Title
Real Exchange Rates and Foreign Portfolio Investment

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Publication Date
2019

Peer reviewed|Thesis/dissertation

UNIVERSITY OF CALIFORNIA SAN DIEGO

Real Exchange Rates and Foreign Portfolio Investment

A dissertation submitted in partial satisfaction of the
requirements for the degree
Doctor of Philosophy

in

Economics

by

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2019

The dissertation of Patrick Bloom is approved, and it is acceptable in quality and form for publication on microfilm and electronically:

Chair

University of California San Diego

2019

EPIGRAPH

The only moment of happiness possible, that's the present.

The past gives regrets. And the future uncertainty.

Man understood this very quickly and invented religion. It forgives him for the evil he's done in the past and tells him not to worry about the future—because he'll go to Paradise.

That means, take advantage of the present.

—Arsene Wenger

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ACKNOWLEDGEMENTS

Thanks to my advisor Marc Muendler for all of the guidance. Thanks also to my committee for helpful comments.

Above all, thank you to my best friends for making this life worth living: Tim Cussins, James Dent, Luke Egeler, Paul Hanly, Ben Jackson, Rob Laragh, Mike Thornley, and Diego Vera.

VITA

1982	Born in Pasadena, California
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ABSTRACT OF THE DISSERTATION

Real Exchange Rates and Foreign Portfolio Investment

by

Patrick Bloom

Doctor of Philosophy in Economics

University of California San Diego, 2019

Marc-Andreas Muendler, Chair

Chapter 1 uses real interest rates to show that the long-term real exchange rate and a risk premium are more volatile than the nominal exchange rate for four developing countries. Chapter 2 finds country-level effects of foreign portfolio investment in 18 developing countries and proposes a channel for real exchange rate volatility driven by foreign portfolio investment. Chapter 3 shows that there are plant-level productivity gains in Chile from small levels and small increases in foreign ownership typical of portfolio investment.

Nominal exchange rate changes can be decomposed into inflation differentials and real components, each having different causes and consequences. Although we have explanations for each component, the relative importance of the long-run real exchange rate has previously not

been quantified. Chapter 1 uses inflation-linked bond data for Brazil, Mexico, South Africa, and Turkey to quantify the contribution of those components to exchange rate changes against the United States. We find that the long-term expected real exchange rate plus its risk premium is even more volatile than the nominal exchange rate.

Volatility and unforecastability of real exchange rates is a fundamental puzzle of international economics, and these features are even more pronounced in developing countries. In chapter 2, we present a new fact, that inward portfolio investment in equities predicts the extensive margin of imports in 18 developing countries. With this we build a purely real model in which foreign investors finance new intermediate inputs and increase productivity in the tradeable goods sector. We express the Balassa-Samuelson determined real exchange rate as a function of foreign investment. We use the established fact that investors in developed countries exhibit positive feedback or operate under portfolio constraints and show how therefore the real exchange rate reacts positively to equity prices. We test and confirm the prediction of the model that equity portfolio investment predicts exchange rates at quarterly frequencies. We also confirm that the extensive margin of imports comoves with the real exchange rate at annual frequencies, and do not reject that equity portfolio investment acts through this channel only.

In chapter 3, we measure the effect of foreign ownership on the productivity of Chilean manufacturers between 1998 and 2001. Total factor productivity is measured at the plant level using multiple alternative methods. Both the level of foreign ownership and increases in foreign ownership are significant predictors of productivity. These effects remain when restricting the sample to plants with low foreign ownership and small changes in foreign ownership, showing the importance of foreign portfolio investment on productivity. A non-parametric fit suggests that low levels of foreign ownership are as significant as larger stakes. When controlling for endogeneity in the foreign investment decision by instrumenting with total developed countries' portfolio outflows the positive effects on productivity remain. Finally we show that foreign ownership predicts that firms source more of their intermediate inputs from abroad.

Chapter 1

Nominal vs long-term real exchange rate volatility

1.1 Introduction

The exchange rate between two currencies determines the relative price of domestic goods and assets between the two countries. Exchange rate changes are therefore a combination of differentially changing domestic price levels and a changing relative price level. This paper quantifies the importance of the first, nominal, contribution, and the second, real, contribution.

