Export Dynamics in Large Devaluations[1]

Preliminary and Incomplete

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Abstract

This paper studies export dynamics in emerging markets following large devaluations. We document two main features of exports that are puzzling for standard trade models. First, given the change in relative prices, exports tend to grow gradually following a devaluation. Second, high interest rates tend to suppress exports. To address these features of export dynamics, we embed a model of endogenous export participation due to sunk and per period export costs into an otherwise standard small open economy. In response to shocks to productivity, interest rates, and the terms of trade, we find the model can capture the salient features of export dynamics documented. At the aggregate level, these features of export dynamics affect the net export and debt dynamics and thus have an impact on intertemporal borrowing and lending.

JEL classifications: E31, F12.

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1 Introduction

We study export dynamics in emerging market economies. We focus on periods of economic turmoil characterized by large devaluations and high interest rates. Two features of export dynamics stand out. First, exports tend to expand gradually following a devaluation. Relative to the change in the real exchange rate, we find the change in exports tends to be fairly low initially and increases steadily over the next four years following the devaluation. This is true when looking at the volume of trade or the number of products exported. The second feature of exports that we emphasize is high interest rate tend to suppress exports. The countries experience bigger increases in their interest rates face a slower export growth. We also computed the partial correlation between interest rates and exports. Controlling for changes in relative prices, we find that interest rate movements tend to reduce exports. Again, this is true when looking at either the volume or extensive margins of exports. These two features of export dynamics pose a challenge for standard static trade models such as the Armington, Eaton-Kortum, or Melitz models. In these models exports move proportionally to relative prices and interest rates have no direct role for trade.[1]

We develop a small open economy model that can capture these gradual export dynamics and has a role for interest rates on exports. In our model, the amount a country can export depends on the stock of exporters currently actively selling overseas as well as the terms of trade. Similar to the literature that considers the export decision of firms subject to sunk costs (see Baldwin and Krugman (1989), Dixit (1989a b), Roberts and Tybout (1997), Das, Roberts and Tybout (2007), and Alessandria and Choi (2007)), in our model exporters require both an up-front and ongoing investment to export.[2] We allow for idiosyncratic shocks to the cost of exporting. Thus,

[1] In these models interest rates can have an effect on trade through general equilibrium factors. In particular, a rise in world interest rates encourages savings which can stimulate exports. This makes the finding of a negative correlation of interest rates and exports even more puzzling.

[2] Some alternative approaches to generate gradual export growth include introducing habit persistence into an export supply function (Gertler, Gilchrist, Natalucci), allowing adjustment costs in trade (Engel and Wang), and

non-exporters will start exporting when the value of exporting exceeds the cost of starting to export. Similarly, exporters will continue to export as long as the value of exporting exceeds the cost of continuing to export. As long as the up-front cost exceeds the continuation cost, the stock of exporters is a durable asset that will adjust gradually to a shock. It also implies that interest rate fluctuations will potentially affect the incentive to export by altering how the future benefits of exporting are discounted.

We first use our model to study the dynamics of exports, relative prices, and interest rates. We find the model can generate gradual export growth following a worsening of the real exchange rate as the economy takes time to build up its stock of exporters. Exporters gradually enter the export market to economize on the costs of exporting. We also find that the model can generate a negative comovement between interest rates and exports as in periods of high interest rates investments in exporting are less attractive. When the model economy experiences a bigger interest rate shock, the export elasticities show a smaller increase over time. Interest rate movements dampen export growth in our model.

Having found that our model can capture some features of export dynamics that are challenging for standard trade models, we next ask whether matching these export dynamics alters the dynamic pattern of international borrowing and lending. We find that models that ignore the gradual dynamics of exports but get the same average response lead to very different net export and debt dynamics With no gradual export entry, what we call a no sunk cost model, net exports peak in the third quarter and decline monotonically while with in the sunk cost model, the movements in net exports are more hump shaped, peaking about 6 quarters after the onset and declining more gradually. The different net export dynamics imply that ignoring the gradualness of export expansion would lead indebtedness rises more in the long run. Thus after 6 years indebtedness in the no sunk cost model has risen 140 percent while in the sunk cost model it has

modelling customers as durable assets (Drozd and Nosal).

risen only 120 percent. Therefore, these features of export dynamics affect the dynamic pattern of international borrowing and lending. This result is related to the literature on the J-curve that argues that the short-run dynamics of net exports are primarily attributed to difficulties in adjusting the mix of imports and exports. For instance, Baldwin and Krugman (1989) show that net exports may be slow to adjust following a real exchange rate depreciation if there are sunk costs of exporting. Similarly, Roberts and Tybout (1997) show exports will respond gradually following a depreciation. It is also interesting to compare this finding with the work of Alessandria and Choi (2007) who show that sunk costs have a minor impact on the dynamics of net exports in response to productivity shocks compared to a model without sunk costs in a two country GE model. Similar to Alessandria and Choi we also develop a general equilibrium model of sunk export costs; however, in contrast here we also consider shocks to interest rates and the terms of trade.

The paper is organized as follows. The next section documents the dynamics of exports, exchange rates, and interest rates in some emerging markets. Section 3 develops our benchmark model. In section 4 we calibrate the model and in section 5 we examine the model's predictions for export dynamics. Section 6 concludes.

2 Data

In this section we document key relationships between exports, the real exchange rate, and interest rates in a sample of small open economies that experienced a large real exchange rate depreciation in the past two decades. We explore this relationship for aggregate exports at the macro level and for the extensive margin of exports at the mico level.

Table 1: List of 11 countries and crisis dates

Country	Crisis date
Argentina	December 2001
Brazil	December 1998
Columbia	June 2002
Indonesia	April 1997
Korea	October 1997
Malaysia	July 1997
Mexico	December 1993
Russia	July 1998
Thailand	June 1997
Turkey	January 2001
Uruguay	June 2002

2.1 Macro Data

Table 1 shows the list of eleven countries we consider along with the crisis dates. As mentioned above, the choice of the sample is dictated by two considerations: the countries are small open economies which experienced a recent real exchange rate depreciation, and data is available for at least 24 quarters after the event. The data appendix provides further details on the data sources and construction of all series.

Figure 1 shows the evolution of average exchange rates, interest rates and exports in a 40 quarter window around the large devaluations in 11 emerging market economies, relative to their levels on the eve of these episodes. All data has been deseasonalized. The large devaluations are characterized by big real exchange rate depreciations, measured using the producer prices relative to the US produce prices. Moreover, these countries also experienced a spike in interest rates, measured as a JP Morgan EMBI spread. On average the real exchange rate increase by about 40 log points initially and the interest rate spread rises about 1800 basis points. These increases exhibit some mean reversion but are at high levels 8 quarters after the devaluation. In contrast, the response of exports, measured in dollars, was muted. For more than four quarters, exports barely changed from their pre-crisis level and only increased gradually, when real exchange rates were actually beginning to appreciate again. These export and relative price dynamics suggest there is a relatively low elasticity initially that increases with time.

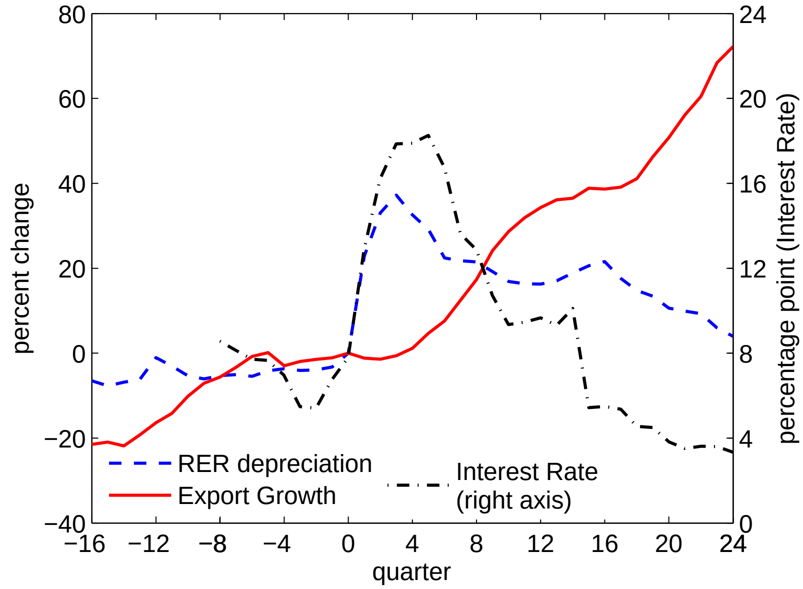


Figure 1: RER, Interest Rates, and Exports for 11 Countries

The sluggish response of exports to large devaluations in emerging economies is not typically observed in advanced economies. The interest rates movement, which is absent in devaluations in advanced economies, suggest that the increase in the interest rate is one possible explanation for the slow growth explanation. We categorize the 11 emerging economies into two groups based on the cumulative increase in their interest rates 12 quarters following the crisis date. The high interest rate countries are Argentina, Korea, Malaysia, Russia, and Thailand. The low interest rate countries are Brazil, Colombia, Indonesia, Mexico, Turkey, and Uruguay.

Figure 2a and 2b show the average interest rate, exports, real exchange rate, and the export elasticity to the real exchange rate in the two groups.

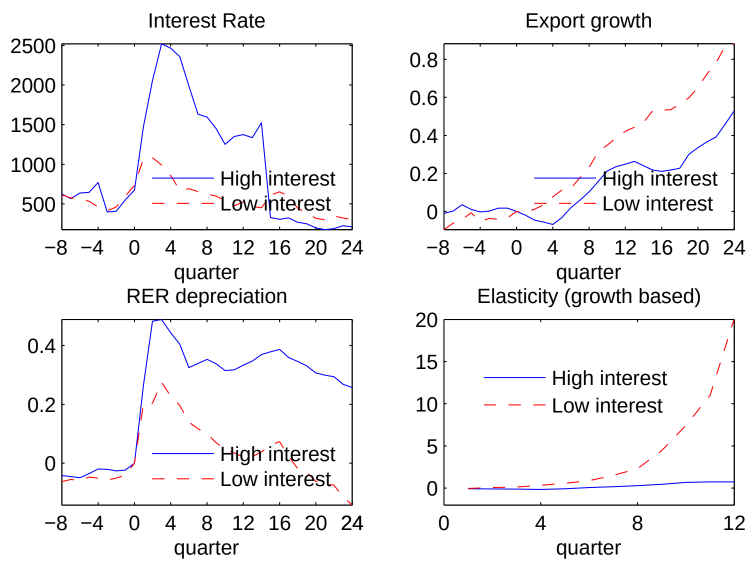


Figure 2a: High Interest Rate Countries v.s. Low Interest Rate Countries

Figure 2a present export growth and real exchange depreciation relative to the level of these variables in the crisis date. The implied trade elasticity is defined as the ratio of export growth to the real exchange rate depreciation. In Figure 2b, we detrend the export and real exchange rate using the H-P filter and compute the trade elasticity using the detrended variables. These figures show that on average, the high interest rate countries experienced an more than 2500 basis point increase in their interest rates, compared to the 1000 basis point increase for the low interest rate countries. At the same time, the real exchange rate depreciation for the high interest rate countries are bigger and more persistent. However, the export growth for the high interest rate countries is lower through the 24 quarters after the devaluations. The average difference between the export growth rate is more than 10%. The export elasticity to the real exchange rate is substantially below the level for the low interest rate countries. Even after we take out the trend in the export, the export elasticity is low for the high interest rate countries and high for the low interest rate countries. For both groups, the trade elasticity increases with time. The short run elasticity is low, and the long run elasticity is much higher.

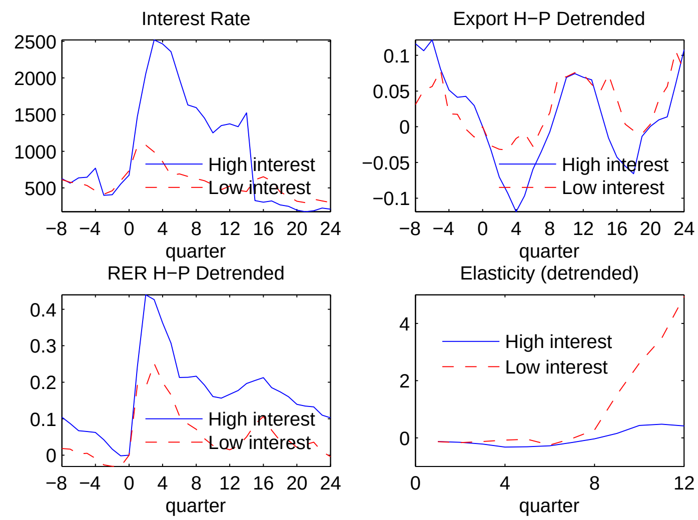


Figure 2b: High Interest Rate Countries v.s. Low Interest Rate Countries

Table 3 examines the contemporaneous relationship between exports, interest rates and real exchange rates in more details. Since we have short panels for each country, we compute the partial correlations of exports with interest rates and exchange rates respectively, keeping the other variable constant. As the table shows, controlling for exchange rates, interest rates are negatively related to exports for all emerging market countries. In other words, an increase in interest rates is associated with a fall in exports, keeping exchange rates constant.

