abrupt and unexpected reversals in foreign capital in ows. The paper follows the empirical research that documents regularities among historical sudden stop episodes including Calvo et al. (2004), Guidotti et al. (2004), Calvo and Talvi (2005) and Kehoe and Ruhl (2009). In this respect, it contributes to the previous analysis in three ways: by modifying the Calvo sudden stop identi cation methodology to account for graduality, by expanding the time frame and the set of economies traditionally considered and by classifying episodes according to the exibility of the nominal exchange rate.[2] In doing so, I show that, while previous ndings - current account adjustment, depreciation of the real exchange rate and fall in output and TFP - apply to economics with exible exchange rates, macroeconomic variables in a currency union respond di erently.

Closely related, the paper also speaks to the collection of articles that propose amendments to the standard open economy neoclassical model in order to reconcile theoretical predictions with the observed behavior of macroeconomic variables, especially, TFP, during a sudden stop. For example Meza and Quintin (2007) allow for endogenous factor utilization, Neumeyer and Perri (2005), Christiano et al. (2004) and Mendoza (2006) introduce advanced payments of inputs and Mendoza (2010) directly assumes that exogenous productivity shocks trigger the collateral constraints that drive sudden stops. I bring an alternative explanation to the table: selection into production.

In second place, the paper contributes to the well-known oating vs. xed exchange rate debate. Among these papers, Curdia (2007), Braggion et al. (2009) and Fornaro (2015) together with many others argue that policy rules that target in ation are superior in terms of welfare to those that prioritize exchange rate stability. I nd, however, that accounting for rm dynamics can reverse this conclusion. More recently, the emphasis has been on the interaction of wage rigidity and the exchange rate regime. For example see Farhi et al. (2013) Schmitt-Grohe and Uribe (2016) and Gal and Monacelli (2016)). I coincide with the latter in concluding that increased exibility is not necessarily desirable within a currency union. The mechanism in this paper is

[2] This is not, however, the rst paper to classify the massive reversals that Southern-European countries experienced between late 2009 and 2011 as sudden stop episodes (see Merler and Pisani-Ferry (2012) and Gros and Alcidi (2015) for an earlier discussion).

novel nonetheless: the cleansing effect of an internal devaluation is increasing in the degree of rigidities.

The third strand of the literature to which this paper closely relates is trade models of heterogeneous firms a la Melitz (2003) which emphasize firm selection into domestic and international markets by featuring fixed production and exporting costs.[3] Even though the main focus of these papers is on the welfare effects of trade liberalizations, the real exchange rate depreciation that results from a balance of payment crisis resembles the reverse of a unilateral trade liberalization. This makes the New New Trade Theory framework a suitable starting point for my analysis.

Unlike the canonical Melitz (2003) model, however, I do not restrict attention to competition in the labor market and incorporate pro-competitive effects of trade by departing from constant elasticity of substitution (CES) preferences. In doing so, I follow papers in the style of Bernard et al. (2003), Feenstra (2003), Behrens and Murata (2006) and, more specifically, Melitz and Ottaviano (2008), that feature endogenous variable mark-ups. This allows me to defuse, at least in the short-run, the negative dependence between domestic and exporting cutoffs that drives the baseline result in the Melitz (2003) model. I preserve, however, the role that wages play in the Melitz (2003) model within the Melitz and Ottaviano (2008) framework. My approach is to modify the quasi-linear-quadratic preferences proposed by Ottaviano et al. (2002) and assume that leisure is the homogeneous good. The result is that the demand for differentiated varieties is no longer independent of labor income and a new demand effect of wages emerges.

While most of the standard models are static, this paper is closer to the subset within the trade literature interested in firm dynamics and business cycles.[4] The most notable reference is Melitz and Ghironi (2005) which embeds the steady-state version of the Melitz (2003) model into a two country DSGE model. To gain tractability, however, Melitz and Ghironi (2005) eliminate fixed production costs such that all firms in the market choose to produce and exit is driven by exogenous death shocks. In addition, because their focus is on the Balassa-Samuelson effect, the main driver of the business cycle is an aggregate productivity shock. My paper, instead, incorporates selection into production and studies the effects of exogenous current account shocks on productivity.[5] Moreover, it is, to the best of my knowledge, the first study to incorporate nominal rigidities and, thus, to be able to discuss the role for monetary policy in a similar setting.[6]

Finally, this paper is deeply connected to the literature that studies the contribution of reallocation to TFP growth. Two theoretical arguments have been put forward to date. On the one

[3] For an exhaustive review of the literature refer to Melitz and Redding (2014).

[4] Alternatively, models are commonly assumed to be dynamic but with a stationary equilibrium featuring constant aggregate variables.

[5] Bilbiie et al. (2012) and Ottaviano (2012) among others already consider the effect of endogenous entry and/or new product variety in a business cycle model. They do so, however, in a closed economy setting.

[6] Bilbiie et al. (2008) and Bilbiie et al. (2014) introduce price adjustment costs in a closed-economy DSGE model with endogenous entry and product variety to study optimal monetary policy.

hand, Hsieh and Klenow (2009) show that increases in allocative e ciency, that involve closing gaps in the return of inputs, increase aggregate productivity. On the other hand, Caballero et al. (1994)'s interpretation of Schumpeter et al. (1939)'s creative destruction argument, emphasizes the role of reallocation among new and incumbent rms as an important factor of growth. The paper presents a model based on the second current, emphasizing the cleansing e ect of internal devaluations, but discusses both conjectures in the empirical analysis.

Even more closely related, the pre-crisis slowdown of productivity in Southern Europe has recently prompt an increasingly popular narrative that links declining TFP and enhanced misallocation with capital in ows. Papers on this topic are often grouped based on the margin of misallocation suggested: while Benigno and Fornaro (2014) considers a model of misallocation between a tradable and a non-tradable sector; Dias et al. (2016), Garca-Santana et al. (2016), Reis (2013) and Gopinath et al. (2017) show, and formalize in the later cases, that resources were also misallocated within the sector level. My work contributes to this hypotheses in two dimensions: from the empirical side, I show that the negative relationship between capital ows and TFP growth in Southern Europe is symmetric i.e. productivity improved as the crisis hit and foreign capital retrenched. From the theoretical side, I provide an alternative framework that reconciles both sets of papers by endogenizing rms decision to export and, thus, the size of the exporting sector.

2 Aggregate productivity during a sudden stop

The goal of this section is to conduct a systematic analysis of how unexpected capital ow reversals a ect macroeconomic performance. This requires establishing a criterion to identify sudden stops, classifying episodes by exchange rate regime and characterizing the behavior of several macroeconomic variables through a standard event study approach.

2.1 Data and methodology

I follow Cavallo and Frankel (2008) in de ning a sudden stop as an episode in which there is a substantial decline in the capital account surplus together with a recessionary reduction in the current account de cit. In particular, I develop an algorithm that classi es as a sudden stop a period which contains at least one year during which (i) the nancial account surplus has fallen at least one standard deviation below its rolling average, (ii) there is a simultaneous decline in the current account de cit (or an equivalent decline in foreign reserves) and (iii) GDP per capita contracts.[7] The start and end of each episode is marked by the rst and last year within

[7] This contrasts with Cavallo and Frankel (2008), who de ne as noticeable a reduction in the nancial account surplus that is two standard deviations above the mean standard deviation for the corresponding decade.

the period in which the nancial account surplus is half a standard deviation below the rolling average.[8]

The two latter requirements ensure that the capital ow reversals captured by the algorithm strictly qualify as sudden stops. First by requiring that the nancing disruption is accompanied by an appropriate macroeconomic adjustment. Second, by ruling out booming episodes that display similar characteristics, for example a positive trade shock.

Annual data on the current and capital accounts for all available countries comes from the IMF's International Financial Statistics Database (IFS) for the period 1990-2015 and complemented with data on GDP per capita growth from the World Bank's World Development Indicators Database.[9]

The total number of episodes that I identify using this methodology is 73, representing 4.1% of total available country/year observations in my sample.[10] My criterion is able to successfully identify all traditional sudden stop episodes previously discussed by the literature - mostly 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.[11]

I build on Ilzetzki et al. (2017) updated de facto coding system as opposed to relying on declared exchange rate regime reported to the IMF in order to classify episodes. In my baseline results, I consider as prevalent the exchange rate regime that was in place during the last year of the sudden stop. I distinguish four di erent cases: a currency union, a hard peg, a soft peg and a exible arrangement.[12] Out of the 73 episodes identi ed, 10 occur within a currency union (8 in the Euro Area and 2 in the West African Economic and Monetary Union), 1 in a hard peg system, 38 in a soft peg regime and 24 in a exible arrangement.

To characterize the behavior of the macro-economy as a sudden stop unfolds I use data on GDP, nal private consumption, employment, total factor productivity, the current account de cit and the real exchange rate. All variables are compiled from the World Development Indicators except for Total Factor Productivity, TFP, that is collected from the Conference Board's Total Economy Database and the current account de cit from the IMF's World Economic Outlook Database.

[8] I refer the reader to Appendix A for further details.

[9] Note that I do not consider countries which are small, both in terms of population (below one million inhabitants) and in terms of GDP (below one billion USD). My nal sample covers 119 countries.

[10] The total number of episodes is 91, however, I drop one-year long episodes that start in 2009 as these are rather explained by the global trade collapse as opposed to a country-speci c reversal of ows. The complete list of crisis episodes per country, plus data availability, can be found in the Appendix A.

[11] I acknowledge that my methodology does not account for changes in Target 2 balances in the Eurozone and, thus, prevents me from measuring private capital ows accurately. However, this is not problematic for my purposes as the algorithm already identi es the GIIPS episodes.

[12] In terms of the IMF Annual Report on Exchange Arrangements and Exchange Restriction ne classi cation, I deviate as follows: (1) I manually divide code 1 into currency union and no separate legal tender and (2) I group codes 3 to 5 in a single category which I call exible arrangements.

I compute the mean and median path of each of these aggregate variables across the episodes conditional on their exchange rate classi cation and plot them in Figures 1 and 2 together with standard error bands. In order to capture the buildup and end phase of each episode, I consider six year windows that begin two years before the start of each reversal and mark the start and the average duration of a sudden stop.

As is standard in much of the literature, I focus on the cyclical component of most of the variables by looking at its percentage deviation from the trend.[13] However, as I am interested in comparing the performance of variables before and after the episode, instead of using the Hodrick-Prescott lter, I t a linear trend using a pre-crisis sample.

2.2 Results

Figure 1 illustrates how domestic variables respond to an unexpected reversal of capital ows 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 smooth decline in employment levels, measured as the number of employed workers, and a signi cant collapse in total factor productivity. The last two graphs capture the response of the external sector: capital out ows coincide with a depreciation of the real exchange rate, represented by a decline in the index plotted in Figure 1. The current account de cit is reduced sharply, almost reaching trade balance as soon as one year after the start of the episode. Finally, the average duration of an episode is slightly less than two years.