Standard expositions of exchange rate determination rely primarily on differential inflation, uncovered interest parity, and purchasing power parity. By design those approaches ignore the violation of purchasing power parity, even though it is known to be large and persistent (Rogoff 1996.) The real exchange rate for traded goods may even be as volatile as for non-traded goods (Engel 1999). [1]

[1] Engel (1999) demonstrated this for the US exchange rate versus several developed countries using five different metrics for traded goods prices. Further work documenting this fact across many currency pairs by Betts and Kehoe (2008) used sectoral gross output deflators or producer price indices for traded goods prices, whereas Burstein, Eichenbaum, and Rebelo (2006) used a weighted average of import and export price indices for developed countries. Yepez and Dzikpe (2019) extend Engel's methods to developing countries with similar results.

The standard exchange rate model in small, open economy macroeconomics (illustrated in e.g. Chari, Kehoe, and McGrattan 2002) is that monetary shocks interact with sticky prices. In this model, a positive monetary shock with fixed prices increases output and depreciates the currency, and then as prices adjust the real exchange rate returns to its previous level under presumed relative purchasing parity. This mean-reversion implies that the long-term expected real exchange rate would be much less volatile than the current nominal exchange rate. We provide evidence against this theory.

Earlier empirical work by Mussa (1986) founds that real exchange rates were less volatile under fixed nominal regimes than under floating nominal exchange rate regimes. He concluded that sticky prices were the dominant mechanism. However, we find that these inflation-linked bond markets do not agree that real exchange rate volatility is transient and mean-reverting as sticky prices adjust.

Real exchange rate changes between advanced economies are humped-shaped in that they are initially persistent and then mean reverting. Burstein and Gopinath (2014) document that the half-lifes of those real exchange rate changes are between 1.5 and 6 years. This would imply that current real exchange rate changes would not greatly influence very long-term expectations because current changes largely die out over time.

Clarida (2012) studies daily currency fluctuations between the dollar and the pound, euro, and yen. He assumes a constant long-term expected real exchange rate, and attributes all variation to the risk premia. This amounts to assuming that future relative purchasing power parity holds over the sample.[2] This paper instead examines countries where neither absolute nor relative PPP is expected versus the US. This is a richer problem in exchange rate economics.

The contribution of this paper is to solve for the expected long-term real exchange plus its risk premium as a function of observables, assuming only no-arbitrage, and then to quantify this component with market data. We find that the long-term expected real exchange rate plus its risk

[2] We will return to this alternative framework and compare our decomposition to Clarida's at the end of section 2.

premium is even more volatile than the nominal exchange rate.

The rest if this paper is organized as follows. Section 2 shows the financial math relating exchange rates, price levels, real yields, and expectations. Section 3 discusses how we will apply this framework. Section 4 describes the sources for data. Section 5 covers possible complications or problems. Sections 6 reports the results. And section 7 concludes.

1.2 Definitions and foundations

1.2.1 Pricing measure and domestic bonds

Any asset with uncertain payoff x_T can be priced as

$$x_t = \mathbb{E}_t\left[\frac{1}{I_t} m_T x_T\right] = \frac{1}{I_t}\mathbb{E}_t\left[m_T x_T\right], \tag{1.1}$$

where I_t is the gross nominal interest rate between periods t and T, and m_T is the pricing kernel or stochastic discount factor (following e.g. Harrison and Kreps 1979). The existence of this m_T follows only from no-arbitrage and its uniqueness from market completeness, or that all of these assets are tradeable. In this paper, we will be careful to sub-script all variables such that z_s is $\mathcal{F}_s$-measurable, where $\mathbb{E}_s$ indicates an expectation conditional with respect to $\mathcal{F}_s$. $\mathbb{E}_t\left[m_T\right] = 1$ and m_T is non-negative almost everywhere, so we can define $m_T = \frac{d\mathbb{Q}}{d\mathbb{P}}$ as a Radon-Nikodyn derivative and rewrite the pricing formula as

$$x_t = \mathbb{E}_t^{\mathbb{Q}}\left[\frac{1}{I_t} x_T\right] = \frac{1}{I_t}\mathbb{E}_t^{\mathbb{Q}}\left[x_T\right]. \tag{1.2}$$

Actual expectations are formed under the physical probability measure $\mathbb{P}$ whereas the risk-neutral measure $\mathbb{Q}$ prices assets.

The application to pricing domestic bonds is that, with a price of 1, they have a certain payoff I_t.