The relation between exports and the real exchange rate, given interest rates is mixed. For about half our sample countries the relationship is positive, and on average it is small and slightly negative.

2.2 Micro-evidence on Export Dynamics

In this section we use disaggregate data to study some features of export dynamics following these devaluation episodes. First, we study the movements in the volume and variety of manufactured goods exported to the US as well as the dynamics of export prices. We study the exports to the US because we have high-frequency disaggregated data for this market coming from all countries.

Table 2: Partial Correlations

Country	Exports & Interest Rate (Given RER)	Exports and RER (Given Interest Rate)
Argentina	-0.03	-0.53
Brazil	-0.57	-0.33
Colombia	-0.26	-0.29
Indonesia	-0.80	0.43
Korea	-0.41	0.19
Malaysia	-0.38	-0.32
Mexico	-0.37	0.60
Russia	-0.67	0.48
Thailand	-0.66	0.37
Turkey	-0.15	-0.03
Uruguay	-0.04	-0.29
All	-0.36	-0.02

Notes: All variables are in logs, deseasonalized and HP filtered. Data is at quarterly frequency and the sample is restricted to 12 quarters after the devaluation.

Also, the US is typically the largest trading partner for these countries and thus exports to the US are likely to be somewhat representative of overall exports. We find three main features: First, the volume of exports grows gradually. Second, the extensive margin grows gradually. Third, export prices tend to fall substantially less than the real exchange rate. Next, we analyze the newly aquired custom trade data for Argentina and Uruguay. The costom trade data for Argentina is at the product and destination level. The costom trade data for Uruguay is at the firm, product, and destination level. Using the extensive data, we examine the importance of extensive margin in driving export dynamics for these two countries.

2.2.1 Quantities of Exports to US

To get a sense of what drives the gradual response in exports we consider more micro-oriented data on how the number of products and destinations change following a devaluation. We undertake this analysis using highly disaggregated monthly US data on imports (from the Census). An advantage of using this data is that we can also eliminate any concerns from the previous country-level analysis that the gradual increase in exports reflects a gradual increase in global economic activity or a change in the industry composition of exports. Specifically, to control for changes in the economic environment we next consider how a devaluing country's exports to the US gain market share in US imports.[3]

We begin by constructing a trade-weighted measure of each country's market share. That is, we define country i's share of US imports as

$$s_{it}^{\$} = \sum_{j} \alpha_{ij} \frac{m_{ijt}}{\sum\limits_{i,exChina} m_{ijt}},$$

where m_{ijt} is US imports from country i of HS code j in period t. To control for changes in the industry composition of trade we weigh import shares by each country's trade weights using a 10 year window around the devaluation

$$\alpha_{ij} = \sum_{t=-60}^{60} m_{ijt} / \sum_{t=-60}^{60} \sum_{j} m_{ijt}$$

Note, to control for the rising share of trade from China, we measure import shares relative to US imports excluding China.

To study the source of the export growth, we construct a measure of the change in the extensive margin. We measure the extensive margin as a count of the distinct number of HS-10 codes shipped to different US customs districts. This is the finest level of disaggregation in the publicly available trade data. Thus we define the extensive margin, $\#_t$,

$$\#_{it} = \sum_{p} \sum_{j} I\left(m_{pijt} > 0\right).$$

[3]This does not fully capture the potential changes in exports, since changes in relative prices could also lead to a change in the share of imports in US expenditures. However, this effect is likely to be small since devaluing countries are likely to have a relatively small impact on the relative price of imports to domestic expenditures.

To account for the growth in trade we also measure this as a share, $s_{it}^{\#}$ where

$$s_{it}^{\#} = \frac{\#_{it}}{\sum_{i,exChina} \#_{it}}$$

Lastly, since we are looking at the how a country's share of US imports changes, we construct a measure of the real exchange rate purged of changes in the bilateral real exchange rate with the US. Figures 3A and 3B summarize the average dynamics of each of these variables for our panel of 11 countries. The individual country dynamics are plotted in the appendix. To smooth out some of the variation in the data, we present statistics in six month intervals.[4] Figure 3A shows how our share measures vary over time. Figure 3B shows our measures vary when we remove a log-linear trend.

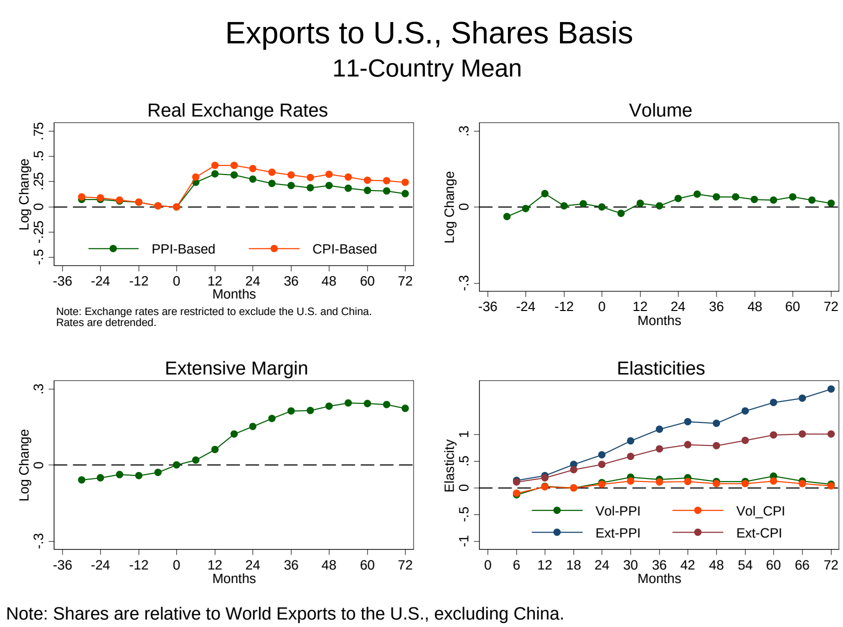


Figure 3A: Dynamics of Exports to US - Share basis

The first panel in each figure shows the dynamics of a trade weighted real exchange rate

[4] Our measure of the extensive margin is the average number of HS10-districts per month rather than a count of HS10-districts observed in a six month interval.

for each country. Real exchange rates are measured using producer prices and consumer prices. Producer price based real exchange rate fluctuations are slightly smaller than consumption based real exchange rates. In general, the real exchange rate depreciates about 30 to 40 percent over the first year. Over the subsequent 3 years the real exchange rate appreciates slightly, thus changes in relative prices are quite persistent. The second panel shows how our measure of the volume of exports evolves. The third panel shows how the extensive margin evolves. The last panel shows how exports evolve with relative prices using a measure of the ratio of mean change in exports to the mean change in the real exchange rate. The elasticity of the export share is close to zero initially and rises to about 50 percent over 36 months. Whether this is persistent beyond three years depends on our detrending method. The elasticity of the extensive margin is considerably larger. Depending on our de-trending it 1/3 to twice as much over the first three years. In short, the evidence from the US is consistent with our finding using the aggregate data of a weak, gradual export response following a devaluation. The US data points to the extensive margin as being important in these export dynamics.

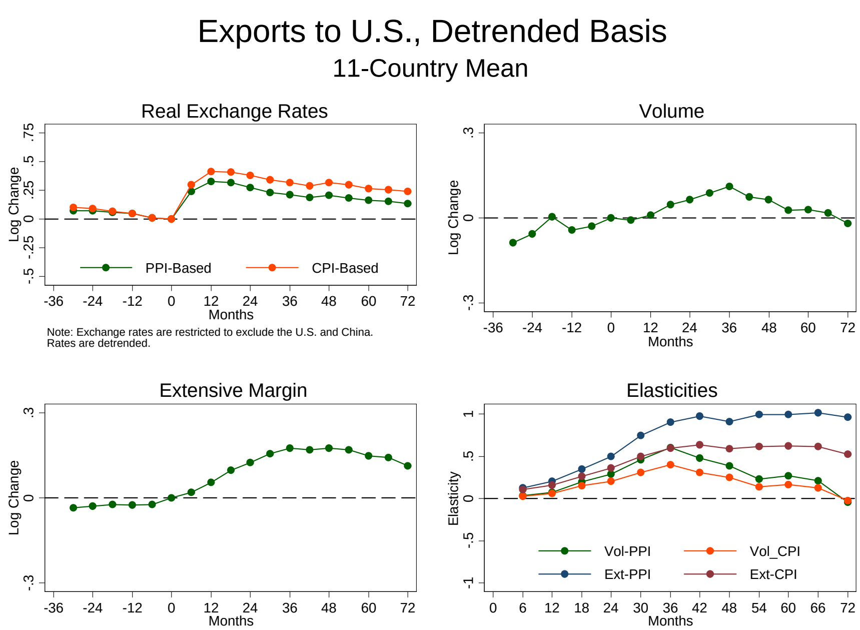


Figure 3B: Dynamics of Exports to US - Detrended

2.2.2 Prices of Exports to US

We next document the dynamics of export prices of devaluing countries. Specifically, we use data on disaggregated U.S. imports to construct the price of imports from the devaluing country relative to all the price of all US imports. We find that these prices decline about 3 to 5 percent in the first year and 5 to 8 percent in the second and third year of the devaluation. This suggests that either pass-through is pretty minor initially or that there is a lot of curvature in production so increasing sales is quite costly in the short-run.

Specifically, using HS10 data, we define the price of good j from country i in period t as $\mathrm{p}_{ijt} = \ln(V_{ijt}/Q_{ijt})$ and the price for the rest of the world as $\mathrm{p}_{Rjt} = \ln(V_{Rjt}/Q_{Rjt})$. We measure prices in year long windows that start with the month the devaluation occurs. Given these prices we define the relative price, $r_{ijt} = p_{ijt} - p_{Rjt}$. We do this for crisis and noncrisis periods.

We aggregate these relative prices using trade weights. Specifically we construct the aggregate relative unit value, R_{it}, as

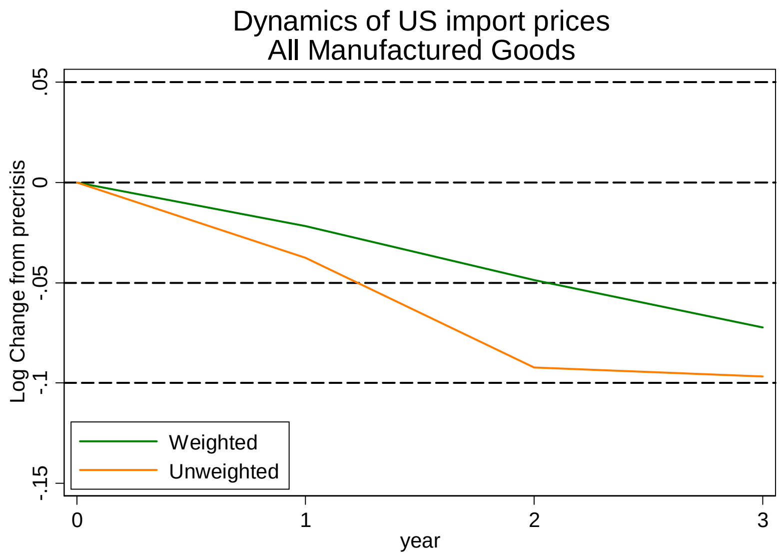
$$R_{it} = \sum_{j=1}^{N} \alpha_{ijt} r_{ijt}$$

where $\alpha_{it} = V_{ijt} / \sum_{i=1}^{N} V_{ijt}$. We also consider an unweighted average of prices as $\alpha_{ijt} = 1/\!\!/N$.

For each country i we then construct relative prices R_{it+k} and $\overline{R}_{it+k}$ where the bar measures the relative price in non-crisis years. It is a way of detrending the data. (Specifically, we construct 4 year non-overlapping windows and examine the evolution of relative prices. Typically, relative prices are rising in periods 4 years prior or periods starting 4 years after the crisis). Figure 4 plots the median demeaned relative price (i.e. median R_{it+k} - median $\overline{R}_{it+k}$) and shows that prices fall typically 2 to 3 percent the first year, 5 percent the second year, and 7 percent by the third year.

The declines are a bit larger for less important goods.