The results for a currency union are summarized by Figure 2. The response of all variables but TFP is similar, in qualitative terms, to that depicted in the exible exchange rate case. The unexpected reversal of ows is associated with a decline in output, consumption and employment. There is a gradual reduction in the current account de cit that yet persists fours 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, 2.5 years.

The most notable di erence across the plots is the behavior of TFP: whereas productivity clearly falls in the rst case, in line with the ndings of the literature, there is a minor yet persistent improvement in TFP within currency unions. In particular, looking in greater detail into individual episodes, sudden stops in currency unions are typically preceded by periods of worsening TFP performance which come to a halt as the capital ows reversal materializes.[14] In contrast, periods of capital in ows in free- oating regimes are characterized by increasing TFP records that completely reverse as the sudden stop hits the economy.

[13] The current account de cit, expressed as a share of GDP, and the real exchange rate index, with base t-2, are the exception.

[14] Given the reduced sample size in Figure 2, standard error bands are admittedly large to be able to draw solid conclusions.

There are additional, although arguably minor, di erences 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 2. This holds in both absolute and relative to GDP terms. Moreover, controlling for the size of output contraction, the fall in private consumption is larger in the currency union. To see this clearly I compute the share of output contraction that is explained by cuts in consumption: 80% on impact and 76% overall in the currency union vs 72% on impact and 68% overall in the free oating regime.

2.3 Robustness

I conduct a battery of robustness checks to evaluate the consistency of my results[15]. Regarding the exchange rate classi cation, I consider alternative de facto coding systems, such as Shambaugh (2004) and Klein and Shambaugh (2008), that allow for regime changes in higher frequency. I also redo the analysis taking as given the exchange rate regime prevalent at the start of the sudden stop. This is motivated by the fact that, although in most cases countries abandoned pre-existing pegs because of a sudden stop, in a minority of cases the order reversed. Moreover, I remove episodes in which the exchange rate regime changed more than once as this is due exclusively to missing data.

Regarding the event study, I explore alternative methods to detrend the data including a one-sided HP lter, the Hamilton (2017) lter and di erent sample lengths. I also measure labor input as total hours worked instead of employment and consider alternative TFP data sources such as the Penn World Tables. Finally, I control for the degree of economic development and show that results are not driven by advanced vs. developing structural di erences.

3 Firm-level productivity during a sudden stop

I now resort to micro-evidence to document the role of selection into production in shaping the behavior of aggregate productivity. Given obvious data restrictions, I conduct a case study approach. I compare two historical sudden stop episodes occurred in a single country, Spain, under the two alternative exchange rate regimes considered in the event study above[16].

[15] Results available upon request.

[16] The choice of Spain as a case study is admittedly driven by data availability. However, the comparison of episodes within the same economy should address, at least partially, legitimate concerns regarding di erences in countries' structural characteristics, such as the degree of economic development, driving my results. Moreover, the Spanish economy has been previously analyzed within the misallocation debate (see Gopinath et al. (2017)) and, thus, makes for an interesting benchmark for comparison.

3.1 A tale of two sudden stops

The methodology outlined above identi es two sudden stop episodes in Spain's recent economic history. The rst coincides with the 2009-93 Exchange Rate Mechanism (ERM) crisis and the second with the 2009-2013 European Sovereign Debt crisis.

It is easy to nd parallels between both episodes, especially regarding the onset. Both were preceded by periods of increasing capital in ows, declining international competitiveness and widening current account de cits. These were abruptly reverted following a con dence shock a ecting the European integration project; the negative outcome of the Danish referendum on the Maastricht Treaty, in the rst case, and the Greek announcement of substantial upward revisions in the government budget de cit, more recently. The ight of international investment led to an urgent correction of misaligned real exchange rates and boost exports in order to close the trade gap.

The response of exchange rate policy to these events, however, diverted signi cantly. While the peseta was devalued in three occasions during the 1992-93 crisis, Spain was already sharing a common currency with its largest trading partners in 2010 and underwent a process of internal devaluation.[17] Consistent with my previous results, TFP fell following the nominal depreciation in 1992, while it increased during the 2009-13 period. I take these episodes as representative of sudden stops under exible arrangements and currency unions, respectively, and use rm-level data to explore what is driving the observed aggregate TFP pattern.[18]

3.2 Data

I use rm-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 Industry. The ESEE surveys all manufacturing rms operating in Spain with more than 200 workers and a sample of rms between 10 and 200 workers, providing a rich panel dataset with over 1,800 rms for the period 1990-2014.[19] It covers around 35 percent of valued added in Spanish manufacturing and provides information on the rm's balance sheet together with its pro t and loss statement.

[17] In 1992, it was rst 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.

[18] It can be argued that Spain does not strictly classify as a oating exchange rate regime in 1992-93 as it remains a member of the Exchange Rate Mechanism, a multilateral party grid of exchange rates established in 1979. However, the repeated realignments of its central rate against the deutsche mark implied that the overall devaluation of its currency was even larger than that of the oating currencies such as the pound. In order words, despite the formal membership of the ERM, the exchange rate e ectively behaved as exible.

[19] Large rms will be overrepresented in my sample. Given that rms that enter are typically small while those that exit range from small to medium-sized, this could potentially weaken the role of extensive margin in my analysis. Keeping this caveat in mind, my ndings should be interpreted as a lower bound.

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.[20] This is particularly true for the exit of rms as the dataset clearly di erentiates between rms that decide not to collaborate in a given year, rms that exit the market and rms that are a ected by a split-up, a merge or an acquisition process. In addition, rms that resume production or collaboration with the survey are re-included in the sample and properly recorded. As for entry, new rms 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.

There are other advantages of the ESEE dataset that are also worth highlighting. It is the only dataset with reliable nancial information going back as early as the beginning of the 1990s, allowing me to study the 1992-93 episode. It also provides rm-level records of the value of exports which is most often strictly con dential in Spain. [21]

Finally, given the e orts devoted to ensure consistency and accuracy during the data collection process, the required cleaning procedure is minimal. I simply drop rms that, at some stage, do not provide the variables necessary for computing productivity at the individual level i.e. rms with zero or negative values for value added and capital stock.[22]

3.3 Estimating rm-level TFP

I measure real output as nominal value added divided by an output price de ator. Obtaining an appropriate industry-speci c output price de ator series, however, is challenging for two reasons. First, the data needs to go back in time at least until 1990, while Eurostat series, the standard source, only start around 2000. Instead, I use the producer price index provided by the National Statistics Institute (NSI). Second, the ESEE provides its own industry classi cation based on the sum of the three-digit NACE Rev.2 codes to 20 manufacturing industries. Given that the mapping is not strictly one-to-one, deriving corresponding industry-speci c de ators requires implementing a weighting strategy.[23] My approach is to use sector contribution to

[20] The other existing rm-level dataset, as used in Garca-Santana et al. (2016), 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 built using the same source of data that constitutes the Spanish input for ORBIS, annual nancial statements that rms are obliged to submit to the Commercial Registry, and, thus, is subjected to the same criticism. Please check Almunia et al. (018b) for more details.

[21] To the best of my knowledge, the only available dataset is the foreign transactions registry collected by the Bank of Spain containing transaction-level data which can be aggregated to the rm-level using the rm's scal identi er as done in Almunia et al. (018a). Given the administrative nature of the dataset, however, only large operations are recorded. Moreover, the minimum reporting threshold changed from 12,500 to 50,000 euros in 2008, hindering the possibility of correctly measuring the extensive margin of exports.

[22] Note that I drop the entire rm and not only the rm-year observation. The reason being that I want to prevent rms disappearing (and maybe then reappearing) in the sample strictly due to the cleaning procedure.

[23] For example, manufacturing industry with ESEE code 7 (paper) corresponds to NACE Rev.2 codes 171 and 172.

total manufacturing value added in 2018, also provided by the NSI, as the relevant weight.[24]

I follow the literature in using the wage bill, deflated by the above price series, instead of employment to measure the labor input, in order to control for heterogeneity in labor quality across firms. To measure capital stock I use two different variables given existing data restrictions: for the 1990-1999 period I use total real net capital stock whereas for the 2000-2014 period I use the book value of fixed assets deflated by the price of investment goods from the National Statistics Institute. [25,26]

Industry elasticities for capital and labor are estimated using Ackerberg et al. (2015)'s algorithm and firm-level productivity is then computed as a standard Solow residual.[27] I consider the labor-weighted average of firm-level TFP as my aggregate measure of productivity.[28]

3.4 Analysis

Aggregate TFP as computed from the micro-data decreased by 10.87% during the 1992-1993 episode while increased by 10.02% in the 2009-2013 period. While consistent with the results of the event study, the granularity of the data allows for a more detailed investigation regarding the drivers of productivity.

The lower tail As a simple yet insightful exercise, I first document changes in the distribution of firm-level TFP before and after each of the crises. ?? plots a kernel probability distribution estimate of log productivity before and after the sudden stop episode for both the 1992-1993 and the 2009-2013 crisis. There are a number of patterns that are worth noting. First, there is ample heterogeneity in TFP levels among firms in any given year as already highlighted by the literature. Second, the shape of the distribution is reasonably similar and remains unchanged throughout both crisis periods. Third, changes in TFP are not clearly explained by major shifts in the distribution. A visual inspection suggests that the lower tail concentrates most, if not

[24] The NSI provides weightings for the 2010-2018 period only. I use 2018 figures, as opposed to taking an average or an alternative year, because 2018 is the only year for which there are no missing values.

[25] Total real net capital stock is defined as the value of the stock of total net capital at 1990 constant prices which I simply convert into base year (2015) prices.

[26] I conduct several robustness exercises in order to check whether the change in the capital stock measure impacts my results. First, for the years for which the two series overlap, 1993-1999, I estimate that the correlation coefficient at the firm-level is 0.9.

[27] Ackerberg et al. (2015) improves on the Wooldridge (2009)'s extension of the Levinsohn and Petrin (2003) approach by allowing for dynamics in labor and unobserved serially correlated shocks to wages. Their framework also overcomes Gandhi et al. (2016)'s concern regarding the non-identification result of the proxy variable approach by assuming a Leontief production function in materials. As a robustness check, nevertheless, I show that these two alternative methodologies generate firm-level TFP series which are highly correlated with my baseline TFP. I also redo the analysis with a gross output specification.

[28] I consider labor, as opposed to value added, weights when aggregating TFP for two reasons. On the one hand, I will be presenting a theoretical model with labor as the only factor of production where labor shares are the appropriate weight. On the other, large firms in terms of employment are overstated in my sample, as explained above, and, thus, labor weights are consistent with the interpretation of my results as a lower bound.

all, of the action: it lengthens as TFP decreases in the former crisis while shortens considerably as TFP increases in the latter case.

Estimating moments of the distribution confirm the above hypothesis with higher-order moments experiencing the largest swings.[29] During the 1992-93 crisis firms display lower productivity on average and the dispersion of log TPF levels increases. The increase in dispersion, however, is asymmetric, the distribution of unproductive firms expands while that of productive changes little with the coefficient of skewness declining from -0.40 to -1.24. Moreover, increasing kurtosis, 7.04 vs. 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 2009-2013 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.