Figure 4

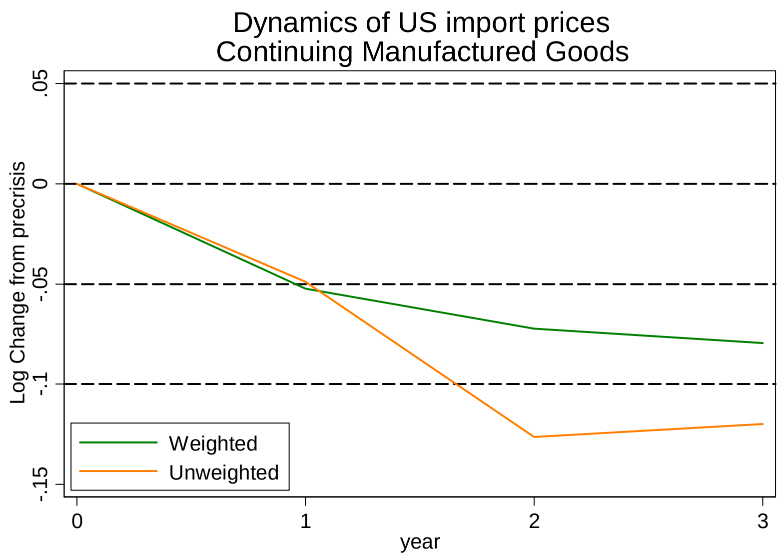


We also measure the change in relative prices for a basket of goods which are traded in each period. We define the change in relative prices as

$$\Delta r_{ijt} = r_{ijt} - r_{ijt-1}.$$

This requires goods to be sold in both periods. Figure 5 plots export prices for these continuing goods. Obviously, there are fewer goods the longer the interval. The decline is larger for these goods, about 5 percent the first year and 7 percent the second year, and 8 percent by the third year. The larger declines for continuing good suggest that new goods are relatively more expensive goods.

Figure 5



2.2.3 Trade Transaction Data for Argentina and Uruguay

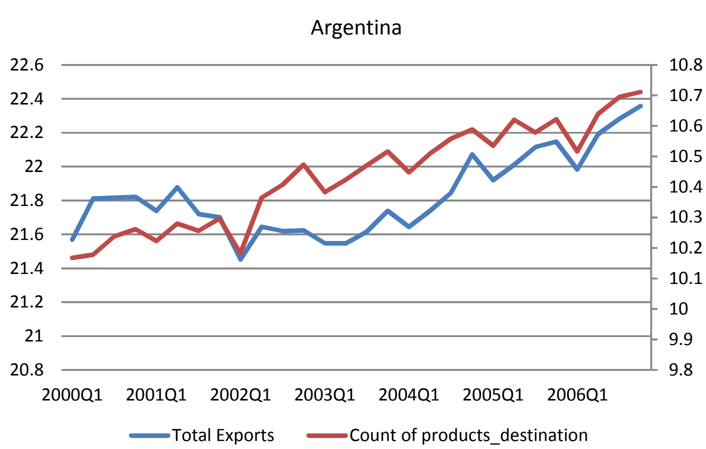
Our detailed trade data are the customs data on import and export shipment. The data vary somewhat in coverage over time, but give detailed information for each trade shipment, generally including the name of the importer or exporter, the date of declaration, the source or destination country, the quantity, weight, price, and value of the good, along with detailed information at levels at least as disaggregated as the 10-digit or 11 digit HTS classification. We obtained most of our data from Penta-Transaction, a private provider of trade statistics that receives the shipment data from the customs authorities. We obtained data on all trade in goods for Argentina and Uruguay for the 2000 to 2011 period. We restrict our data to the manufacture goods.

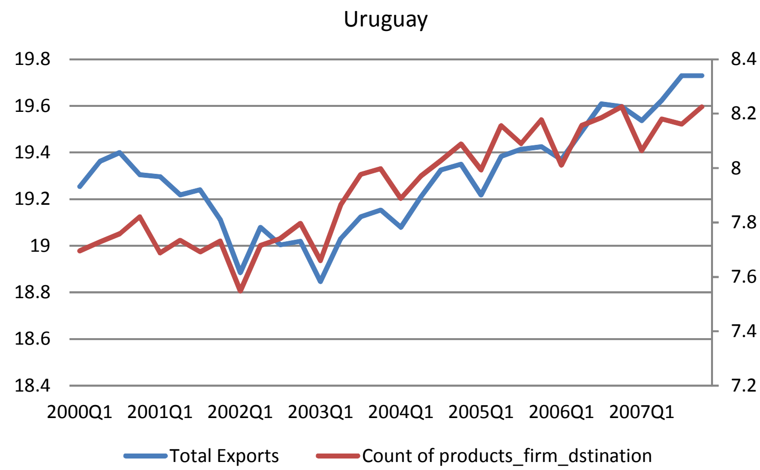
First, Table below reports the summary statistics for exports from Argentina and Uruguay in 2000 and 2003. Note that we do not have the information about exporting firm for Argentina. The HTS codes are in 11 digits for Argentina and 10 digits for Uruguay.

Table 3: Export Summary Statistics

	Argentina		Uruguay	
	2000	2003	2000	2003
# of exported HS codes	10927	11384	1912	2067
per firm, median			2	2
per firm, maximum			83	71
# of destination countries	172	198	100	129
per firm, median			1	1
per firm, maximum			35	36
# of destination country x HTS combinations	56545	69897	4733	5907
per firm, median			2	2
per firm, maximum			170	165
# of exporting firms			1005	1227

Next, we decompose aggregate exports into (i) the number of firms selling and (ii) average sales per firm. Denoting by $X_n(t)$ aggregate exports to market n in year t, by $N_n(t)$ the number of firms selling there, and by $\overline{x}_n(t)$ aggregate sales per firm. The figure below plots the time series of the aggregate exports and the number of export goods defined by the product, exporter, and destination country.

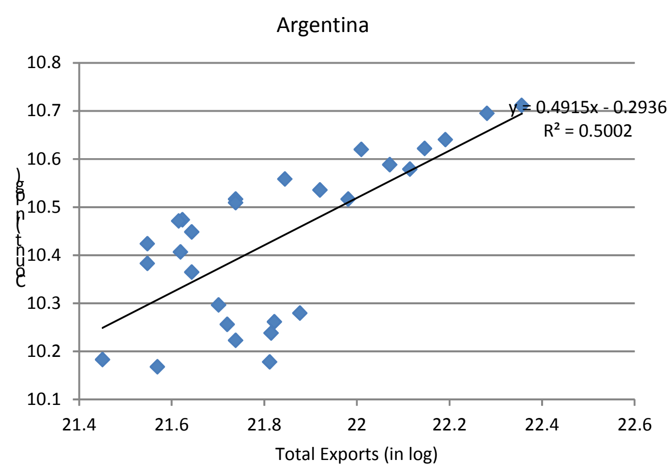


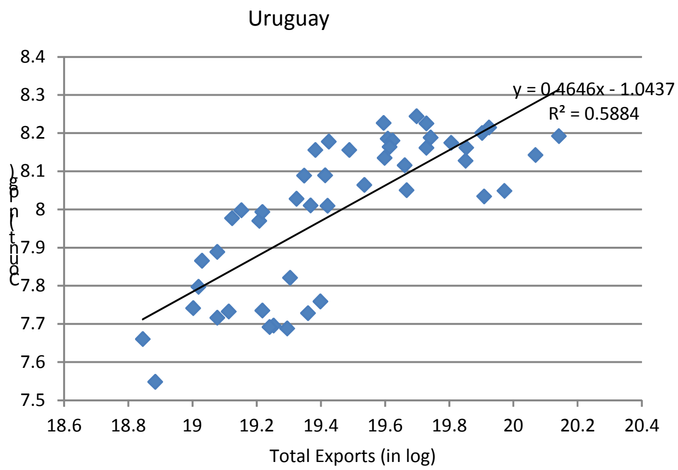


We can write the identity:

$$\ln X(t) = \ln N(t) + \ln \overline{x}(t).$$

The regression coefficient is around 0.5. A doubling of export value reflects just about 50 percent more exporters. The value of exports from each exporter rise by slightly more than 50 percent. Using the US import data and define the number of exporters by the number of products, the average regression coefficient is 0.4.



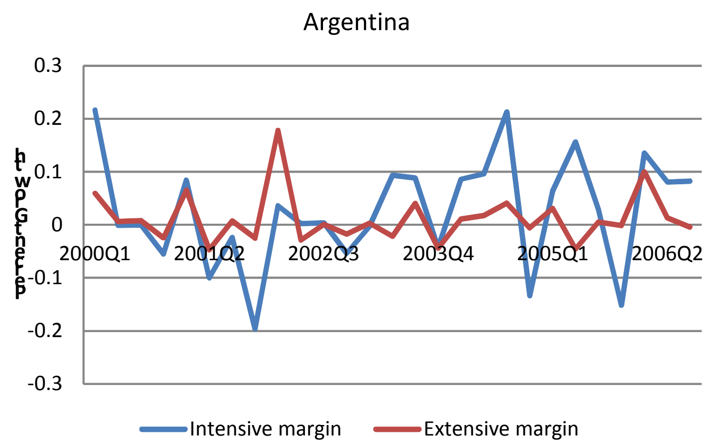


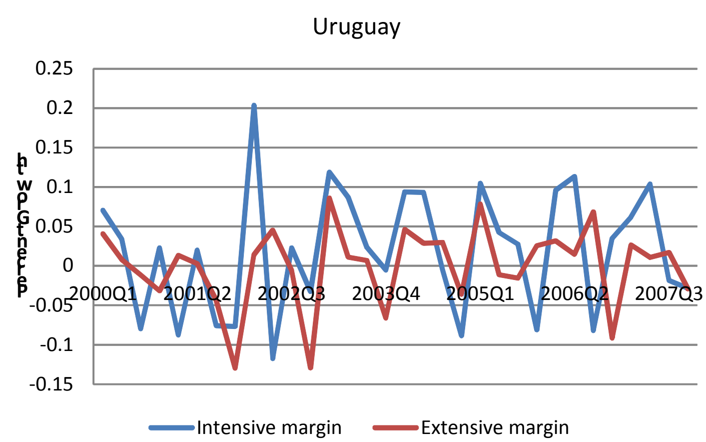
Lastly, we examine how important are the extensive margins for driving export growth. We can disaggregate the intensive margin from the exporters' margins of entry and exit as follows:

$$\frac{X(t)-X(t-1)}{X(t-1)}$$

$$= \underbrace{\sum_{j\in CN^{t-1,t}} \frac{[x(j,t)-x(j,t-1)]}{X(t-1)}}_{\text{Intensive Margin}} + \underbrace{\left(\sum_{j\in EN^{t-1,t}} \frac{x(j,t)}{X(t-1)} - \sum_{j\in EX^{t-1,t}} \frac{x(j,t-1)}{X(t-1)}\right)}_{\text{Extensive Margin}}$$

where $X(t)$ denotes the total exports in year t, $x(j,t)$ is exports by group j in period t. The term $CN^{t-1,t}$, $EN^{t-1,t}$, and $EX^{t-1,t}$ represents the set of product, destination (and firms) combination that exported in $t-1$and t, that exported in t but not $t-1$, and that exported in $t-1$ and not t, respectively. We refer to these sets of group as pairwise continuing, pairwise entering, and pairwise exiting. The first term on the right hand side is the intensive margin and captures the change in imports from continuing exporters. The second term is the extensive margin and captures the volume of exports from new exporters net of the volume lost from those that stopped exporting in period t. The figures below show the breakdown of the aggregate movements in trade by intensive margin and extensive margin for Argentina and Uruguay. We define exporter by the most detailed information. For Argentina, it is the product x destination pair. For Uruguay, it is the product, destination and firm combination. The figures show that the extensive margin is important, particularly for Uruguay. Recall that Uruguay is a low interest rate country. The smaller interest fluctuation suggests that the exporters' entry and exit play a bigger role in driving the export dynamics.





3 Model

We develop a small open economy model with endogenous entry and exit from exporting to study exports and exporter participation over the business cycle. We assume a unit mass of imperfectly substitutable goods are produced in the small open economy. These goods differ in the costs they require to be shipped overseas so that only a subset of products are exported. The economy faces shocks to the interest rate, productivity, terms of trade, and discount factor. All intermediates are subject to the same aggregate productivity shock z_t. One period bonds are used for intertemporal consumption smoothing. We write out a planners problem and derive the equilibrium conditions.[5]

All intermediate goods are available for domestic consumption. When consumed domestically, these domestic intermediate goods are homogeneous.[6] Some intermediates are exported each period by incurring a fixed cost. When sold abroad these intermediate goods are viewed as being differentiated.