Figure 3 summarizes graphically the predominant role of the lower tail by presenting the mean change in log(TFP) per percentile of the distribution. On average, the change in productivity is close to zero during both episodes across the entire distribution, with the notable exception of the 1% percentile where TFP decreases by 70% during 1991-1993 while increases by 73% during 2009-2013.[30] Although the standard errors are admittedly large for the 1% percentiles in both cases, the difference relative to other percentiles is big enough to remain relevant.

While these findings already support a narrative of shifting productivity cutoffs, there is yet room for skepticism. 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 would therefore consider weighted measures. Moreover, it should aim to disentangle the role of incumbent, entering and exiting firms in shaping TFP patterns. This is precisely what I propose to do next.

Decomposing TFP growth Consider the dynamic version of the Olley and Pakes (1996) decomposition introduced by Melitz and Polanec (2015) which is given by

$$\Delta Z_t = \Delta \bar{Z}_t^C + \Delta \mathrm{Cov}(s_{i;t}^C; Z_{i;t}^C) + s_t^N (Z_t^N - Z_t^C) + s_{t-1}^X (Z_{t-1}^X - Z_{t-1}^C)$$

where C denotes incumbent firms, N denotes entering firms, and X denotes exiting firms.[31] The first two terms of the decomposition represent the contribution of incumbent firms while

[29] Refer to Table A.2 for further details.

[30] In the former case, the 5% percentile also shrinks although by a smaller magnitude, 36%.

[31] This version differs from the widely used Foster et al. (2001) decomposition in allowing for differences in the reference productivity for entrants, exiters and incumbents. Intuitively, the contribution of entrants (exiters) is now equal to the change in productivity one would observe if entry (exit) was elided. Moreover, it has a direct mapping into a theoretical model of firm productivity heterogeneity, circumventing recent critiques to accounting exercises measuring reallocation by Hsieh and Klenow (2017). Even so, results are robust to considering Foster et al. (2001) and Griliches and Regev (1995) alternative decompositions.

the last two terms represent the contribution of entering and exiting firms, respectively. All measures refer to aggregate TFP over the base and end years.

The interpretation of the above decomposition is straightforward. On the one hand, entrants (exiters) contribute positively to TFP growth when their average productivity is higher (lower) than the incumbents' counterpart. These contributions are weighted by the market share of entrants, s_t^N, and exiters, s_{t-1}^X, respectively. On the other hand, the contribution of incumbent firms is given by the change in their average TFP and a measure of market share reallocation i.e. the covariance between firm-level market share and productivity level.

It is not possible, nonetheless, to distinguish between the "within" and "between" firm component of incumbents under this framework. This hinders the possibility of testing Caballero et al. (1994) cleansing hypothesis whereby resources released by unproductive exiting firms are successfully reallocated to more productive surviving firms. To circumvent this drawback, I follow Dias and Marques (2018) in applying the Foster et al. (2001) decomposition to incumbents such that

$$\Delta Z_t = \sum_{i \in C} s_{i,t-1} \Delta Z_{i,t} + \sum_{i \in C} Z_{i,t-1} \Delta s_{i,t} + \sum_{i \in C} \Delta s_{i,t} \Delta Z_{i,t} + s_t^N (Z_t^N - Z_t^C) + s_{t-1}^X (Z_{t-1}^X - Z_{t-1}^C)$$

The first term measures the contribution of within-firm productivity changes of incumbents weighted by their initial share. The second term captures the contribution of market share reallocation. The third term is known as the cross-effect, it captures the covariance of market share and productivity changes for an individual firm.

The results of the TFP growth decomposition for the two sudden stops are summarized in Table 1. 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. Among incumbents, there is some reallocation of market shares towards more productive firms. However, it is far from enough to overcome the pronounced fall in within-firm productivity and the cross-term.[32]

In contrast, the increase in TFP experienced during 2009-2013 is largely 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 2009-2013 episode, firms that exit the market were, on average, bigger in terms of labor market share, 7.01% vs. 2.78%, and three times as unproductive in relation to incumbents, 27.16% vs. 9.17%, than their 1992-1993 counterparts. Moreover, the annualized exit rate more than doubled from 4.47% to 9.19%.[33]

[32] Note that finding procyclical firm-level productivity is not surprising, especially, given that I have no feasible way of controlling for variable capacity utilization.

[33] The corresponding averages for the entire sample are the following: the annualized exit rate is 7.71%, the

Back to Table 1, the contribution of incumbents, although half as important, is also remarkable. It is still the case that average productivity of incumbents is procyclical, yet the positive effect of the between and cross terms dominate overall. The increase in resource reallocation and a stronger correlation between productivity changes and market share together with the positive contribution of exiting firms is consistent with a cleansing effect of the 2009-13 sudden stop which is absent in the 1992-93 episode. The cleansing hypothesis, as discussed by Caballero et al. (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.

The cleansing hypothesis 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 whereas high productivity firms are more likely to grow every period. I follow Foster et al. (2016) and Dias and Marques (2018) in using empirical specifications that are consistent with these models to test whether sudden stop episodes accelerate these dynamics. In order words, under the cleansing hypothesis, one should expect a stronger correlation between survival, employment and capital growth and productivity levels as the crisis unfolds. The empirical model is simply given by

$$y_{it} = \; + \; tfp_{it} + \; ss^1_t + \; ss^1_t \; tfp_{it} + \; ss^2_t + \; ss^2_t \; tfp_{it} + \; _{it}$$

where y_{it} stands for a set of explanatory 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 employment and/or capital growth in the regressions for input growth. The regressor ss^1_t is a dummy variable for the 1992-93 sudden stop, ss^2_t is a dummy variable for the 2009-13 sudden stop and tfp_{it} captures the log of firm-level productivity.

For the exit specification, the relationship between survival probability and productivity is expected to be positive and, thus, < 0. Under the cleansing hypothesis, this correlation should strengthened during a sudden stop episode and one would anticipate < 0 and < 0. Note that the sign of parameters and provide additional insights regarding the interaction terms. They capture the change in exit rate during the sudden stops that is not correlated with productivity. When positive, it suggests that the increase in exit rates during the crises is disproportionately larger for the least productive firms. For the input growth specification, the exact opposite applies.

Results of these regressions are summarized in Table ??. 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. Based on the estimates,

labor share of exiting firms is 6.43% and the difference in TFP between exiting firms and incumbents is 14.09%.

2009-2013 is a period of increasing exit rates, especially among the less productive rms. Note that while the coe cients and have the correct sign, they are smaller in magnitude than and and, more importantly, not statistically di erent from zero.

The second and third columns support further the predictions of the cleansing hypothesis for the 2009-13 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. Together with the negative sign of coe cient , there is evidence that high productivity levels somewhat shielded rms from shrinking during the crisis years. The fourth and fth columns show the capital growth speci cations for completeness. Results, however, are uninformative with estimated coe cients displaying no statistical signi cance.

To further understand the quantitative relevance of my results, Figure ?? plots the implied di erences in exit probability and labor growth between two rms with productivity level one standard deviation above and one standard deviation below the sectoral mean during normal times, the 1992-93 sudden stop and the 2009-13 sudden stop. The di erence in exit rates is 3.7% in the baseline scenario and increases during sudden stops. While the increase is minor during the 1992-93 episode, up to 4.3%, the implied di erence almost doubles in the latter case, 7.1%. The magnitudes of the di erence for labor growth follow a similar pattern. The baseline gap between a high productivity and low productivity rm is only of 0.9%, increasing to 1.1% during the rst sudden stop and up to 2.6% over the second. Note that results for labor growth are robust to considering the subsample of continuing rms.

Allocative e ciency Finally, I evaluate an additional theoretical channel through which reallocation may contribute to TFP growth - increased allocative e ciency. I follow the literature in measuring the marginal revenues product of capital and labor and interpret changes in dispersion through the lenses of the Hsieh and Klenow (2009) framework. I rst obtain sector-level measures of dispersion in logs which I then aggregate into an economy-wide labor-weighted average.

Figure 5 reports the within-sector standard deviations of marginal revenue products of capital and labor relative to 1990, which is normalized to one. The dispersion of log(MRPK) is declining over time until the late 1990s when the trend clearly reverses. During the 2000s there is a gradual increase in dispersion, with the more pronounced hikes taking place from 2005 onwards. This is somewhat interrupted during the recent crisis during which dispersion is reduce slightly with the trend reverting back to the pre-crisis level by the end of the sample. The overall description holds for the dispersion of log(MRPL) too, although the latter depicts much larger volatility.

The increase in the dispersion of log(MRPK) during the pre-crisis had been already documented by both Gopinath et al. (2017) and Garca-Santana et al. (2016) using di erent datasets for the Spanish manufacturing sector. The di erence here is the pattern of log(MRPL); while the former papers had reported a relatively flat (or even declining) path, I find that it follows a similar, yet more pronounced, trend to that of log(MRPK). According to the Hsieh and Klenow (2009) framework this can be interpreted as evidence of changing external distortions that affect both factors of production.[34] Alternatively, internal distortions, such as heterogeneity in price markups, would generate observationally equivalent patterns. I take the latter stance as the constant mark-ups assumption has been disproved by the industrial organization literature (see Syverson (2004) and De Loecker and Warzynski (2012) as examples).[35]

In sum, the above findings call for a theory of sudden stops that features heterogeneously productive firms, selection into production and endogenous variables mark-ups. All of these elements, together with the exchange rate dimension, are featured in the theoretical model that I develop in the next section.

4 Theoretical model

Consider an infinite-horizon small open economy. Time is discrete and indexed by t. The economy is populated by a representative household that consumes goods and leisure and engages in financial transactions with foreign investors. There is also a large number of differentiated firms that produce the consumption goods using labor supplied by the households, and a monetary authority that sets the nominal exchange rate as the policy instrument.

4.1 A representative household

The representative household derives utility from leisure and the consumption of a set of differentiated goods $q_t(\omega)$ and supplies differentiated labor inputs to firms. The lifetime utility is given by

$$E_0\left[\sum_{t=0}^{\infty} \beta^t U(q_t(\omega); L_t^i)\right] \quad (1)$$

where E_t is the expectation operator conditional on the information set available at time t and β is the discount factor. The period utility function is assumed to be:

$$U(q_t(\omega); L_t^i) = \alpha \int^{N_t} q_t(\omega) d\omega - \frac{1}{2}\gamma \int^{N_t} q_t(\omega)^2 d\omega - \frac{1}{2}\eta\left(\int^{N_t} q_t(\omega) d\omega\right)^2 + \int_0^1 (\bar{L} - L_t^i)\, di$$

where $\bar{L}$ is the household's endowment of time and N_t the number of differentiated varieties available in the economy. This is a slightly modified version of the Melitz and Ottaviano (2008) preferences. The original functional form is particularly appealing for three reasons. Firstly, it

[34] In the model this is represented by an output distortion.

[35] See Fernandez et al. (2015) for evidence on the evolution of Spanish price-cost markups for the 1995-2012 period.

captures love of variety through , which determines the level of product di erentiation between consumptions goods and is assumed to be strictly positive. As increases, consumers place higher weight on the distribution of consumption across varieties. In second place, its 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 absence of xed costs of production. Third, it generates endogenous variable mark-ups which capture the e ect of market competition of rm sales (the so-called pro-competitive e ect) as opposed to standard CES preferences.

I depart, however, from assuming the existence of an homogeneous numeraire good with linear production technology that pins down the wage in the economy, as endogenous uctuations in the wage level are vital for the analysis. Moreover, in the context of an internal devaluation, it is also essential to capture any changes in demand patterns that may arise from movements in wages. My approach is to explicitly model labor supply decision by assuming preferences that are linear in leisure.[36] The demand parameters and therefore measure the substitutability between consumption of di erentiated goods and leisure and are also assumed to be strictly positive.

Labor supply is di erentiated: there is a unit continuum of labor types which are imperfect substitutes between them. Firms can aggregate labor types according to $L_t = (\int_0^1 L_t^{i\,\frac{\;\;1}{}} di)^{\frac{}{\;\;1}}$. I assume that the representative household supplies all the di erentiated labor inputs as in Woodford (2011).[37] Suppose, for example, that each member of the household specializes in one occupation. The representative household therefore has monopoly power to set the wage for each labor type, W_t^i.

The representative household can only engage in nancial transactions with foreign investors by trading in risk-free foreign denominated bonds B_t which pay a debt elastic rate of return:

$$R_t = R_t + \quad (e^{B \quad B_t} \quad 1) + (e^{\;t \quad 1} \quad 1) \qquad (2)$$

where R_t is the world interest rate and B is the steady state level of debt.[38;39] The only source of uncertainty is $_t$ which is interpreted as a country risk premium shock, similar to that of Drechsel and Tenreyro (2017) and assumed to follow an AR(1) process in logs. A sudden stop in the model is a positive realization of $_t$: an unexpected increase in the cost of international borrowing that forces the domestic economy to deleverage internationally by expanding net exports.

[36] Given the quasi-linear functional form, there is no income e ect for di erentiated varieties. However, changes in wages will a ect demand through the substitution e ect.

[37] This is equivalent to assuming that each household specializes in the supply of one type of labor input as long as there are equal number of households supplying each type.

[38] This debt-elasticity of the interest rate is assumed to ensure a stationary solution to the model after de-trending following Schmitt-Grohe and Uribe (2003).

[39] 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.

The budget constraint of the representative agent in terms of domestic currency can be written as:

$$\int^{N_t} p_t(!)q_t(!)d! + {}_tB_t = \int_0^1 W_t^i L_t^i \, di + {}_t + {}_tR_{t-1}B_{t-1} \qquad (3)$$

where $W_t^i L_t^i$ is the income derived from supplying di erentiated labor input i, $_t$ is pro t received from rms and $_t$ denotes the nominal exchange rate, de ned as units of domestic currency needed to buy one unit of foreign currency.

Each period the household chooses $q_t(!);B_t;L_t^i$ and W_t^i to maximize the expected present discounted value of utility, equation (1), subject to the budget constraint, equation (3), and the demand for type i labor input, which is given by

$$L_t^i = \left(\frac{W_t}{W_t^i}\right) L_t$$

where L_t is a CES aggregate of the di erentiated labor services and measures the elasticity of substitution across di erent labor input types.

Optimality conditions Given quadratic preferences, it may well be the case that not all di erentiated goods are demanded by the household. However, when a particular good is consumed, its inverse demand is determined by

$$q_t(!) \quad Q_t = {}_t p_t(!) \qquad (4)$$

where Q_t is the consumption level over all varieties and $_t$ is the time t Lagrangian multiplier. Consumption of a given variety decreases with price, the marginal utility of wealth and total consumption.

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

$$_t = R_t E_t\left[\frac{_{t+1}}{_t} \, _{t+1}\right] \qquad (5)$$

A higher interest rate and expectations of nominal exchange rate depreciation both increase the returns from foreign investments and, thus, encourage consumer savings.

Solving for the optimal wage for labor type i

$$W_t^i = \frac{}{1}\frac{1}{_t} \qquad (6)$$

Intuitively, higher wages increase household's wealth everything else equal. Given diminishing marginal utility, the Lagrangian multiplier falls. Equation (6) also implies that the optimal exible wage is equalized across labor types i.e. $W_t = W_t^i$.

Finally, note that the representative household will be willing to satisfy rms' labor demand as long as the real wage covers the marginal rate of substitution between consumption and leisure:

$$\frac{W_t}{P_t} \qquad \frac{1}{(\quad Q_t)N_t \quad Q_t}$$

where N_t represents the total number of di erentiated varieties available for consumption.

4.2 Firms

There is a continuum of rms, each choosing to produce a di erent variety ! . Labor is the only factor of production and the unit production cost is a concave function in the factor price i.e. $C_t = W_t$, where $0 <$ $\quad 1$ is the labor income share.[40] Firms only di er in the productivity level z which is drawn from a Pareto distribution $1 \quad G(z) = (\frac{1}{z})^k$ with shape parameter k and minimum productivity level equal to one.

The main focus of the paper is the short-run and, as such, cross-country reallocation of rms is not allowed. [41] This implies that there is a xed number of potentially active rms in the economy which will decide whether to produce or not in each period based on pro tability.

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 > 1. While domestic demand for variety z, $q_t^H(z)$, is given by equation (4), the foreign demand for a domestic variety z, $q_t^F(z)$, is given by

$$q_t^F(z) = A \quad Bp_t^F(z) \qquad (7)$$

where A and B are exogenous given a small-open economy setting. As opposed to the standard two-country model, changes in the domestic economy do not a ect equilibrium foreign outcomes. In the spirit of Demidova and Rodriguez-Clare (2009), Appendix ?? shows that my small open economy is a special case of the two economy framework where the share of incumbents in Home, $n = \frac{M}{M + M}$, approaches zero.[42]

[40] To rationalize this functional form, suppose there is a second factor of production, land, which is inelastically supplied by households and the production function is Cobb-Douglas. If the rental price of land is assumed to be constant, the unit production cost is given by $C_t = (\frac{W_t}{})\ (\frac{}{1})^{1}$.

[41] Note that this is only true for the baseline set-up. In one of the extensions, I allow for rm entry and exit and study long-run implications instead.

[42] In the limit z^F is una ected 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.

Optimality conditions The pro t maximization problem delivers the following set of rst-order conditions

$$q_t^H(z) = \frac{t}{}[p_t^H(z) \quad \frac{W_t}{z}]$$

$$q_t^F(z) = \frac{t}{}[p_t^F \quad \frac{t(W_t\,)}{z}]$$

$$q_t^{\ F}(z) = B\,[p_t^{\ F}(z) \quad \frac{W_t}{_t z}]$$

where the expressions for domestically-consumed domestically-produced, henceforth domestic goods, $q_t^H(z)$, and exported goods, $q_t^{\ F}(z)$, are given by the optimization of domestic rms while the expression for imported goods, $q_t^F(z)$, results from the optimization of foreign rms. Note that the corresponding prices are also derived from the above expressions.

Firms also choose labor by solving a cost minimization problem. The labor demand for a domestic rm with productivity level z is given by

$$L_t(z) = \frac{}{W_t^1}\frac{q_t(z)}{z} \tag{8}$$

where $q_t(z)$ will be either $q_t^H(z)$ or $q_t^{\ F}(z)$ depending on whether the labor input hired will be used to serve the domestic or the export market.

4.3 Aggregation and market clearing

Before formally providing a de nition of the competitive equilibrium in this model, it's useful to consider the equilibrium building blocks separately. In particular, the focus is on the derivation of aggregate variables and the market clearing conditions.

Productivity thresholds Given the assumption on the distribution of productivity, the aggregate productivity level for a given market can be summarized by the corresponding productivity threshold. [43] This is simply the productivity level of the marginal rm that is indi erent between producing or not in a speci c market.

On the supply side, a zero-pro t condition will hold: rms earn zero pro t in a given market whenever their price is equal to its marginal cost. On the demand side, the linearity of consumer's demand gives rise to the existence of a choke price. This is the maximum price that can be charged for a given variety at which demand is driven down to zero. By combining these

[43] See Section 5 for the formal proof.

two conditions the equilibrium thresholds can be expressed as

$$z_t^H = \frac{+ \; N_t}{\frac{1}{t} + \; P_t} W_t \tag{9}$$

$$z_t^F = \frac{+ \; N_t}{\frac{1}{t} + \; P_t} \quad {}_t(W_t) \tag{10}$$

$$z_t{}^F = \frac{B}{A}\frac{W_t}{t} \tag{11}$$

where z_t^H is the productivity threshold for domestic rms serving the domestic market, z_t^F is the importer threshold and $z_t{}^F$ is the exporter threshold. Given the small open economy set-up, the productivity threshold for foreign rms serving the foreign market, $z_t{}^H$, which is exogenously determined, is irrelevant for the analysis.

Number of rms The number of active rms in the domestic market, N_t is the sum of domestic rms that serve the domestic market, N_t^H, plus the number of foreign importers, N_t^F. Given the number of incumbents in both markets, M and M , and the Pareto distribution assumption, the number of rms is given by

$$N_t = M\left(\frac{1}{z_t^H}\right)^k + M\left(\frac{1}{z_t^F}\right)^k \tag{12}$$

where $(\frac{1}{z^H})^k$ is the probability that an incumbent has a productivity level above the cuto and, thus, generates positive pro ts. Note that because each rm specializes in a particular variety, N_t is also the number of di erentiated varieties available for consumption in the small open economy.