The mass of exported products is endogenous and denoted by N. We assume that there is also a one period lag in changing the export status. Therefore the measure of exporters which export in the current period is determined in the previous period as N_{t-1}. Furthermore, to export a variety of an intermediate good there is an international trading cost. The size of the cost depends on the producer's export status in the previous period. In particular, a fraction $n_{0,t} \in [0,1]$ of non-exporters can be converted into exporters by incurring a cost $F_0(n_{0,t})/z_t$. Additionally, a fraction $n_{1,t} \in [0,1]$ of products exported in the current period period can be exported in the next period by incurring a cost $F_1(n_{1,t})/z_t$. These costs are weakly increasing in the fraction of new or continuing exports. These costs are valued in units of labor and also scaled by the productivity z_t. These costs can not be recovered when a product is no longer exported. When the marginal cost of entering the export market is greater than the marginal cost of continuing in the market place, the export cost structure implies exporting requires an investment. Note that this setup is isomorphic to assuming that exporters differ in their startup and continuation cost of exporting and there is also a temporary, iid (across plants) shock to this fixed cost. In the terms of Caballero and Engel, this is a "generalized" sunk export cost model. The law of motion

[5] Supporting the allocations as competitive equilibrium is easy enough. The only difference is that there is a wedge in the labor supply decision.

[6] Because all domestic intermediate goods available and face the same aggregate productivity, it is without loss of generality to assume that domestic intermediate goods are homogeneous.

for the number of exporters is[7]

$$(1) \quad N_t = n_{1,t} N_{t-1} + (1 - N_{t-1})\, n_{0,t}.$$

The total number of new entrants is $(1 - N_{t-1})\, n_{0,t}$, and the total number of continuing exporters is $n_{1,t} N_{t-1}$.

Production of each variety at home requires labor and is subject to constant returns to scale, so $y_0 = z l_0$. We assume exported intermediates are produced with diminishing returns, $y_1 = e^z l_1^\alpha$. Exporters take the price per unit, 1/P, as given each period. Below we consider alternate ways to endogenize P.

Consumers consume a composite good made by combining domestic goods and foreign goods imported from abroad. Imports, M_t are exchanged using the revenue from exporting and the net financing from international borrowing and lending. The borrowing and lending is via one-period discount bonds, as in standard small open economy RBC models. The asset position is denoted by B_t. The bonds are assumed to be denominated in foreign goods.

The economy is subject to interest rate shocks r_t as well as shocks to the discount factor, β_t, and the marginal utility of labor, $\widehat{\kappa}_t$. We use the shocks to the discount factor, β_t, to dampen the tendency to save when the interest rate rises. We use the shocks to the marginal utility of leisure to shift the relative price of domestic and foreign goods. It is an alternative way of getting the terms of trade to move around. In the sensitivity we consider foreign demand shocks. To keep the model stationary we include a small adjustment cost on bonds.[8]

[7] A simple extention is to include capital in the production of intermediate goods. We consider the linear production function with labor only in this version because it is widely used in the trade literature.

[8] Any other way of making the economy stationary is fine too. See Smith-Grohe and Uribe () for alternative methods to close the small open economy models.

The planner's problem is

$$
\begin{aligned}
V\left(z, r, \beta, \widehat{\kappa}, P, N_{-1}, B\right) &= \max_{n_0, n_1, l_0, l_1, B'} u\left[G\left(X, M\right), \widehat{\kappa} L\right] + \beta_t E V\left(z', r', \beta', \widehat{\kappa}', P', N, B'\right) \\
M &= \frac{N_{-1} z l_1^{\alpha}}{P} - \frac{B'}{1+r} + B - \frac{\psi}{2}\left(B' - \bar{B}\right)^2 \\
X &= z l_0 \\
L &= l_0 + N_{-1} l_1 + N_{-1} F_1\left(n_1\right)/z + \left(1 - N_{-1}\right) F_0\left(n_0\right)/z \\
N &= n_1 N_{-1} + \left(1 - N_{-1}\right) n_0 = n_0 + \left(n_1 - n_0\right) N_{-1}
\end{aligned}
$$

The total labor employed to produce domestic goods X is l_0 and to produce exports is $N_{-1} l_1$. Imports, M, are equal to the total export revenue and the net borrowing net of the adjustment cost. We assume the adjustment cost for bonds takes a quadratic form with the cost adjustment parameter ψ. Labor used to produce each variety in the export sector is l_1. The total labor employed in the export sector depends on the number of active exporters N_{-1}, and the exports can be exchanged for foreign goods at the relative price P to generate the export revenue as discussed earlier. The total labor is allocated to produce domestic goods, export goods, and to pay the exporting cost. Given our assumption about the exporting cost, the total cost for the new entrants is $\left(1 - N_{-1}\right) F_0\left(n_0\right)/z$, and the total cost for the continuing exporters is $N_{-1} F_1\left(n_1\right)/z$.

Substituting the constraints into the value function and taking FOCs yields the first order conditions:

$$
\begin{aligned}
l_0 &: \; u_c G_x z = -\widehat{\kappa} u_l \\
l_1 &: \; u_c G_x z = u_c \frac{G_M z \alpha l_1^{\alpha-1}}{P} \\
B' &: \; u_c G_M \left[\frac{1}{1+r} + \psi \left(B' - \bar{B} \right) \right] + \beta E V_B = 0 \\
n_1 &: \; 0 = \widehat{\kappa} u_l \left[F_1' \left(n_1 \right) / z \right] N_{-1} + \beta E V_N N_{-1} \\
n_0 &: \; 0 = \widehat{\kappa} u_l \left[F_0' \left(n_0 \right) / z \right] \left(1 - N_{-1} \right) + \beta E V_N \left(1 - N_{-1} \right) \\
N_{-1} &: \; V_{N_{-1}} = \frac{u_c G_M z l_1^{\alpha}}{P} + \widehat{\kappa} u_l \left[l_1 + F_1 \left(n_1 \right) / z - F_0 \left(n_0 \right) / z \right] + \beta E V_N \left(n_1 - n_0 \right) \\
B &: \; V_B = -u_c G_M
\end{aligned}
$$

Rearranging terms, we get the optimality conditions that characterize the equilibrium allocations. There are three static optimality conditions:

$$
\begin{aligned}
(2) \quad u_c G_x z &= -\widehat{\kappa} u_l \\
(3) \quad G_x &= \frac{G_M \alpha l_1^{\alpha-1}}{P} \\
(4) \quad F_1' \left(n_1 \right) &= F_0' \left(n_0 \right).
\end{aligned}
$$

Equation (2) equates the marginal rate of substitution between working and consuming domestic goods to the marginal rate of transformation which is z due to the assumption of linear production function with labor. Equation (3) equates the marginal rate of substitution between the domestic and imported goods to the relative price of the goods. Equation (4) shows that the marginal cost of adding new exporters should equal to the marginal cost of keeping existing exporters in the marketplace, which is quite intuitive.

There are also two intertemporal Euler equations

$$(5) \quad u_c G_M \left[\frac{1}{1+r_t} + \psi \left(B' - \bar{B} \right) \right] = \beta_t E \left[u_{c'} G_{M'} \right]$$

$$(6) \quad \widehat{\kappa} u_l \left[F_1' \left(n_1 \right) / z \right] = -\beta E \left[\frac{u_{c'} G_{M'} z' l_1'^{\alpha}}{P'} + \widehat{\kappa}' u_{l'} \left[l_1' + F_1 \left(n_1' \right) / z' - F_0 \left(n_0' \right) / z' - F_1' \left(n_1' \right) / z' \left(n_1' - n_0' \right) \right] \right].$$

The first intertemporal optimality condition (5) is the standard Euler equation for bonds. It is clear that the adjustment cost for bonds is needed to keep the economy stationary when we assume $\beta = \frac{1}{1+E[r]}$. The second intertemporal optimality condition is for the adjustment of the extensive margin of exporting. The left hand side is the marginal cost of paying the entry cost today. The right hand side is the marginal benefit from having an additional exporter in the next period. Paying the entry cost for an extra exporter today lowers the cost of exporting tomorrow, saving the entry cost of a new exporter and alters the difference in the adjustment cost for new entrants and existing exporters. Because the optimality condition (4) holds, the condition (6) also implies that the marginal cost of keeping existing exporters is equal to the marginal benefit of keeping them around.

As we showed earlier in the empirical section, interest rates negatively impact the number of exporters. The above Euler condition for the number of exporters makes it clear why the extensive margin of exporting respond to the movements in the interest rates. When the interest rates are higher, the marginal benefit of paying for the exporting cost is lower. Therefore, both the number of new entrants and the number of continuing exporters decrease, leading to a reduction in the total number of exporters relative to the case where there is no dynamic export decision. This effect is stronger if there is also a shock to β. For instance, suppose $\beta_t = \frac{1}{1+r_t}$. In this case, the first intertemporal equation will still hold at the old steady state but the rhs of the second equation will not so that the gains from exporting will be lower. This clearly shows how shocks to the discount factor will discourage exporting.

3.1 Export Supply Function

We assume that given total exports and the number of exports, the price of exports (1/P) satisfies the following equation[9]

$$(7) \quad EX/N = zl_1^{\alpha} = N_{-1}^{\frac{\gamma-\theta}{\theta-1}} \left(1/P\right)^{-\gamma} Y_t,$$

where θ denotes the elasticity of substitution between varieties and γ the elasticity of substitution between exports and domestic goods in the ROW. This equation can be derived from the optimization problem of a representative agent in the ROW. By varying γ we can change how prices respond to a change in exports or exporters. The number of exporters, or the extensive margin of exports, affects the export supply function. For example, if $\gamma = 1.5$ and $\theta = 5$ then doubling the number of exporters increase export revenues by 12.5 percent holding the price of inputs constant. If $\gamma = \theta$ then doubling exporters doubles exports.

This export supply function can be derived from the consumer maximization problem that the rest of the world solves, where the demand for exports from the SOE is the export supply function in our model. This formula is derived in the appendix.

We consider two possible drivers of relative prices. In the first, we assume that amount exported will push the terms of trade around. In this case, to get the terms of trade to move we require shocks to the marginal utility of leisure, $\widehat{\kappa}$. In the second, we assume that P is exogenous and that exports are then endogenously determined.

[9]The appendix presents the details of the problem that the rest of the world solves, where the demand for exports from the SOE is the export supply function in our model.

3.2 Steady State Equilibrium

We first describe the steady state equilibrium. We will calibrate and solve the model dynamics numerically in the subsequent subsection. To simplify the calculation, we assume the following functional forms for the preference and technology. We assume that $G(x, M) = \left[x^{\frac{\gamma-1}{\gamma}} + \omega^{\frac{1}{\gamma}} M^{\frac{\gamma-1}{\gamma}}\right]^{\frac{\gamma}{\gamma-1}}$, where ω is the Armington weight on the domestic goods, and γ is the elasticity of substitution between home and foreign goods.[10] Next, we assume that we have GHH preferences $u(C, L) = \frac{(C - \kappa_t L^{\eta})^{1-\sigma}}{1-\sigma}$, where σ is the risk aversion coefficient, η governs the labor supply elasticity, and κ is a scale parameter for the aggregate labor supply. The GHH preference is widely used to study the business cycles for small open economies. It eliminates the wealth effect from the labor supply. Finally for the exporting cost, we assume that $F_1(n_1) = f_1 n_1^{v_1}$ and $F_0(n_0) = f_0 n_0^{v_0}$, where f_0 and f_1 are the parameters that governs the size of the exporting cost, ν_0 and ν_1 are the curvature parameter for the cost functions. As typically assumed in the literature with trade cost, the marginal cost of exporting increases with the number of new entrants. Therefore, we require $\nu_0 > 1$ and $\nu_1 > 1$. When $\nu_0 = \nu_1$, the relative size of the cost parameters f_0 and f_1 determines whether the entry cost has a sunk component or not.

[10] We assume that the economy and ROW have the same preference and thus the same elasticity of subsitution parameter.

The steady state equilibrium satisfies

$$\begin{aligned}
n_0 &= \frac{1-n_1}{1-N}N \\
n_0 &= \left[\frac{v_1 f_1}{v_0 f_0}\right]^{\frac{1}{\nu_0-1}} n_1^{\frac{\nu_1-1}{\nu_0-1}} \\
\bar{L} &= l_0 + N l_1 + N f_1 n_1^{v_1} + (1-N) f_0 n_0^{v_0} \\
M &= N^{\frac{\gamma-1}{\theta-1}} P^{\gamma-1} Y + \frac{r\overline{B}}{1+r} \\
N l_1^{\alpha} &= N^{\frac{\gamma-1}{\theta-1}} P^{\gamma-1} Y \\
x &= z l_0 \\
\widehat{\kappa}\eta L^{\eta-1} &= G_x z \\
l_1\left(\frac{1-\alpha}{\alpha}\right) &= f_1 n_1^{v_1} - f_0 n_0^{v_0} - \nu_1 f_1 n_1^{v_1} + \nu_0 f_0 n_0^{v_0} + \nu_0 f_0 n_0^{v_0-1}
\end{aligned}$$

and the constraints.