Price level The aggregate price level is given by the sum of prices of all goods consumed domestically, that is, prices of domestically produced goods consumed domestically and import prices

$$P_t = N_t^H \int_{z_t^H} p_t^H(z)\frac{g(z)}{1 \quad G(z_t^H)}\,dz + N_t^F \int_{z_t^F} p_t^F(z)\frac{g(z)}{1 \quad G(z_t^F)}\,dz$$

which combined with the optimal price expressions that result from the rm's maximization problem and the number of active rms in equilibrium, equation (12), can be considerably simpli ed to read

$$P_t = \frac{2k+1}{2k+2}\frac{W_t \, N_t}{z_t^H} \tag{13}$$

Wage level Nominal rigidities are introduced in the form of sticky information in the wage setting process. The representative household is assumed to update its information set for each labor type it supplies with a probability . The aggregate wage is then given by

$$\log W_t = \sum_{s=0}^{\infty} (1 \quad)^s E_{t \ s} \{\log W_t^i\} = \log \frac{}{1} + \sum_{s=0}^{\infty} (1 \quad)^s E_{t \ s} \{\log (\frac{1}{t})\} \tag{14}$$

Labor market clearing To ensure that the labor market clears in equilibrium, aggregate labor demand must equal aggregate labor supply. To aggregate domestic individual labor demand given by equation (8), sum across all active domestic rms using the Pareto distribution assumption. Labor market clearing then boils down to

$$L_t = \frac{k}{(k+1)(k+2)} \frac{}{W_t^{1 \ \ 2}} M \left[\frac{t}{}(z_t^H)^{(k+2)} + B \frac{2}{t} (z_t^F)^{(k+2)} \right] \tag{15}$$

The balance of payments condition Combining some of the equilibrium conditions above, together with the domestic rms' aggregate pro t equation and the consumer's budget constraint gives the aggregate resource constraint of the economy, which, in an open-economy setting, is simply the balance of payments condition. In other words, it states that the current account must be equal to the capital account in equilibrium,

$$EX_t \quad IM_t = {}_t P_t (B_t \quad R_t B_{t \ 1}) \tag{16}$$

where EM_t and IM_t, the total export and import revenues in domestic currency terms, are given by

$$IM_t = \int^{N_t^F} p_t^F(!) q_t^F(!) d! = \frac{1}{k+2} M \frac{t}{} \frac{(\ t(W_t) \ )^2}{2} (z_t^F)^{(k+2)} \tag{17}$$

$$EX_t = {}_t \int^{N_t^F} p_t^F(!) q_t^F(!) d! = \frac{1}{k+2} M \frac{B}{2} \frac{(\ W_t \ )^2}{t} (z_t^F)^{(k+2)} \tag{18}$$

4.4 Exchange rate policy

To close the model, exchange rate policy needs to be determined. The central bank implements monetary policy by setting the nominal exchange rate as its sole instrument. I allow for two extreme policy regimes. First, consider a currency union. This is equivalent to assuming that the central bank can perfectly commit to a currency peg in which $_t$ is one at every period$t$.

Second, assume a policy of strict zero wage in ation targeting. This rule simply o sets all the distortions originating from nominal rigidities in the economy by implementing the exible wage equilibrium, which is given by equation (6). Any movements in the real exchange rate will translate one-to-one into movements in the nominal exchange rate. This is the equivalent to a oating arrangement in this framework.

4.5 Equilibrium

I am now ready to define a rational expectations equilibrium as a set of stochastic processes $\{z_t^H; z_t^F; z_t^{F}; IM_t; EX_t; L_t; N_t; B_t; R_t; P_t; \;_t; W_t\}_{t=0}^{\infty}$ satisfying equations (2),(5),(14) and (9)-(18) given the exogenous process $\{\;_t\}_{t=0}^{\infty}$ and the central bank's policy $\{\;_t\}_{t=0}^{\infty}$.

5 Some analytical results

Before proceeding to the full characterization of the model's solution, it is useful to build some intuition on the potential impact of a sudden stop on productivity. To this end, I restrict attention to partial equilibrium such that a sudden stop is represented by an exogenous fall in wages and/or an increase in the nominal exchange rate.

5.1 Aggregate productivity

The variable of interest is domestic aggregate productivity, i.e. the average of active domestic firms' productivity level. The following Lemma establishes that z_t^H is the key statistic independently of how this average is computed.

Lemma 1. Domestic aggregate productivity - whether unweighted, weighted by revenue or output - is fully summarized by the domestic productivity threshold z_t^H.

Proof. See Appendix C.1 □

In other words, changes in productivity in this model are governed by firms' entry and exit dynamics. This is in contrast to alternative views in the literature that either model productivity as an exogenous shock to the economy or allow for variable capacity utilization.

Note further that, given Lemma 1, the terms (domestic) aggregate productivity and (domestic) productivity threshold, z_t^H, are used interchangeably for the rest of this section.

5.2 Pro-competitive, cost and demand channels

Following Lemma 1, it suffices to focus on the equilibrium expression for the domestic productivity threshold, z_t^H. 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 log deviations from steady state:

$$\hat{z}_t^H = \underbrace{\frac{1}{2k+2}\,\frac{N\;W}{z^H}\,\hat{N}_t}_{\text{Pro-competitive}} + \underbrace{\hat{W}_t}_{\text{Cost}} + \underbrace{\hat{\ }_t}_{\text{Demand}}$$

where $\hat{X}_t$ is the log deviation and X is the steady state value of X_t.

Proof. See Appendix C.2 □

The intuition is straightforward. In the first place, a larger number of active firms in the market, $\hat{N}_t > 0$, 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) that only considers competition in the goods market.

Second, a higher aggregate wage, $\hat{W}_t > 0$, will also lower the firm's profit margin by increasing the costs to all firms. Again, a higher productivity level is then required to remain profitable and select into production, therefore, average productivity increases. This is what I denote the cost effect, which is the underlying mechanism in the canonical Melitz (2003) model that focuses on competition in the labor market.

Finally, higher aggregate demand from consumers, $\hat{\ }_t < 0$, raises individual firm demand at all productivity levels and loosens the minimum productivity requirement. Less productive firms have a higher chance of entering or remaining in the market. This final channel, a novelty of this model, is referred to as the *demand effect*[44]. It is worth noting at this stage that changes in aggregate demand will be driven by movements in the wage level through its effect on the labor supply choice i.e. higher wages increase the relative price of leisure and substituting away consumption into differentiated goods.

5.3 Sudden stops and productivity

To fully trace the impact of a sudden stop on productivity, it is then essential to understand the interaction of these three channels and the scenarios under which each of them will operate. A sudden stop forces a real exchange rate depreciation in the domestic economy. This implies a nominal exchange depreciation, a lower wage level (internal devaluation) or a combination of both. The following proposition considers the two extreme scenarios in partial equilibrium

Proposition 2. Given a sudden stop,

[44] Strictly speaking 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.

1. If the nominal exchange rate burdens the adjustment, only the pro-competitive channel operates and productivity falls

$$\hat{N}_t < 0; \ \hat{W}_t = 0 \ \text{ and } \ \hat{\ }_t = 0 \Rightarrow \hat{z}_t^H < 0$$

2. If the wage levels burdens the adjustment, all three channel operate and the change in productivity is ambiguous

$$\hat{N}_t < 0; \ \hat{W}_t < 0 \ \text{ and } \ \hat{\ }_t > 0 \Rightarrow \hat{z}_t^H \ ? \ 0$$

Proof. See Appendix C.3 □

First suppose that the nominal exchange rate depreciates one-to-one with the real exchange rate i.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 with the loss of competitiveness of foreign firms. There is an unambiguous fall in productivity as a result of this negative pro-competitive effect.

Suppose instead that the aggregate wage adjusts completely, W_t falls, while keeping the nominal exchange rate unchanged. Under this alternative setting, the negative pro-competitive effect remains 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.[45] In other words, all three channels are operating.

The change in productivity is therefore ambiguous in the latter case and depends on parameter values. It is possible, nonetheless, to show under which parameterizations, the demand effect dominates and productivity increases.

Corollary 1. A sufficient condition for $\hat{z}_t^H > 0$ is that $\ < \frac{1}{1+k}$

Proof. See Appendix C.4 □

There are three key parameters for this condition to hold: the degree of wage rigidities, , the share of labor income, , and the shape parameter of the productivity distribution, k. They each determine the size of the demand, cost and pro-competitive effect respectively. In what follows I discuss how to calibrate these, together with the rest of parameters, and analyze their role in determining the overall change in productivity in the general equilibrium setting.

[45] Recall that a negative demand effect is represented by a positive change in $\hat{\ }_t$.

6 Numerical analysis

The goal of this section is to quantify the effects of a sudden stop under different exchange rate regimes. To do so, I first discuss how the baseline model is augmented for this part of the analysis. All structural parameters of the model are calibrated using available Spanish aggregate and firm-level data. As the model cannot be solved analytically, I next explore its properties by generating impulse response functions, focusing exclusively on a risk premium shock and studying the role of specific parameters in shaping the TFP result.[46] The section then concludes with a welfare comparison of alternative monetary policy rules.

6.1 Additional assumptions

The baseline model, described in Section 4, is modified in two ways to better suit the analysis that follows: the number of incumbents is allowed to vary and the exchange rate policy is reformulated as a Taylor-type rule. It is important, however, to stress, that none of these modifications change in any way the results reported in the previous sections.

The pool of potentially active firms, M, is assumed to be constant in the benchmark case. I now relax this assumption, although only partially, to circumvent the production boom that otherwise would be generated by a sudden stop episode.[47] This feature of the baseline model is common to many other papers in the sudden stop literature as discussed by Kehoe and Ruhl (2009). In particular, they show that models that abstract from financial frictions are unable to reproduce observed decreases in output and TFP. While my baseline model improves on matching the latter, it remains unfulfilling regarding the former.

Amendments proposed by the literature include imported intermediate goods, labor frictions, variable capacity utilization, Greenwood et al. (1988) preferences and exogenous decrease. As none of them are fully satisfactory and given the new extensive margin introduced by my model, the approach I follow is to assume a law of motion for the number of incumbents such that $M_t = \frac{M}{{}_t w_t^{1}}$. The interpretation is the following: additional labor, domestic or foreign, is required to set up a new firm and, thus, the pool of potentially active firms depends negatively on the cost of labor input, either the domestic wage, $_t$, or the foreign wage, normalized to one, in domestic currency, $_t$. The parameter measures the degree of complementarity between domestic and foreign labor in setting up new firms.

This assumption captures, in essence, some of the implications of the long-run version of the baseline model. Further details of the extension together with results are available in Section 7.1. In short, the long-run version features a fixed input requirement in the form of capital for the production of any differentiated variety. Capital is produced under perfect competition and

[46] Existence and uniqueness of steady state is relegated to Appendix A.

[47] Note this is true independently of the exchange rate policy that is implemented.

accumulated through an investment decision. This follows closely Ottaviano (2012) in putting the Melitz and Ottaviano (2008) in a DSGE framework. The only di erence is that the xed input requirement is assumed to be a combination of domestic and foreign capital and, thus, the number of potentially active rms depends on the price of both types of capital i.e. domestic wages and the exchange rate.

The second modi cation consists of a generalization of the two exchange rate regimes considered in Section 4. Suppose monetary policy sets the nominal exchange rate following

$$(\ ^{w}_{t})^{\ w} (\ _{t})^{1 \quad w} = 1 \qquad (19)$$

where $\ ^{w}_{t} = \frac{W_t}{W_{t \ 1}}$ is wage in ation and 0 $\ _w$ 1 is the weight that the monetary authority puts on wage stabilization. A currency union and a strict wage in ation target are the two extreme versions of this rule, with $\ _w$ set equal to zero and one respectively. I refer to all the intermediate cases as the dual mandate.

6.2 Calibration

Table 3 provides a summary of the parameters of the model, their baseline values and the source or empirical target. The rst set of parameters are standard, and, thus, values are set in line with the literature and, when possible, consistent with Spanish statistics. The time period of the model is a quarter. Accordingly, the discount factor is chosen to be 0.99. The output elasticity parameter is set to 0.64, roughly the average labor share over the 2002-2008 period and within the range that is common in the literature.[48] For the elasticity of substitution for labor types and the index of wage rigidities, values are taken from Gal and Monacelli (2016) which are based on empirical studies on European countries conducted by the OECD. In terms of trade costs, is equal to 1.3 following Melitz and Ghironi (2005) and many others. The steady state level of debt, B, is assumed to be zero, such that trade is balanced in steady state. Regarding the preference parameters, , and , I borrow the values proposed in Ottaviano (2012), all equal to 10.[49]

The ESEE rm-level data presented in Section 2 is then used to estimate the shape parameter of the Pareto distribution, following the approach proposed by Del Gatto et al. (2006). Given the observed cumulative distribution, $G(z)$, I run the following regression for every year and industry

$$\ln(1 \quad G(z)) = \ _0 + \ _1 \ln(z) +$$

where, assuming a Pareto distribution, the slope coe cient, $\ _1$ provides me with a consistent estimator for k. For the 2002-2008 period, k is estimated to be, on average, equal to 1.9,

[48] Throughout the calibration I take as the initial reference point the years 2002 to 2008.
[49] Note, however, that Ottaviano (2012) does not perform a fully- edged calibration exercise but rather a numerical exploration of how heterogeneity a ects the propagation of exogenous technology shocks.

reassuringly close to Del Gatto et al. (2006)'s result of 2 for a combination of European countries in the year 2000. In addition, the regression R^2, which is equal to 0.7, confirms that the Pareto distribution is a reasonable assumption in this setting.

The above estimation provides an additional coefficient, ${}_0$, that maps one-to-one to the realized distribution's cutoff, z^H. I use the corresponding 2002-2008 average as a first moment target and use it in two different ways. On the one hand, I combine it with the 2002-2008 average number of firms in the ESEE sample to back up the value of M given that the number of potentially active firms is unobservable. The corresponding expression is given by $N^H = (\frac{1}{z^H})^k M$.

On the other hand, I also use z^H to determine the value of the foreign demand parameters, A and B. To do so I proceed in three steps. First, I set the relative size of the domestic economy, n, to match the 12% share of all Euroarea manufacturing firms that Spanish firms represent according to Eurostat's Business Demography Statistics. Next, I take the average 2002-08 propensity to export as an additional first moment target which combined with z^H pins down z^F as $\frac{N^F}{N^H} = (\frac{z^H}{z^F})^k$. Third, I structurally estimate the wage level that is consistent with the estimated cutoff using a combination of equilibrium conditions (9),(10),(13) and (12) in steady state. Parameter values for A and B then follow naturally using equation (11) and the trade balance condition.

The risk premium parameter, , although widely used in the literature, is highly controversial in its calibration. Proposed by Schmitt-Grohe and Uribe (2003) as a theoretical mean to ensure stationarity in small open economy frameworks, small values often selected, in the range of 0.001, fail to generate enough volatility in the predicted trade balance to output ratio. In the current setting, measures the severity of the current account reversal given a one standard deviation shock. Thus, I choose its value such that the second theoretical moment of output during a sudden stop exactly matches its empirical counterpart, 3% for the 2009-2013 period.

Finally, there are two parameters which have not yet been calibrated: the degree of complementarity between foreign and domestic labor in setting up new firms, , and the weight that the policy-maker places on wage stabilization, ${}_w$. There is no obvious candidate value for the former. Therefore, I consider an intermediate case for the baseline results, $= 0.5$, while also presenting the extreme scenarios, $= 0.5$ and $= 0.5$, in Appendix C.4. By definition, ${}_w$ is set to zero and one under a currency union and a strict wage inflation target regime respectively. For the dual mandate, I take 0.5 as a benchmark for illustrative purposes, however, it is allowed to fluctuate freely when discussing optimal exchange rate policy.

6.3 Impulse Responses Functions

Figure 6 summarizes the model response of key macroeconomic variables to a sudden stop. 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 is able to predict 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 within a currency unions, such as public capital inflows, that might cushion the adjustment in reality.

The path of TFP diverges across regimes. On the one hand, under the baseline calibration, the negative effect of a lower aggregate demand offsets the positive 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 in the following section.

GDP and consumption are both measured in units of foreign currency to ease comparison with Figures 2 and 1. The model correctly predicts a fall in both variables and under both regimes. Moreover, for a similar GDP decline, the fall in consumption is twice as large in the currency union, consistent with the aggregate data. Note, interestingly, that although the drop of consumption is larger, the recovery is faster with currency union levels improving upon the floating regime as soon as two periods after the shock.

Finally, the response of employment does not match fully the data; while the event study in Section 2 suggests employment in a currency union weakens more than in a floating arrangement, there is a decline in both cases. This is not captured by the model which predicts instead a minor increase in the labor input. Overall, however, the model does a decent job in capturing the rest of observed patterns.

Impulse response functions for all other endogenous variables can be found in Figure ??. The current account surplus is explained by a simultaneous increase in export and decline in imports. In the currency union, there is an immediate decline in the price index while wages fall in a staggered fashion. In the floating regime, the exchange rate depreciates on impact with wages and prices remaining unchanged. In both regimes, the number of firms and, thus, the number of varieties falls with the shock.

6.4 The role of ω, and k

The analytical results of Section 5 point to three structural parameters as the main determinants of the overall response of TFP: the degree of wage rigidities, ω, the share of labor income, , and the shape parameter of the productivity distribution, k. I next extend this analysis to the general equilibrium framework.

The upper left graph in Figure 7 plots the immediate impact of TFP, in log deviations from steady state, for both the currency union and the floating arrangement regimes for $0.1 \le \omega \le 0.9$. By definition, under the floating arrangement wages are stabilized completely and, thus, there is no effect of wage frictions whatsoever. For the currency union, nevertheless, higher wage flexibility (higher ω) leads to a smaller increase in TFP. This result holds through in cumulative terms (see upper right graph). The next two graphs, in the lower panel of Figure 7, decompose the effect of a sudden stop on TFP into the demand, pro-competitive and cost effects for the currency union as defined in Proposition 1.[50] As wages become more flexible, the unit production cost falls by more. The opposite is true for the demand effect: when more labor types are allowed to adjust their wages, the labor-specific wage declines by less and, thus, the required increase in marginal utility of wealth is smaller i.e. the positive contribution of negative demand shrinks. The magnitude of the pro-competitive effect also varies with the degree of wage flexibility. The intuition relies on second round effects. As wages fall by more and the increase in productivity cutoff is smaller, the reduction in the number of competitor declines and the pro-competitive effect weakens.

Figures 8 and 9 perform the same exercise for $0.1 \leq \alpha \leq 0.9$ and $1.5 \leq k \leq 2.5$ correspondingly. On the one hand, as the share of labor falls, the drop in wages that is required to regain international competitiveness increases substantially in a currency union. The greater the fall in wages, the stronger the demand effect and the larger the improvement in TFP. Once again, there is little change in the floating arrangement as the adjustment of the exchange rate is not affected by the production structure of the economy. On the other hand, the shape parameter measures the relative number of low-productivity firms; as it increases, there is a higher concentration of firms in the lower end of the productivity scale. According to the results depicted in the upper left graph of Figure 9, the behavior of TFP is robust, even if quantitative terms, to different parameterizations of k.

6.5 Welfare

As there is no closed-form representation of the welfare function, I evaluate welfare losses numerically. In particular, I calculate the fraction of labor, λ_L, that equates the conditional expectation of short-term future utility along the equilibrium as of time zero to its value in the non-stochastic steady state.[51,52] Note that λ_L is implicitly given by the expression

$$E_0\left[\sum_{t=0}^{T} \beta^t U(q_t^r(\omega), L_t^r)\right] = U(q(\omega), (1+\lambda_L)L) \tag{20}$$

where $q_t^r(\omega)$ and L_t^r represent the optimal consumption and labor supply paths associated to

[50] Note that for the floating arrangement it is still the case that only the pro-competitive channel operates.

[51] As in Schmitt-Grohe and Uribe (2007), I consider the conditional rather than the unconditional expectation because different policy regimes tend to have different stochastic steady states. Note that although this strategy computes the constrained policy rule associated with a particular initial state of the economy, this is precisely the state that is of interest for my analysis: the non-stochastic steady state.

[52] I consider a finite sum of future utilities because of mean reversion in the capital account dynamics. I set $T = 20$ in line with the IRFs.

a particular exchange rate policy r and the right-hand side term measures utility at the non-stochastic steady state. Note that the left-hand side of (20) is evaluated up to second-order.

The first column of Table 4 summarizes the welfare loss associated with each exchange rate rule for different values of parameter . Suppose = 1, the exchange rate regime that minimizes welfare losses is the currency union with costs increasing monotonically with the magnitude of the coefficient $_w$ i.e. as nominal exchange rates bear more of the real exchange rate adjustment. The exact opposite applies at the other extreme; when = 0 strict wage inflation targeting is ranked as the most desirable policy rule. When is set to some intermediate value, say for example 0.5, the dual mandate regime performs best in welfare terms. It is remarkable, however, that the currency union dominates strict wage inflation targeting.

I also report the corresponding output losses, measured as domestic production in real terms, in columns (2) and (3). On impact output declines the most in a currency union whereas the cumulative effect is larger in the strict wage inflation targeting regime. Note that, as described above, for lower values of the model is unable to generate observed declines in production and the shock leads to overall output gains.

7 Extensions

7.1 A long-run analysis (Work in progress)

7.2 Accounting for unemployment (Work in progress)

8 Conclusion

This paper has sought to answer a classical question in International Macroeconomics: how should exchange rate policy respond to a sudden stop episode? While the literature has commonly supported exchange rate flexibility, it has often overlooked the response of TFP in the analysis. I study the question anew, emphasizing the differences in TFP patterns that emerge across exchange rate regimes in the aggregate data and relating them to observed differences in firm dynamics at the micro-level.

The empirical analysis of the paper delivers two main findings. First, TFP systematically collapses under a flexible exchange rate arrangement while it improves, albeit moderately, within a currency union. Second, the difference in productivity growth is largely explained by the reallocation of resources from unproductive exiting firms to productive survivors. While this cleansing effect is quantitatively noticeable after an internal devaluation, it is unobserved during a nominal depreciation according to the case studies here considered.

I develop a model that is able to make sense of these empirical facts and then use it to inform the optimal policy debate. The model features three key elements: rm selection, variable mark-ups and elastic labor supply in a small open economy DSGE setting. When jointly combined, productivity is endogenously determined by the number of rms, the marginal utility of wealth and the unit cost of production. The e ect of a sudden stop on productivity works through the combination of each of these channels and depends directly on the degree of currency appreciation vs wage devaluation.

Simulations of the model show that the welfare ranking of policy rules in this framework is sensitive to the calibration. In particular, a currency union dominates any other form policy if nominal devaluations increase enough the cost of setting up new rms.