Given the curvature in the production of exported goods, it is useful to define the real exchange rate as the relative price of domestic consumed to imported goods. We define the RER as the marginal rate of substitution between domestic and imported consumption.

$$RER = \frac{G_x}{G_m}.$$

3.3 Calibration

This subsection describes how we set the parameters in the model. We pin down some parameters based on the standard values. We calibrate the remaining parameters so that the steady state equilibrium can match certain empirical moments in the data. Finally, we consider shocks that can match the dynamics of real exchange rates and interest rates.

First, we set the time discount factor β, the risk aversion σ, and labor supply parameter η to the standard values. The elasticity of labor supply parameter η is taken from Mendoza (1991).

The elasticity of substitution γ and curvature in production α (which is related to θ) will determine the response of the volume and variety of exports. Given the elasticity of the value of exports to the real exchange rate is quite low in the data - around 5 percent over the first year - we require a very low value for γ. We choose $\gamma = 1.1$. This value is well within the range of estimates in the literature. Next, given the small decline in export prices relative to the real exchange rate we require substantial curvature in the production of exports, thus we start with $\alpha = 1/4$. Lastly, given the gradual nature of the expansion of exporters we require substantial dispersion in entry and continuation costs and thus set $v_0 = 4.5$. We will present sensitivity to these parameters.

Table 3: Pre-determined parameters

β	σ	η	γ	α	v_1	ν_0
0.99	2	1.5	1.1	1/4	4.5	4.5

Given the pre-set parameters, we calibrate the remaining parameters to match the target statistics in the steady state as shown in Table 4.

Table 4: Calibrated parameters

Parameters	Target
$\overline{B}$	debt/imports=10
f_0	exporter ratio N=25%
f_1	exit rate of exporter $1 - n_1 = 1.5\%$
ω	labor for exports $\frac{Nl_1}{Nl_1+l_0} = 15\%$
κ	total labor normalization

In particular, for the average debt level in the steady state, we can set it so that $\overline{B}/M = b$ (debt equal to b times quarterly imports) . If imports are 15 percent of GDP then this is equivalent to 37.5 percent of GDP. We can set f_0 so that 25 percent of the plants export (i.e. $N = 0.25$) and set f_1 so that 1.5% of exporting plants exit each quarter. We can set ω so that exports use 15 percent of the workers (tr=15%). Finally, the parameter κ is used to normalize the total labor in the economy. One remark is that the value of the calibrated parameters all depend on the value we set for ν_0 and ν_1.

Consistent with evidence in Das, Roberts and Tybout (2001), we assume that exporting is a very persistent activity. Empirical evidence for the US is that about 10 to 12 percent of existing exporters exit per year. Evidence for Colombia and Chile shows even less exit from exporting. However, many of exiting exporters are relatively small, thus the share of trade accounted for exiting exporters is less than the amount of exit. Since we have no heterogeneity in production in the model, we target an exit rate of 1.5 percent so that $n_1 = 0.985$ and $n_0 = \frac{1-n_1}{1-N}N$. Given our choice of debt that implies imports as a function of exporters.

$$M = \frac{(1+r)}{(1-r(b-1))} N l_1^{\alpha}.$$

The ratio of fixed costs can be solved from the marginal entry and exit decisions

$$f_1 = \frac{\nu_0 n_0^{v_0 - 1}}{\nu_1 n_1^{v_1 - 1}} f_0$$

Combining our target of the labor share in exporting $\frac{Nl_1}{Nl_1 + l_0} = 15\%$, and the aggregate labor constraint we can then solve for the entry cost

$$f_0 = \frac{(1-\alpha)\, tr\overline{L}}{\alpha N \left[(1-v_1) \frac{f_1}{f_0} n_1^{v_1} + \left[\frac{1}{\beta} v_0 / n_0 - (1-v_0) \right] n_0^{v_0} \right] + (1-\alpha)\, tr \left[N \frac{f_1}{f_0} n_1^{v_1} + (1-N)\, n_0^{v_0} \right]}$$

and then using the labor decision for exporters

$$l_1 = \frac{\alpha f_0}{1-\alpha} \left[(1-v_1) \frac{f_1}{f_0} n_1^{v_1} + \left[\frac{1}{\beta} v_0 / n_0 - (1-v_0) \right] n_0^{v_0} \right].$$

Note if there is no sunk aspect to exporting then

$$l_1 = \frac{\alpha f_0}{1-\alpha} v_0 N^{v_0 - 1}.$$

Using these values we can solve for κ from the labor supply condition (2)

$$\kappa = \frac{(X)^{-\frac{1}{\gamma}} \left(X^{\frac{\gamma-1}{\gamma}} + \omega^{\frac{1}{\gamma}} M^{\frac{\gamma-1}{\gamma}} \right)^{\frac{\gamma}{\gamma-1} - 1}}{\eta \bar{L}^{\eta - 1}}.$$

Finally, we assume the stochastic processes for the productivity, interest rates, and labor wedge shock to be

$$\log z_t = \rho_z \log z_{t-1} + \varepsilon_t^z,$$

$$r_t - \overline{r} = \rho_r \left(r_{t-1} - \overline{r}\right) + \varepsilon_t^r,$$

$$\widehat{\kappa}_t = \rho \widehat{\kappa}_t + \varepsilon_t^\kappa$$

We choose the shock process to match the dynamics of interest rates and exchange rates for the average devaluation. We also choose separate processes to match the experience of our low and high interest rate samples. The following table reports the average increase in interest rates, the increase in the labor wedge to move the real exchange rate, plus the persistence of the shocks.

Table 5: Shocks

	e_r^*	e_κ	e_z	ρ_r	ρ_κ	ρ_z
Average	1500	-0.25	-0.05	0.84	0.96	0.95
High	2400	-0.36	-0.05	0.84	0.96	0.95
Low	600	-0.24	-0.05	0.84	0.96	0.95
*Annualized increase in basis points						

In short, interest rates tend to increase about 1500 basis points initially while the real exchange rate increases close to 25 percent. The interest rate movement is slightly less persistent than the exchange rate. Our sample of low interest rate countries has smaller movements in the interest rate and exchange rates than in the high interest countries.

Lastly, to explore the importance of getting export dynamics right on aggregate outcomes we consider a model with no sunk costs that generates the same average elasticity of exports to the real exchange rate over six years.

4 Numerical Exercises

In this section, we examine the export dynamics in our model economy following shocks to the interest rate, productivity, and the labor wedge that generate a large devaluation. We first consider the average dynamics of exports. We then examine the response for high and low interest rate economies.

To simulate the model we log-linearize it around the economy's steady state. The advantage of our modelling approach is to introduce non-constant elasticity trade dynamics in an otherwise standard SOE RBC model. Therefore, most computation techniques for computing dynamic macroeconomic models apply here.

The four panels of Figure 6 plot the dynamics of our model economy. The first panel shows the shocks. The second and third panels show the evolution of nominal exports and the response of the variety of products exported. These both increase gradually over the first 8 to 12 quarters. The last panel shows the response of the export price and the real exchange rate. For convenience, we plot a depreciation as a decline in the export price and the real exchange rate. Both fall immediately, but with the curvature in production of exports, the price of exports falls by less than the RER over most of the first six years. The movements over the first three years are roughly consistent with what we found for US imports.

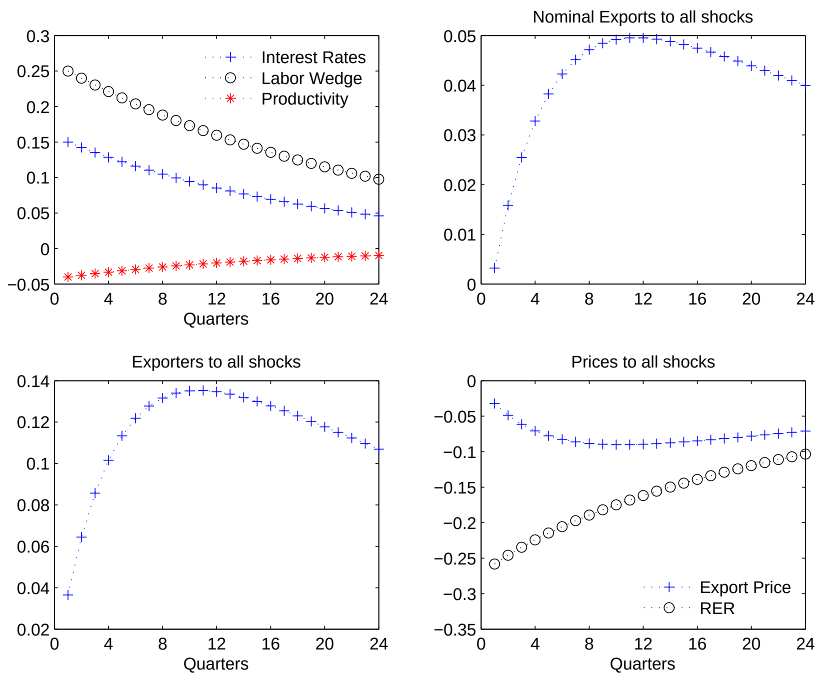


Figure 6: Benchmark Economy: Shocks and Dynamics

Figure 7 shows the elasticity of exports and exporters relative to the price of exports and the real exchange rate. Similar to the data, the export and exporter response is relative small initially and then rises through time.

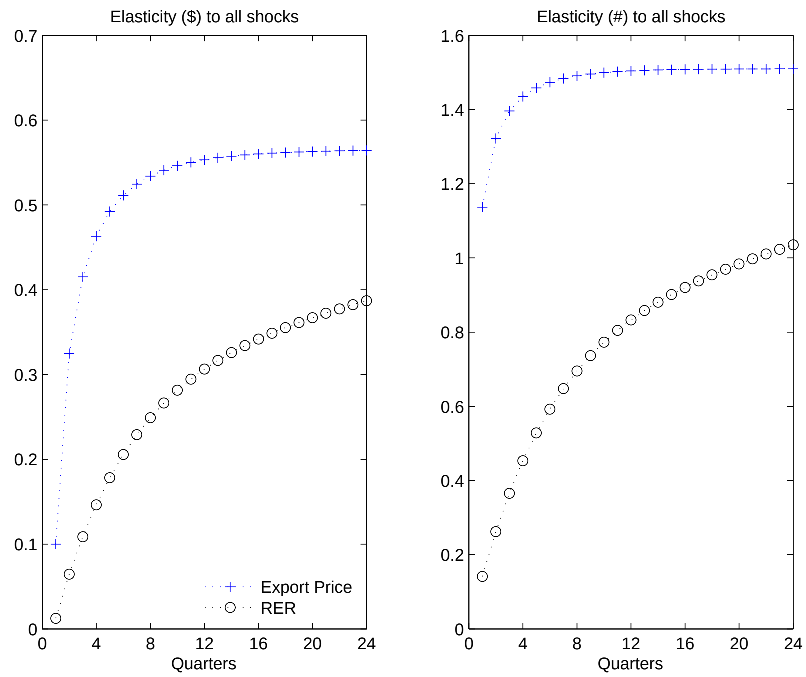


Figure 7: Benchmark Economy: Export Elasticities

Table 6 reports the magnitude of the response over different horizons in the model and the data. In the first year, the value of exports increases by about 5 percent in the model and the data. In the third year the volume increase 52 percent of the real exchange rate in the data and only 29 percent in the model. Over the six years, the model and the data generate and elasticity of 27 percent. In terms of the extensive margin, the model comes quite close to getting the changes at different horizons. The one important failure of the model is that the elasticity of exports is hump-shaped with a peak at about 3 years while in the model the hump in the elasticity is quite small. .[11]

Table 6: Elasticity of Exports and Exporters at Different Horizons

	Avg 1 year	peak 3 years	Avg 6 years
Value			
Data	0.05	0.52	0.27
Model	0.08	0.29	0.28
Extensive Margin			
Data	0.17	0.82	0.72
Model	0.31	0.79	0.76

4.1 High and Low Interest rate shocks

We next consider some of the differences in the export response of our high and low interest rate country samples. Specifically, we hit our model with shocks that generate exchange rate and interest rate movements in line with those in the high and low interest rate countries. Recall, we saw that exports tended to respond relatively more strongly for countries with smaller movements in interest rates and exchange rates.