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Tables

Table 1: Decomposition of TFP growth

	Period 1991-1993	2009-2013
Productivity growth (%)	-10.87	10.02
Shares of productivity growth		
Incumbent rms share	-11.20	3.05
Within rm share	-9.69	-2.41
Between rm share	0.47	3.75
Cross-term share	-1.98	1.71
Net entry share	0.33	6.96
Entrants' share	-0.77	-0.72
Exiters' share	1.10	7.68

Table 2: Reallocation and TFP

	Exit (1)	Labor growth (continuers & exiters) (2)	Labor growth (continuers only) (3)	Capital growth (continuers & exiters) (4)	Capital growth (continuers only) (5)
constant	0.063***	7.619***	7.769***	7.865	6.663
	(0.002)	(0.291)	(0.276)	(18.446)	(20.579)
tfp_{it}	-0.041***	0.980*	1.060**	-11.489	-13.861
	(0.005)	(0.488)	(0.498)	(12.414)	(14.679)
ss_t^1	0.005	-0.582	-0.842	-8.362	-10.654
	(0.005)	(0.886)	(0.883)	(13.137)	(14.147)
ss_t^1 tfp_{it}	-0.005	0.146	0.087	31.244	34.017
	(0.010)	(1.095)	(1.203)	(19.993)	(22.383)
ss_t^2	0.023***	-7.115***	-6.811***	44.912	51.477
	(0.005)	(0.813)	(0.800)	(57.399)	(65.758)
ss_t^2 tfp_{it}	-0.031***	1.637**	1.804**	-22.326	-29.809
	(0.008)	(0.737)	(0.815)	(34.927)	(45.192)
Observations	34,854	30,861	28,275	30,861	28,275
Industry FE	Yes	Yes	Yes	Yes	Yes

Note: Regression for exit is a linear probability model where exit=1 if the rm reports positive activity in period t and no activity in period $t + 1$. Employment and capital growth are measured from period t 1 to period t. tfp_{it} is the log rm-level TFP, ss_t^1 is a dummy equal to one for years 1992-1993 and ss_t^2 is a dummy equal to one for years 2009-2013. Standard errors (in parentheses) are clustered by industry; p < 0:01, p < 0:05, and p < 0:10.

Table 3: Model calibration

	Parameter	Value	Calibration target/source
	Discount factor	0.99	Annual real return on bonds is 4%
!	Index of wage rigidity	0.2	Gali and Monacelli (2016)
	Elasticity of substitution (labor)	4.3	Gali and Monacelli (2016)
	Iceberg trade cost	1.3	Ghironi and Melitz (2005)
	Preference parameter	10	Ottaviano (2012)
	Preference parameter	10	Ottaviano (2012)
	Preference parameter	10	Ottaviano (2012)
B	Steady state level of debt	0	Steady state trade balance
	Labor share	0.64	National Accounts Spain
n	Relative size of SOE	0.12	Business Demographic Statistics
k	Shape productivity parameter	1.9	Estimated from ESEE data
A	Foreign demand parameter		Domestic productivity cuto (1.55)
B	Foreign demand parameter		Share of exporting rms (63.6%)
M	Number of total rms		Active domestic rms (75.86)
	Risk premium parameter	8	Schmitt-Grohe and Uribe

Table 4: Welfare evaluation

	Welfare loss	Output loss (on impact)	Output loss (cumulative)
= 1			
Currency Union	23.59	2.52	11.06
Dual mandate ($_w$ = 0:5)	25.06	2.15	11.58
Floating arrangement	27.59	1.52	11.46
= 0:5			
Currency Union	11.59	1.84	2.78
Dual mandate ($_w$ = 0:5)	11.54	1.34	3.33
Floating arrangement	11.85	0.45	3.22
= 0			
Currency Union	4.04	1.24	-3.91
Dual mandate ($_w$ = 0:5)	2.98	0.61	-3.36
Floating arrangement	1.99	-0.51	-3.48

Figures

Figure 1: Sudden stops in a oating arrangement

Figure 2: Sudden stops in a currency union

Figure 3: Average change in log(TFP) by percentile

Notes:

Figure 4: Di erences between high and low productivity rms

(a) Exit rate

(b) Labor growth (continuers & exiters)

(c) Labor growth (only continuers)

Note: This gure depicts the predicted di erence in probability of exit (panel A, low minus high) and the predicted di erence in labor growth rate (panels B and C, high minus low) between a rm one standard deviation above the sectoral mean and a rm one standard deviation below the sectoral mean. Figures are computed from models estimated in Table ??.

Figure 5: Within-industry dispersion of marginal revenue products of capital and labor.

Figure 6: Macroeconomic e ects of a sudden stop

Figure 7: The role of wage rigidities

Figure 8: The role of the labor share

Figure 9: The role of the shape parameter

Appendices

A Identifying sudden stops: algorithm

The following algorithm combines elements of Calvo et al. (2004) and Cavallo and Frankel (2008).

- Use IMF Balance of Payment annual data for all available countries in the period 1990-2015.
- Drop (i) small countries - in terms of population (below 1 million inhabitants) and in terms of wealth (below 1 billion USD); (ii) countries with incomplete time series.
- Compute year-to-year changes in the nancial account.
- Compute rolling averages and standard deviations of the change in the nancial account with a window length equal to ten years. Check that at least 60% of the observations in the window are available, otherwise set to missing.
- Identify reversal episodes as subsequent country-year observations that show reductions in the nancial surplus half a standard deviation above the mean change as calculated in the previous step. Classify the rst and last country-year observation as the start and end of each episode.
- Filter to keep reversal episodes that contain at least one country-year observation with a reduction in the nancial surplus one standard deviation above the mean change.
- Filter again to keep reversal episodes that are accompanied by a fall in GDP per capita during the same year or the year that follows immediately after.
- Filter again to keep reversal episodes that are accompanied by a fall in the current account de cit during the same year or the year that follows immediately after. Surviving episodes are classi ed as sudden stops.

Note that two further re nements are made. First, one year episodes starting in 2009 are dropped from the nal sample as they simply capture the global trade collapse that followed the burst of the 2008 nancial crisis instead of a country-speci c reversal of capital ows. Second, I collapse adjacent sudden stops into the same episode if the gap among the end of the former and the start of the latter is only one year.

B Model appendix

B.1 A model of two large countries: the limit case

Here I show that the assumptions required to treat Home as a small open economy can be derived from the steady state version of a model with two countries which are symmetric in everything except size i.e. Home is assumed to be small relative to Foreign. In particular, if the two countries are endowed with n and $n \quad 1$ shares of the world's total number of potentially active rms, M,

$$M = nM; \quad M \quad = (1 \quad n)M; \quad n \; 2 \; [0; 1];$$

then the limit case to be considered is one in which $n \; ! \quad 0$. The productivity cuto s of this model would be given by the steady state versions of equations (9) and (10) together with

$$z^{F} = \frac{+ \; N}{— + \; P} \quad (W \;) \tag{21}$$

$$z^{H} = \frac{+ \; N}{— + \; P}(W \;) \tag{22}$$

The number of active rms in Home and Foreign is given by equation (12) and

$$N \quad = (1 \quad n)M \quad (z^{H}) \quad ^{k} + nM\,(z^{F}) \quad ^{k} \tag{23}$$

while the aggregate price level is summarized by equation (13) and

$$P \quad = \frac{2k+1}{2k+2}\frac{(W \;) \; N}{z^{H}} \tag{24}$$

Finally, the balance of payments condition in a zero trade balance steady state can be rewritten as

$$\frac{n}{1 \quad n} = —(\frac{W}{W})^{2 \quad 3}(\frac{z^{F}}{z^{F}})^{(k+2)} \tag{25}$$

To summarize, for a given n, the equilibrium in the model with two countries can be described by Equations (9), (10), (12), (13), (21)-(25) with nine unknown variables $f\,z^{H}; z^{F}; z^{H}; z^{H}; N; N \;; P; P \;; W g$, taking foreign labor input as the numeraire ($W \; = 1$).

This system, however, can be further collapsed into three equations in three unknowns, namely, z^{H}, z^{H} and W:

$$\frac{1}{\quad} z^{H} W = W \; [\; + \frac{\quad}{2k+2}(\frac{1}{z^{H}})^{k} M \, (n + (1 \quad n)(\frac{W}{\quad})^{k})] \tag{26}$$

$$\frac{1}{\quad} z^{H} = [\; + \frac{\quad}{2k+2}(\frac{1}{z^{H}})^{k} M \, ((1 \quad n) + n(\frac{\quad}{W})^{k})] \tag{27}$$

$$\frac{n}{1 \quad n} = \frac{W^{2 \ (k+1) \quad 1}}{2k+1} (\frac{z^{H}}{z^{H}})^{(k+2)} \tag{28}$$

As n ! 0, Equation (32) simpli es to

$$\frac{1}{\quad} z^{H} = [\quad + \frac{}{2k+2} (\frac{1}{z^{H}})^{k} M]$$

which solves for z^{H} as a function only of parameters. I have, thus, proved the rst assumption: the foreign domestic productivity cuto is not a ected by changes at Home for n small enough.

Note that due to the Pareto distribution assumption, z^{H}, cannot fall below one, the minimum value for productivity. Therefore, I need distinguish between two di erent cases. Suppose

$$\frac{1}{\quad} < \quad + \frac{}{2k+2} M \tag{29}$$

then the solution to the above equation is larger than one. Once, I have solved for z^{H}, the foreign demand for the domestic variety is given by

$$q^{F}(z) = \frac{1}{+ \ N} (\quad + \frac{}{1} P \ ) \quad \frac{}{1} \frac{1}{} p^{F}(z) \tag{30}$$

where $N = M (z^{H})^{k}$ and P is a function of z^{H} as given by Equation (24), and, thus, constant.

Suppose, instead, the opposite is true, and the inequality given by Equation (29) does not hold. In such a case z^{H} remains at one so that all foreign rms produce, $N = M$. This also means, that the choke price for Foreign is not binding[53] and a new equation for the aggregate price level in Foreign is required. In particular, the new price level is given by

$$P = (\frac{2}{M} \quad \frac{}{+ \ N})^{1} [\frac{\frac{1}{}}{+ \ N} + \frac{1}{b} \frac{k}{k+1}]$$

The rest of the argument follows: foreign demand for the domestic variety is given by Equation (30) which implies that A and B in Equation (7) are constants as none of the foreign variables i.e. z^{H}, N and P, are a ected by changes in Home.