Figure 8 plots the dynamics of the interest rate, real exchange rate, nominal exports and exporter for countries with large movements in interest rates and exchange rates (titled High) and countries with small changes in interest rates and exchange rates (titled low). With the larger

[11] This problem is even more severe looking at the higher frequency data as the peak elasticity of the volume of exports is 0.61 36 months after the devaluation.

relative price movements in High we see bigger movements in nominal exports and exporters.

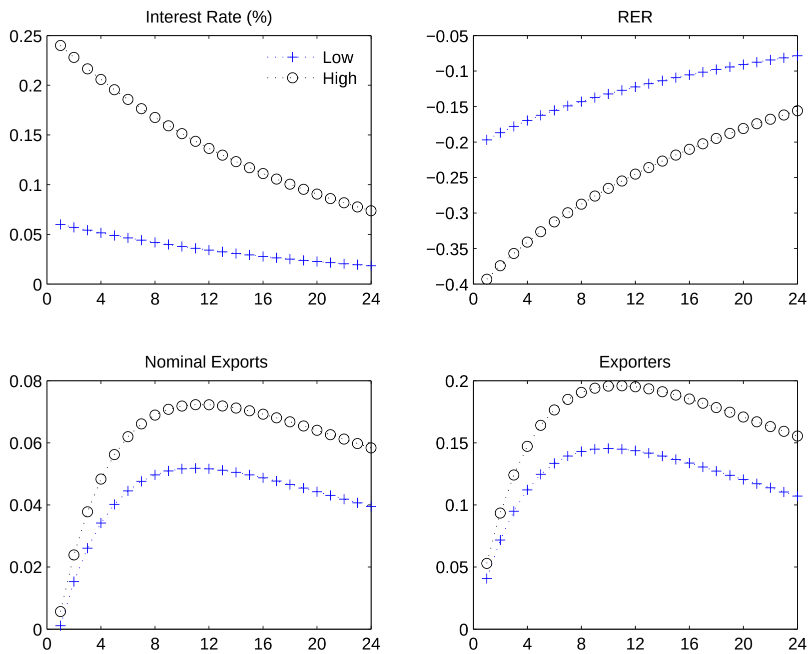


Figure 8: High and Low Interest Rate Economies: Shocks

Figure 9 shows the dynamics of the elasticity of exports and exporters for the High and Low countries. Now we see that relative to the change in the real exchange rate the change in exports and exporters are larger for the case of small interest and exchange rate movements. Indeed we find that at the end of six years the elasticity of exports with respect to the RER is about 25 percent smaller for the High countries. The weaker response arises because there is relatively less entry when interest rates movements are large. Thus, it appears that interest rate movements dampen export growth, although the magnitudes are somewhat below what we find in the data.

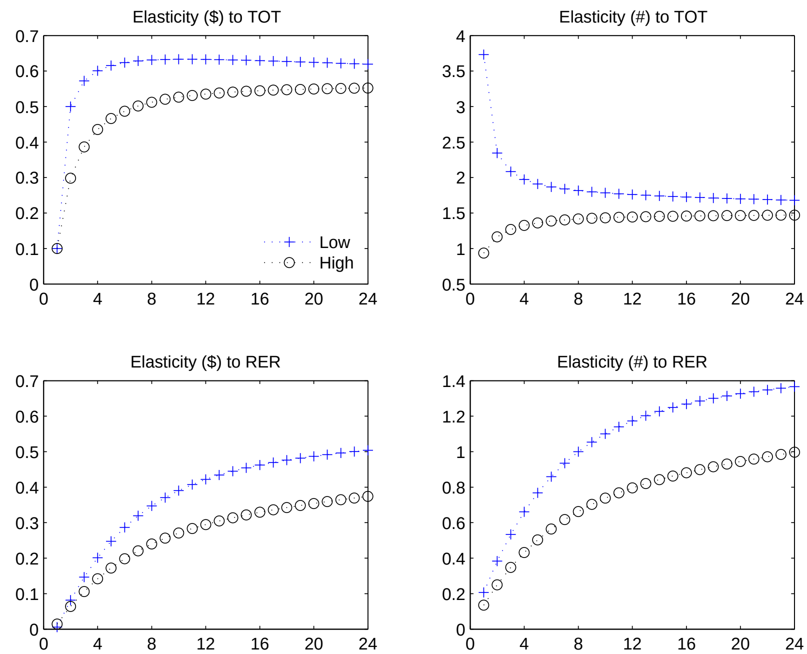


Figure 9: High and Low Interest Rate Countries: Export Elasticities

4.2 Macro effects

We now examine the implications of gradual export dynamics for intertemporal borrowing and lending. To get a sense of whether the pattern of borrowing and lending is affected by the nature of export costs, we consider a variation of our model with no sunk aspects to exporting. To make a fair comparison, the only parameter we change is $v_0 = v_1$. We set these to get the same elasticity of exports to the real exchange rate over the first 6 years. This requires lowering the dispersion in fixed costs from $v_0 = 7$ to $v_0 = 1.45$.

Figure 10 plots the dynamics of interest rates, real exchange rates, nominal exports and exporters following our benchmark shock. As expected, with no sunk aspect exports and exporters respond more initially than with the sunk cost and less in the long-run. This is the only way to get the elasticity figures right on average. Figure 11 plots the elasticity of exports and exporters relative to the export price and real exchange rate. Note that the elasticity is not quite constant in the no sunk cost model because the lag to enter foreign markets introduces a role for the interest rate.

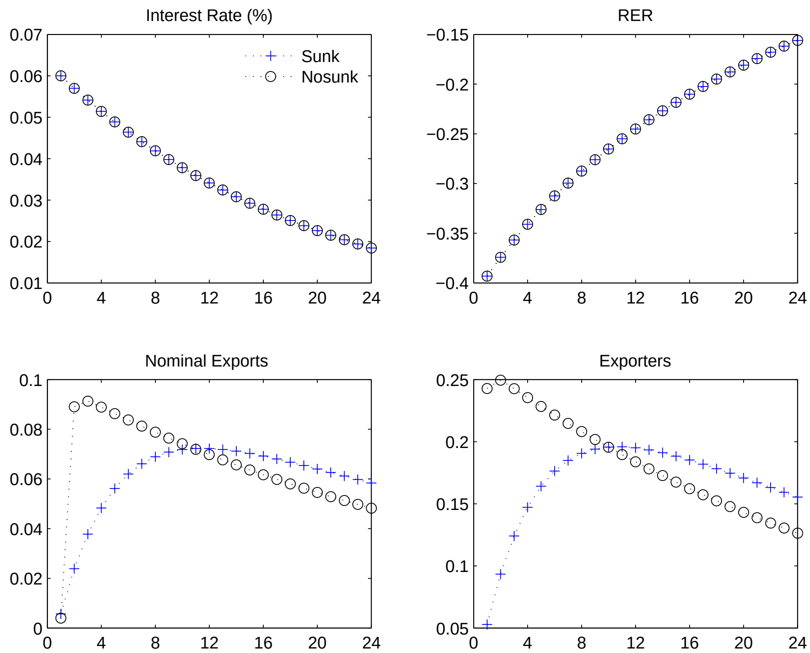


Figure 10: Sunk and No Sunk Cost Models: Shocks and Export Dynamics

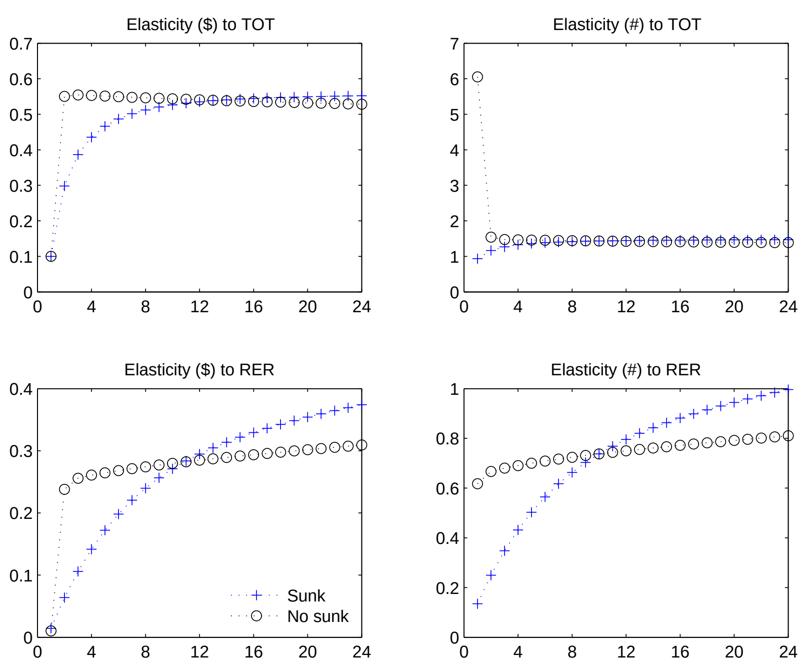


Figure 11: Sunk and No Sunk Cost Models: Export Elasticities

Finally, Figure 12 plots the dynamics of debt measured relative trade (exports + imports) and net exports in the two models. With no sunk cost, relative to the sunk cost model net exports responds less in the first period and more in second through fifth quarters. With no sunk cost, net exports peak in the third quarter and decline monotonically. With the sunk cost, the movements in net exports are more hump shaped, peaking about 6 quarters after the onset and declining more gradually. The different net export dynamics imply that in the no sunk model indebtedness rises more in the long run. Thus after 6 years indebtedness in the no sunk cost model has risen 98 percent while in the sunk cost model it has risen only 87 percent.

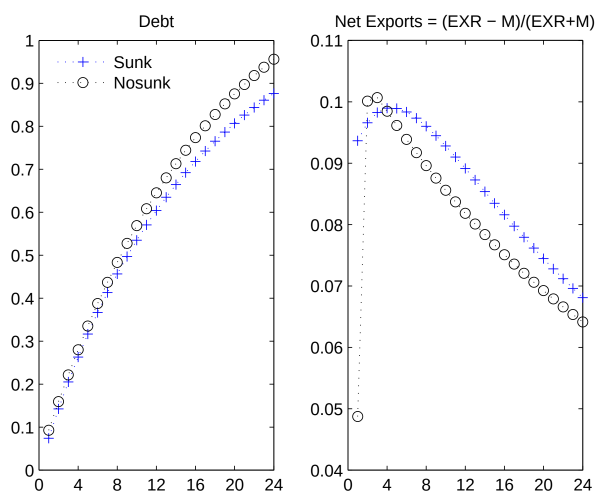


Figure 12: Sunk and No Sunk Cost models: Debt and Net Exports Dynamics

5 Sensitivity

To be completed

- **Higher elasticity**
- **Less curvature in α**
- **Less curvature in v0**

6 Conclusions

We study empirically and theoretically export dynamics following a devaluation in a number of emerging markets. We document two key features of exports. First, exports grow gradually with the elasticity rising from 0 to nearly 50 percent over 3 years. This export growth reflects both a gradual decrease in prices as well as an expansion in the extensive margin of trade with the elasticity of product-destinations growing by about twice that of export volume. Second, we find evidence that high interest rates tend to depress exports. These export dynamics are a challenge for standard trade models.

We develop a dynamic model of exporting subject to sunk costs. With these sunk costs, the stock of exporters is a state variable of the economy. In response to shocks similar to those experienced by devaluing countries, exports and exporters grow gradually and interest rates depress export and particularly export expansion. We find the model can capture the very low initial response of exports and exporters following the devaluation as well as the average response over the first six years following the devaluation. We also find that the model can generate an important role for interest rates in depressing exports. Similarly to the data, we find that a smaller elasticity of exports to the real exchange rate when interest rate increases are relatively more important.

We find that there is potentially an important macroeconomic role for modelling the gradual dynamics of exports and exporters. We find that by ignoring the gradual export expansion, one would understate the increase in international borrowing initially and overstate the increase over six years. The gaps can be as big as 20 to 30 percent of the change in indebtedness.

References

[1] Aguiar, Mark and Gita Gopinath, 2007. "Emerging Market Business Cycles: The Cycle Is the Trend," *Journal of Political Economy*, 115(1), 69-102.

[2] Alessandria, George and Horag Choi, 2007a. "Do Sunk Costs of Exporting Matter for Net Export Dynamics?" *Quarterly Journal of Economics*, 122(1), 289-336.

[3] Baldwin, Richard and Paul Krugman, 1989. "Persistent Trade Effects of Large Exchange Rate Shocks," *Quarterly Journal of Economics*, 104(4), 821-854.

[4] Das, Sanghamitra, Mark Roberts and James Tybout, 2007. "Market Entry Costs, Producer Heterogeneity, and Export Dynamics," *Econometrica*, 75(3), 837-873.

[5] Junz, Helen and Rudolf Rhomberg, 1973. "Price Competitiveness in Export Trade Among Industrial Countries." *American Economic Review*, 63(2), 412-418.

[6] Magee, Steven, 1973. "Currency Contracts, Pass-through and Devaluations," *Brookings Papers on Economic Activity*. 1973(1), 303-325.

[7] Meade, Ellen, 1988. "Exchange Rates, Adjustment, and the J-Curve." Federal Reserve Bulletin, 74(10): 633-644.

[8] Mendoza, Enrique. 1995. "The Terms of Trade, the Real Exchange Rate, and Economic Fluctuations," *International Economic Review*, 36(1), 101-137.

[9] Neumeyer, Pablo and Fabrizio Perri, 2005. "Business Cycles in Emerging Economies: The Role of Interest Rates." *Journal of Monetary Economics*, 52(2), 345-380.

[10] Roberts, Marks and James Tybout, 1997. "The Decision to Export in Colombia: An Empirical Model of Entry with Sunk Costs," *American Economic Review*, 87(4), 545-564.

Appendix 1: The Export Supply Function

This appendix describes the derivation of the export supply function. In the ROW final goods are produced using only home and foreign intermediate goods (these are Argentinian goods). A final good producer can purchase from any of the home intermediate good producers but can purchase only from those foreign intermediate good producers that are actively selling in the home market. In each period there are N(s^t) identical foreign intermediate producers selling in the home country

The production technology of the firm is given by a constant elasticity of substitution (henceforth CES) function

$$(8)\quad D(s^t) = \left\{ a_1 \left[\int_0^1 y_h^d(i,s^t)^{\frac{\theta-1}{\theta}} di \right]^{\frac{\theta}{\theta-1}\frac{\gamma}{\gamma-1}} + (1-a_1) \left[\int_0^{N\left(s^t\right)} y_f^d(i,s^t)^{\frac{\theta-1}{\theta}} di \right]^{\frac{\theta}{\theta-1}\frac{\gamma-1}{\gamma}} \right\}^{\frac{\gamma}{\gamma-1}},$$

where $D(s^t)$ is the output of final goods and $y_h^d(i,s^t)$ and $y_f^d(i,s^t)$ are inputs of intermediate goods purchased from home firm i and foreign firm i, respectively. The parameter a_1 determines the weight of home goods in final good consumption. We will assume that a_1 is close to 1. The elasticity of substitution between intermediate goods that are produced in the same country is θ, and the elasticity of substitution between home and foreign aggregate inputs is γ.

The final goods market is competitive. In each period t, given the final good price at home $P(s^t)$, the i_{th} home intermediate good price at home $P_h(i,s^t)$ for $i \in [0,1]$, and the i_{th} foreign intermediate good price at home $P_f(i,s^t)$ for $i \in [0,N]$, a home final good producer chooses inputs $y_h^d(i,s^t)$ for $i \in [0,1]$, and $y_f^d(i,s^t)$ for $i \in [0,N]$ to maximize profits,

$$(9)\quad \max P\left(s^t\right) D\left(s^t\right) - \int_0^1 P_h\left(i,s^t\right) y_h^d\left(i,s^t\right) di - \int_0^N P_f\left(i,s^t\right) y_f^d\left(i,s^t\right) di,$$

. Solving the problem in (9) gives the input demand functions,

$$(10)\quad y_h^d(i,s^t) = a_1^\gamma \left[\frac{P_h(i,s^t)}{P_h(s^t)}\right]^{-\theta} \left[\frac{P_h(s^t)}{P(s^t)}\right]^{-\gamma} D(s^t),$$

$$(11)\quad y_f^d(i,s^t) = (1-a_1)^\gamma \left[\frac{P_f(i,s^t)}{P_f(s^t)}\right]^{-\theta} \left[\frac{P_f(s^t)}{P(s^t)}\right]^{-\gamma} D(s^t), i \in [0,N]$$

where $P_h(s^t) = \left[\int_0^1 P_h(i,s^t)^{1-\theta} di\right]^{\frac{1}{1-\theta}}$, and $P_f(s^t) = \left[\int_0^N P_f(i,s^t)^{1-\theta} di\right]^{\frac{1}{1-\theta}}$. The zero-profit condition in the perfectly competitive market determines the price level of the final good as

$$(12)\quad P(s^t) = \left[a_1^\gamma P_h(s^t)^{1-\gamma} + (1-a_1)^\gamma P_f(s^t)^{1-\gamma}\right]^{\frac{1}{1-\gamma}}.$$

Now we are assuming that we have N identical exporters each charging $\frac{\theta}{\theta-1}\frac{w_f\left(s^t\right)}{A_f(s^t)}$ and so

$P_f(s^t) = N(s^t)^{\frac{1}{1-\theta}} \frac{\theta}{\theta-1} \frac{w_{f(s^t)}}{A_f(s^t)}$. Aggregating over the different exporters we get

$$\begin{aligned} EX\left(s^t\right) &= \int_0^{N\left(s^t\right)} y_f^d(i,s^t) = \int_0^{N\left(s^t\right)} (1-a_1)^\gamma \left[\frac{P_f(i,s^t)}{P_f(s^t)}\right]^{-\theta} \left[\frac{P_f(s^t)}{P(s^t)}\right]^{-\gamma} D(s^t) \\ &= N\left(s^t\right)(1-a_1)^\gamma \left[\frac{P_f(i,s^t)}{P_f(s^t)}\right]^{-\theta} \left[\frac{P_f(s^t)}{P(s^t)}\right]^{-\gamma} D(s^t) \\ &= N\left(s^t\right)(1-a_1)^\gamma \left[\frac{\frac{\theta}{\theta-1}\frac{w_{f(s^t)}}{A_f(s^t)}}{N\left(s^t\right)^{\frac{1}{1-\theta}} \frac{\theta}{\theta-1}\frac{w_{f(s^t)}}{A_f(s^t)}}\right]^{-\theta} \left[\frac{N\left(s^t\right)^{\frac{1}{1-\theta}} \frac{\theta}{\theta-1}\frac{w_{f(s^t)}}{A_f(s^t)}}{P(s^t)}\right]^{-\gamma} D(s^t) \\ &= N\left(s^t\right)(1-a_1)^\gamma \left[\frac{1}{N\left(s^t\right)^{\frac{1}{1-\theta}}}\right]^{-\theta} \left[\frac{N\left(s^t\right)^{\frac{1}{1-\theta}} \frac{\theta}{\theta-1}\frac{w_{f(s^t)}}{A_f(s^t)}}{P(s^t)}\right]^{-\gamma} D(s^t) \end{aligned}$$

Now lets take log deviations from the

$$\ln EX\left(s^t\right) = \gamma \ln\left[\frac{(1-a_1)(\theta-1)}{\theta}\right] + \frac{1-\gamma}{1-\theta}\ln N\left(s^t\right) - \gamma \ln\left[\frac{\frac{w_{f(s^t)}}{A_f(s^t)}}{P(s^t)}\right] + \ln D(s^t)$$

Lets define the terms of trade τ

$$\tau_t = \frac{w_{f(s^t)}}{A_f\left(s^t\right)} / P(s^t)$$

then we can rewrite log deviation of export demand as

$$\widehat{ex}_t = \left(\frac{1-\gamma}{1-\theta}\right)\ln \widehat{N}_t - \gamma \ln \widehat{\tau}_t + \ln \widehat{D}_t$$

In terms of revenue

$$\widehat{exr}_t = \left(\frac{1-\gamma}{1-\theta}\right)\ln \widehat{N}_t + (1-\gamma)\ln \widehat{\tau}_t + \ln \widehat{D}_t$$

The key challenge is then to identify the terms of trade separate from productivity shock or shock to wages..

Appendix 2: Data sources

To be completed

Crisis Dates: We define the end of the pre-crisis period as the month prior to a large devaluation:

- Argentina: December 2001
- Brazil: December 1998

- China: December 1993
- Columbia: June 2002
- India: February 1993
- Indonesia: April 1997
- Korea: October 1997
- Malaysia: July 1997
- Mexico: December 1993
- Russia: July 1998
- Thailand: June 1997
- Turkey: January 2001
- Uruguay: June 2002

US Trade data:
All Haver series are seasonally adjusted with the Haver seasonal adjustment function, and all non-Haver series are seasonally adjusted using X-12-ARIMA in EViews.
PPI-Based Real Exchange Rates

- JP Morgan Broad Real Effective Exchange Rate Index (trade-weighted, 2005 = 100, Monthly Averages): Argentina (FXDARGBC@USECON), Brazil (FXDBRZBC@USECON), China (FXDCHIBC@USECON), Columbia (FXDCOLBC@USECON), India (FXDINDBC@USECON), Indonesia (FXDINBC@USECON), Korea (FXDKORBC@USECON), Malaysia (FXDMALBC@USECO Mexico (FXDMEXBC@USECON), Russia (FXDRUSBC@USECON), Thailand (FXDTHABC@USECC Turkey (FXDTURBC@USECON), and the United States (FXDUSBC@USECON)
- Real Effective Exchange Rate (all fund members, Consumer Price Basis), IMF: Uruguay (C298EIRC@IFS), Uruguay Consumer Prices, IMF (C298PC@IFS), Uruguay Wholesale Prices, IMF (C298PW@IFS)

CPI-Based Real Exchange Rates

- Real Effective Exchange Rate (trade-weighted, all fund members, Consumer Price Basis, 2005 = 100), IMF: Brazil (from IMF website directly), China (C924EIRC@IFS), Columbia (C233EIRC@IFS), Korea (C542EIRC@IFS), Malaysia (C548EIRC@IFS), Mexico (from IMF website directly), Russia (C922EIRC@IFS), United States (C111EIRC@IFS), and Uruguay (C298EIRC@IFS)

- Real Effective Exchange Rate (trade-weighted, CPI-based, broad indices, monthly averages, 2005 = 100), Bank for International Settlements (BIS): Brazil, India, Indonesia, Thailand, and Turkey (All from the BIS website directly)

Trade Weights (Used to restrict trade-weighted real exchange rates to exclude the U.S. and China)

- JP Morgan Broad Index Trade Weights (Based on 2000 trade in manufactured goods) (Available through Haver's website): All countries except Uruguay. Since we do not have trade weights for Uruguay, we did not make the restriction calculation for it

Exports to the U.S. (Volume)

- U.S. Imports of Merchandise, U.S. Census Bureau: All countries (From U.S. Merchandise Trade CDs/DVDs)
- Among other things, this dataset breaks U.S. import values down by HS10 commodity, country of origin, and district of entry.
- U.S. Import Price Index: All Imports (NSA, 2000=100), BLS (PMEA@USECON)
- U.S. Real Manufacturing & Trade Sales: All Industries (SA, Mil.Chn.2005$), BEA (TSTH@USECON)
- Note: We convert the U.S. Imports of Merchandise into real terms using the U.S. Import Price Index and normalize them using the U.S. Real Manufacturing & Trade Sales.

Exports to the U.S. (Extensive Margin)

- U.S. Imports of Merchandise, U.S. Census Bureau: All countries (From U.S. Merchandise Trade CDs/DVDs)
- Among other things, this dataset breaks U.S. import values down by HS10 commodity, country of origin, and district of entry.
- We calculate the extensive margin as the number of distinct HS10 commodity-country-district pairs imported having strictly positive volume.

RESTRICTED REAL EXCHANGE RATES CALCULATION

- For any country x, let qx be the trade-weighted real exchange weight of country x, measured in log changes.
- For any countries x and y, let $\alpha_{x,y}$ be the trade weight, measuring the fraction of x's trade that is with y.
- For any countries/parts of the world x and y, let qx,y be the real exchange rate between x and y, measured in log changes.