B.2 Equilibrium summary

Endogenous variables: $z_t^{H}; z_t^{F}; z_t^{F}; L_t; N_t; B_t; R_t; P_t; \ _t; W_t; \ _t$

Equilibrium conditions

$$z_t^{H} = \frac{+ \ N_t}{\frac{}{t} + \ P_t} W_t \tag{31}$$

[53] The maximum price faced by foreign consumers is actually lower than the choke price they would be willing to pay.

$$z_t^F = \frac{+ \; N_t}{\frac{}{t} + \; P_t} \quad {}_t(W_t) \tag{32}$$

$$z_t^F \; = \frac{B}{A} \frac{W_t}{t} \tag{33}$$

$$N_t = M(z_t^H)^{\;\;k} + M \;\; (z_t^F)^{\;\;k} \tag{34}$$

$$P_t = \frac{2k+1}{2k+2} \frac{W_t \; N_t}{z_t^H} \tag{35}$$

$$L_t = \frac{kb^k}{(k+1)(k+2)} W_t^{2} \quad {}^1 M(\frac{t}{}(z_t^H)^{\;\;(k+2)} + \frac{B \;\; ^2}{}(z_t^F \;\;)^{\;\;(k+2)}) \tag{36}$$

$$1 = \; R_t E_t (\frac{t+1}{t} \frac{t+1}{t}) \tag{37}$$

$$R_t = R_t + \;\; (e^{B \;\; B_t} \;\;\; 1) + (e^{\;t \;\; 1} \;\;\; 1) \tag{38}$$

$$MB \frac{(\; W_t\;)^2}{t}(z_t^F \;\;)^{\;\;(k+2)} \quad M \;\; \frac{{}_t(\;\;{}_t(W_t\;)\;)^2}{}(z_t^F)^{\;\;(k+2)} = 2(k+2)\;\;{}_t(B_t \quad R_{t\;\;1} B_{t\;\;1}) \tag{39}$$

$$W_t = \prod_{s=0}^{1} (\frac{}{1} E_{t\;\;s}(\frac{1}{t}))^{\;(1\;\;\;)^s} \tag{40}$$

$$\text{monetary policy rule} \tag{41}$$

B.3 Steady state

Drop all time subscripts and consider the currency union regime i.e. $= 1$. In the following, I show that the steady state is summarized by one equation in one unknown W, which can be solved numerically provided parameter values.

Combine (31) and (35) to get

$$z^H \quad = W \quad (\;\; + \frac{}{2k+2} N) \tag{42}$$

Rewrite z^F as a function of z^H, given equations (31) and (32)

$$z^H = \frac{}{W} z^H \tag{43}$$

and plug into equation (34)

$$N = (\frac{1}{z^H})^k (M + M \;\; (\frac{W}{}))^k) \tag{44}$$

Next, note that in steady state the interest rate is given by $R = \frac{1}{}$ and bond holdings are $B = B$ (see equations (37) and (38) respectively). Imposing this on the balance of payment condition, (39), together with equations (33) and (43) delivers

C Proofs

C.1 Proof of Lemma 1

Proof. Unweighted average productivity is given by

$$\tilde{z}_t^H = \int_{z_t^H}^{1} z \frac{g(z)}{1 - G(z_t^H)} dz = \frac{k}{k-1} z_t^H$$

Average productivity weighted by output is given by

$$\hat{z}_t^H = \int_{z_t^H}^{1} z \frac{q(z)}{q(\tilde{z}_t^H)} \frac{g(z)}{1 - G(z_t^H)} dz$$

Noting that $\frac{q(z)}{q(\tilde{z}_t^H)} = \frac{z \quad z_t^H}{\tilde{z}_t^H \quad z_t^H} \frac{\tilde{z}_t}{z}$, the above expression simplifies to $\hat{z}_t^H = \tilde{z}_t^H$.

Average productivity weighted by revenue is given by

$$z_t^H = \int_{z_t^H}^{1} z \frac{r(z)}{r(\tilde{z}_t^H)} \frac{g(z)}{1 - G(z_t^H)} dz$$

Noting that $\frac{r(z)}{r(\tilde{z}_t^H)} = \frac{z^2 \quad (z_t^H)^2}{(\tilde{z}_t^H)^2 \quad (z_t^H)^2} \frac{(\tilde{z}_t)^2}{z^2}$, the above expression simplifies to $z_t^H = \frac{2k^3}{(2k-1)(k^2-1)} z_t^H$.

□

C.2 Proof of Proposition 1

Proof. By combining equations (9) and (13), the domestic productivity threshold can be rewritten as

$$z_t^H = \frac{{}_t W_t}{}[\ + \frac{}{2k+1} N_t] \tag{45}$$

To derive the expression in Proposition 1 log-linearize equation (45) around its steady state. □

C.3 Proof of Proposition 2

Proof. To see this formally, combine equations (9), (10), and (12) to rewrite the equilibrium number of active firms in the domestic market as

$$N_t = (\frac{1}{z_t^H})^k [M + M \ (\frac{W_t}{(W_t)\ \ _t})^k]$$

and combine with the expression for z_t^H above, equation (45), to get

$$z_t^H \quad \frac{}{2k+2} \frac{{}_t W_t}{} (\frac{1}{z_t^H})^k [M + M \ (\frac{W_t}{(W_t)\ \ _t})^k] = \frac{{}_t W_t}{} \tag{46}$$

from here it is straightforward to see that there is a negative relationship between z_t^H and $_t$ i.e. the left-hand side of equation (46) is increasing in both z_t^H and $_t$. It then follows that $_{z_t^H;\ _t} = \frac{@z_t^H}{@_t}\frac{_t}{z_t^H} < 0$.

The relationship between z_t^H and W_t is less obvious. The right-hand side of equation (46) is decreasing in wages as $_t W_t \ / \ \frac{1}{W_t^{\frac{1}{}}}$ by Lemma 2. The left-hand side, however, depends on parameter value and, thus, $_{z_t^H;W_t} = \frac{@z_t^H}{@W_t}\frac{W_t}{z_t^H}\ ?\ 0$ □

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

Proof. In steady state, wages are equalized across labor types and equation (14) can be rewritten as

$$_t = \frac{1}{\quad}\frac{1}{W_t}$$

During the dynamics, the negative relationship still holds as

$$_t \ / \ \frac{1}{\quad}\frac{1}{W_t^{\frac{1}{}}}$$

□

C.4 Proof of Corollary 1

Proof. Suppose $ < \frac{1}{1+k}$, then the left-hand side of equation (46) is increasing in wages. Thus, there is an unambiguous negative relationship between z_t^H and W_t that ensures $_{z_t^H;W_t} = \frac{@z_t^H}{@W_t}\frac{W_t}{z_t^H} < 0$ □

Tables

Table A.1: List of sudden stops

country	start year	end year	exchange rate	country	start year	end year	exchange rate
Albania	1991	1992	4	Macedonia FYR	2009	2010	2
Argentina	1995	1995	2	Malaysia	1998	1998	4
Argentina	1999	2002	4	Mali	1991	1991	1
Argentina	2014	2014	3	Mexico	1995	1995	4
Belarus	2014	2015	3	Moldova	1998	2003	3
Brazil	2015	2015	4	Moldova	2012	2013	3
Bulgaria	1991	1991	4	Morocco	1996	1996	3
Bulgaria	2009	2010	2	New Zealand	2004	2010	4
Chile	1999	1999	3	Nicaragua	1991	1991	2
Chile	2009	2010	4	Oman	1999	2000	2
Colombia	1998	1999	3	Oman	2010	2010	2
Croatia	1997	2002	2	Philippines	1998	1998	4
Croatia	2009	2010	2	Poland	1990	1990	4
Cyprus	2011	2011	1	Portugal	2001	2003	1
Czech Rep.	1997	2002	3	Portugal	2009	2013	1
Czech Rep.	2008	2008	3	Romania	1999	1999	4
Czech Rep.	2011	2013	3	Russia	1998	2002	3
Ecuador	1999	2000	0	Rwanda	1994	1994	4
Estonia	1996	2001	2	Saudi Arabia	1992	1992	2
Estonia	2008	2009	2	Saudi Arabia	1999	2000	2
Ethiopia	1991	1991	3	Senegal	1994	1994	1
Ethiopia	2003	2003	3	Sierra Leone	1996	1996	4
Finland	1991	1993	3	Slovak Republic	1997	2002	3
Finland	2013	2013	1	South Africa	2008	2008	4
France	1991	1993	2	Spain	1993	1993	3
Gabon	1999	1999	1	Spain	2009	2013	1
Greece	1993	1993	2	Sri Lanka	2001	2001	3
Greece	2009	2013	1	Sudan	2010	2010	3
Haiti	2003	2003	4	Sweden	1991	1991	3
Haiti	2009	2010	3	Thailand	1997	1998	4
Indonesia	1998	1998	4	Turkey	1994	1994	4
Iran	1992	1995	4	Turkey	2001	2001	4
Ireland	2009	2014	1	Ukraine	1998	2003	2
Israel	2001	2001	3	Ukraine	2014	2015	4
Italy	1993	1994	3	United Kingdom	1990	1991	3
Italy	2011	2014	1	United States	2007	2007	4
Kenya	1991	1992	4	Uruguay	2001	2001	3
Korea	1997	1998	4	Venezuela	1994	1994	4
Latvia	2008	2009	3	Venezuela	1999	2000	3
Lithuania	1997	2002	2	Yemen Rep. of	2009	2014	3

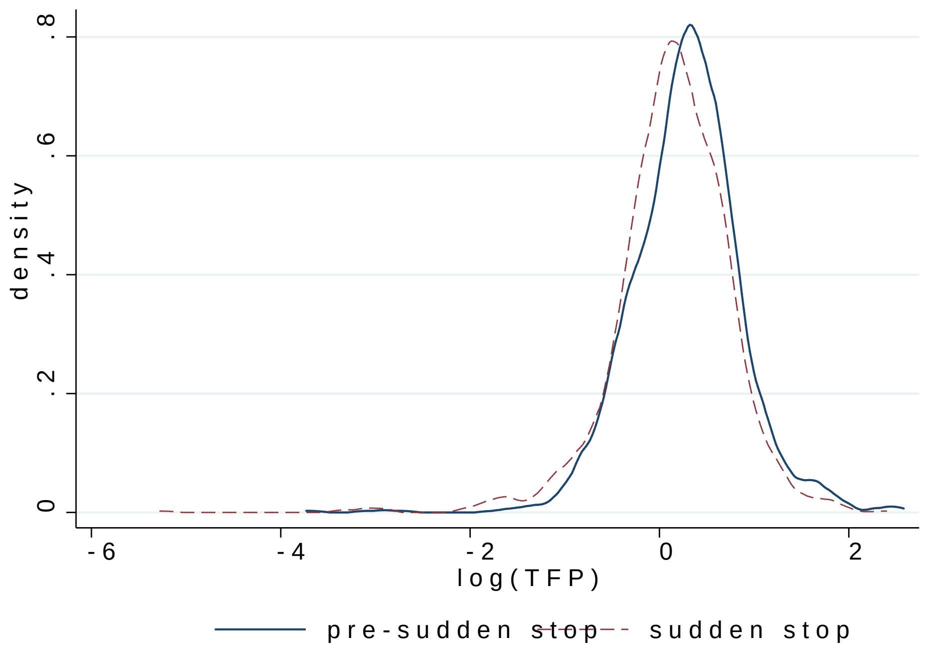
Table A.2: Moments of the distribution

	1992-93 episode		2009-13 episode	
	pre-sudden stop	sudden stop	pre-sudden stop	sudden stop
mean	0.28	0.14	0.11	0.12
mode	0.29	0.17	0.14	0.16
sd	0.58	0.62	0.69	0.62
skewness	-0.40	-1.24	-2.37	-0.89
kurtosis	7.04	10.42	27.92	7.13
min	-3.73	-5.28	-9.07	-3.68
max	2.58	2.40	2.49	2.49

Figures

Figure A.1: Effect of a sudden stop in the distribution of TFP

(a) 1992-93 episode



(b) 2009-13 episode