- Now, let x be the country whose RER we are looking to restrict, and let ROW be the world, excluding x, the U.S., and China. Then we calculated the restricted real exchange rate as:

$$q_{x,ROW} = \frac{(1-\alpha_{CHI,US}-\alpha_{US,CHI})q_x+(\alpha_{x,US}+\alpha_{x,CHI}-\alpha_{CHI,US})q_{US}+\left(\alpha_{x,CHI}+\alpha_{x,US}+a_{US,CHI}\right)q_{CHI}}{\left(1-\alpha_{x,US}\right)\left(\alpha_{US,x}+\alpha_{S,CHi}\right)+\alpha_{CHI\_x}-\alpha_{x,CHI}} /(1\text{-}\alpha_{x,US}\ (\alpha_{US,x} + \alpha_{US,CH}$$

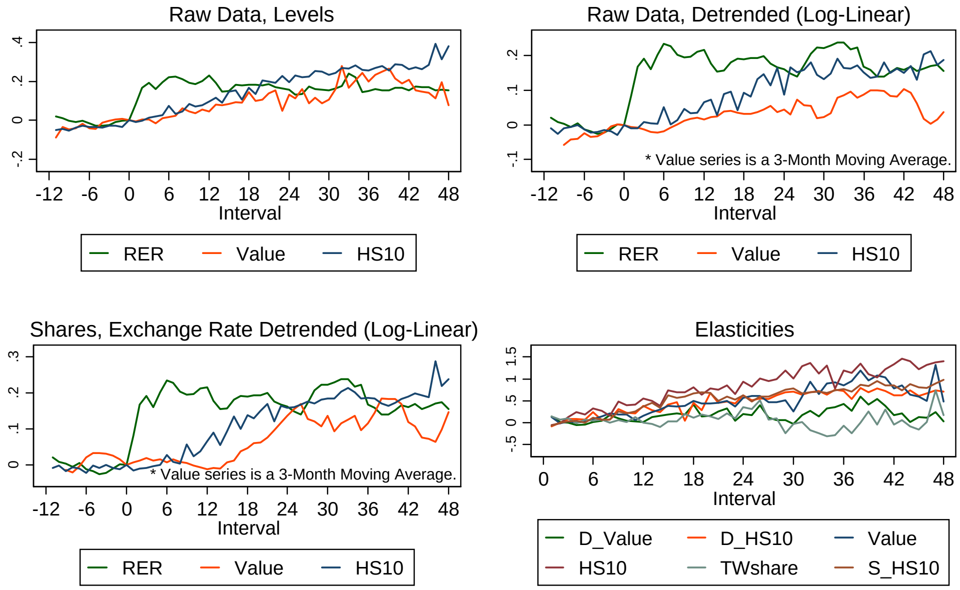
■_(x,CHI) (■_(CHI,x)+ ■_(CHI,US) ■_(US,x)))

Argentina aggregate

- Downloaded from http://www.mecon.gov.ar/peconomica/basehome/infoeco.html
- Production: Índices de Volumen Físico (IVF) en la industria manufacturera [CUADRO 1.15: Encuesta industrial (Total del país, por rama (base 1997=100))]
- Workers: Obreros Ocupados (IOO) en la industria manufacturera [CUADRO 1.15: Encuesta industrial (Total del país, por rama (base 1997=100))]
- Hours: Horas trabajadas (IHT)en la industria manufacturera [CUADRO 1.15: Encuesta industrial (Total del país, por rama (base 1997=100))]
- Spreads: Argentina: Lending Rate: Foreign Currency (% per annum) from the International Monetary Fund minus the 1-Month Nonfinancial Commercial Paper (% per annum) from the Federal Reserve Board
- EMBI -JP Morgain's EMBI dataset
- RERC, RERCUS, RERPUS are downloaded from the [CUADRO 4.14 Tipo de cambio real con EE.UU, Brasil y Europa, y tipo de cambio nominal]
- TOT is measured as the ratio of import prices to producer prices of manufacturers and energy. [CUADRO 4.6 Indice de precios internos al por mayor (IPIM), tasas mensuales y anuales de variación]
- TOT_NIPAY and TOT_NIPAPX use the implicit price deflators from the national accounts: [CUADRO 1.7b Índice de precios implícitos de la Oferta y Demanda Globales por componente, a precios de comprador (1)]
- GDP, C, GFI, EX, M are from [CUADRO 1.2 Oferta y Demanda Globales a valores constantes - Datos desestacionalizados (1)]

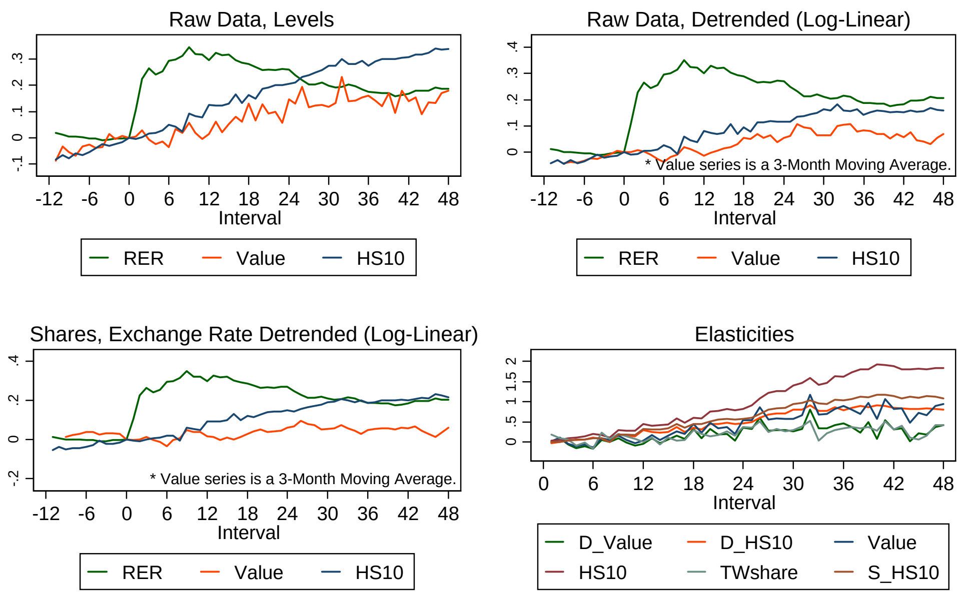
Appendix Figure 1A: Exports to U.S.

1-Month Intervals: 11-Country Median (PPI-Based)

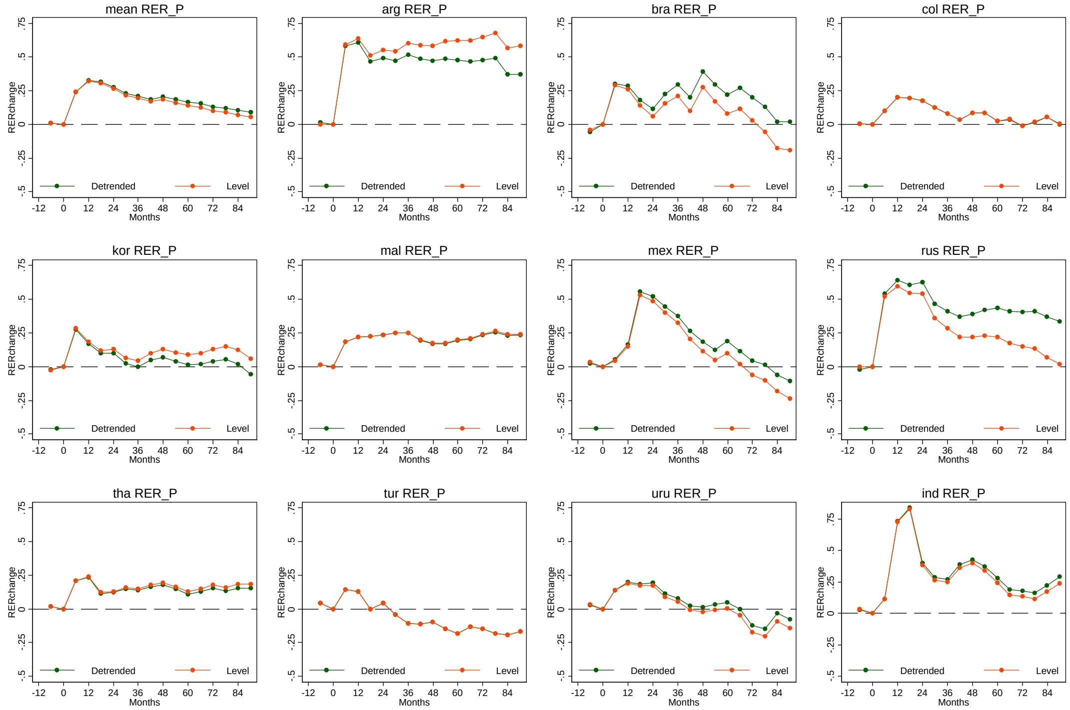


Appendix Figure 1B: Exports to U.S.

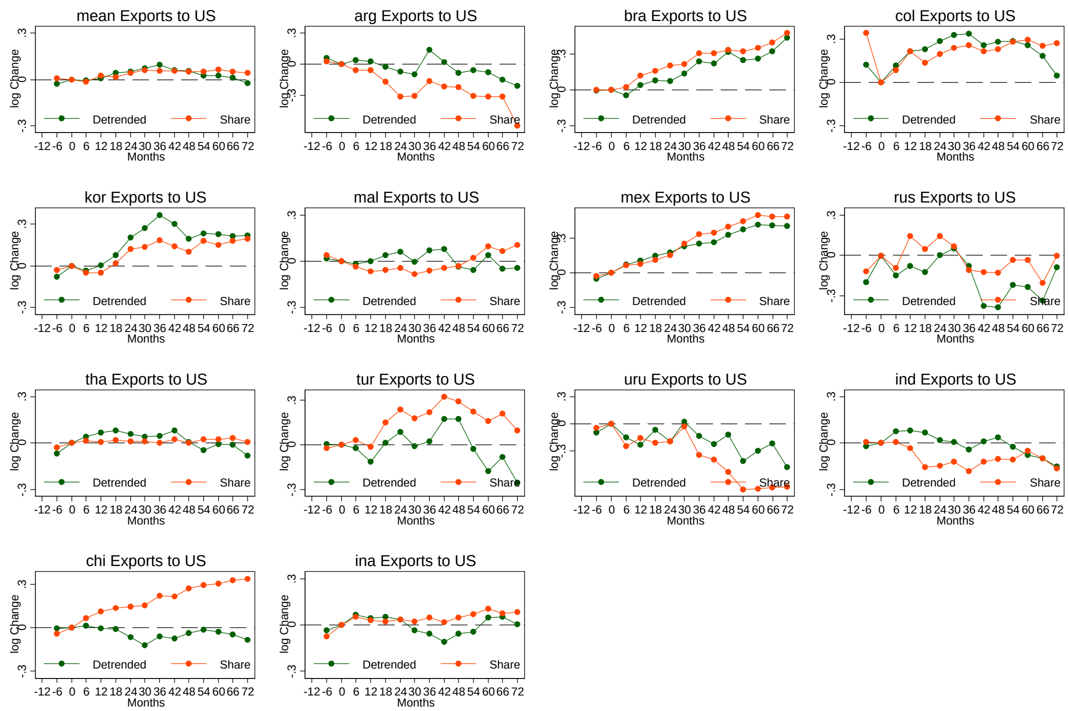
1-Month Intervals: 11-Country Mean (PPI-Based)



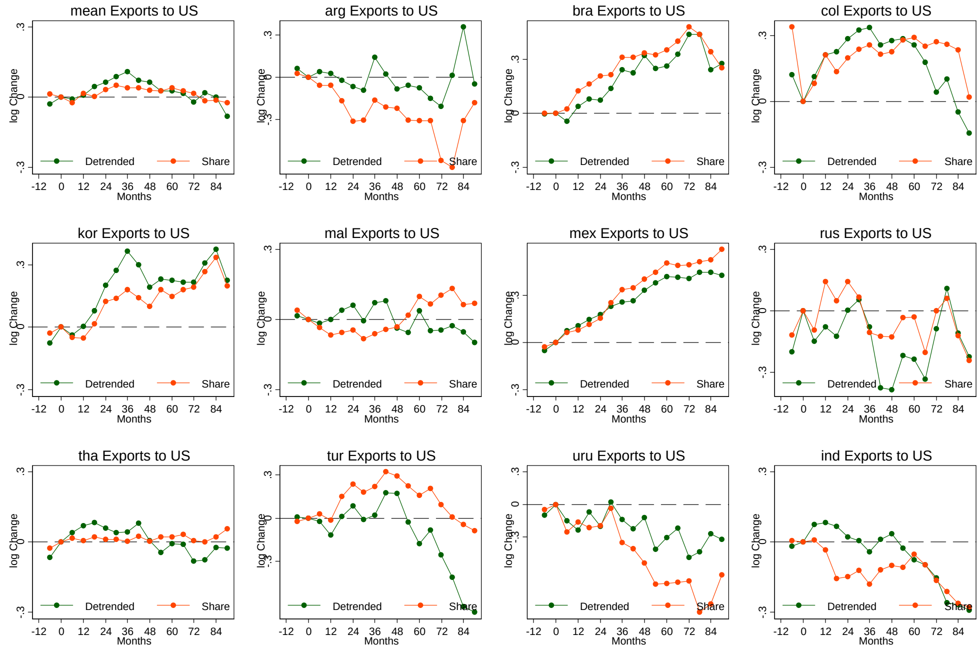
Appendix Figure 2A: Real Exchange Rates



Appendix Figure 2B: Exports to U.S.



Appendix Figure 2B: Exports to U.S.



Appendix Figure 2C: Extensive Margin of Exports to U.S.