1.2.2 Foreign bonds

The nominal exchange rate E_t is expressed in units of domestic currency per foreign currency. Therefore an increase in E_t represents an appreciation of the foreign currency.

Applying the pricing formula to one foreign bond from the perspective of a domestic investor we get

$$E_t = \mathbb{E}_t^{\mathbb{Q}}\left[\frac{1}{I_t} I_t^* E_T\right] = \frac{I_t^*}{I_t}\mathbb{E}_t^{\mathbb{Q}}\left[E_T\right] \tag{1.3}$$

where I_t^* is the gross nominal interest rate on foreign bonds between t and T. This relation is what we know as "Uncovered Interest Parity."

1.2.3 Inflation-linked bonds

An inflation-linked bond pays a certain real return R_t multiplied by the increase in the price level Π_T, where $\Pi_T = {}^{P_T}/_{P_t}$. [3]

Therefore the pricing formula applied to a domestic inflation-linked bond is

$$1 = \mathbb{E}_t^{\mathbb{Q}}\left[\frac{1}{I_t} R_t \Pi_T\right] = \frac{R_t}{I_t}\mathbb{E}_t^{\mathbb{Q}}\left[\Pi_T\right].$$

So

$$\mathbb{E}_t^{Q}\left[\Pi_T\right] = \frac{I_t}{R_t}. \tag{1.4}$$

1.2.4 Foreign inflation-linked bonds

A foreign inflation-linked bond pays a certain real return R_t^*multiplied by the increase in the price level Π_T^*, where $\Pi_T^* = {}^{P_T^*}/_{P_t^*}$.

[3] To be clear, (nominal) bonds pay a certain nominal return, which is risky in real terms. Inflation-linked bonds pay a certain real return, which is risky in nominal terms.

The pricing formula gives us

$$E_t = \mathbb{E}_t^{\mathbb{Q}}\left[\frac{1}{I_t} R_t^* \Pi_T^* E_T\right] = \frac{R_t^*}{I_t}\mathbb{E}_t^{\mathbb{Q}}\left[\Pi_T^* E_T\right]. \tag{1.5}$$

1.2.5 Real exchange rate

The real exchange rate Q_t for the foreign consumption basket with respect to the domestic is

$$Q_t = E_t \frac{P_t^*}{P_t}. \tag{1.6}$$

So real exchange rate growth follows as

$$\frac{Q_T}{Q_t} = \frac{E_T}{E_t}\frac{\Pi_T^*}{\Pi_T}. \tag{1.7}$$

1.2.6 Key identity

Rearranging (1.7) and taking expectations we get

$$E_t \mathbb{E}_t^{\mathbb{Q}}\left[Q_T \Pi_T\right] = Q_t \mathbb{E}_t^{\mathbb{Q}}\left[E_T \Pi_T^*\right].$$

The expectation on the right-hand side appeared earlier in pricing the foreign inflation-linked bond (1.5), so we can replace it and state

$$\mathbb{E}_t^{\mathbb{Q}}\left[Q_T \Pi_T\right] = Q_t \frac{I_t}{R_t^*}.$$

Now we use the pricing formula for the domestic inflation-linked bond (1.4) to substitute for I_t and state Q_t as a function of real returns and expectations:

$$Q_t = \frac{R_t^*}{R_t}\frac{\mathbb{E}_t^{\mathbb{Q}}\left[Q_T \Pi_T\right]}{\mathbb{E}_t^{\mathbb{Q}}\left[\Pi_T\right]}.$$

Plugging this expression for the real exchange rate into the definition of the real exchange rate (1.6) we can solve for the nominal exchange rate:

$$E_t = \frac{P_t}{P_t^*}\frac{R_t^*}{R_t}\mathbb{E}_t^{\mathbb{Q}}\left[Q_T\frac{\Pi_T}{\mathbb{E}_t^{\mathbb{Q}}\Pi_T}\right]. \tag{1.8}$$

This is a sort of "Real Uncovered Interest Parity" relation.

We are interested in the true expected long-term real exchange rate, which we will call $Q_t^E = \mathbb{E}_t^{\mathbb{P}}[Q_T]$. The expectation (1.8) can be rewritten as

$$E_t = \frac{P_t}{P_t^*}\frac{R_t^*}{R_t}Q_t^E\Theta_t, \tag{1.9}$$

which defines Θ_t, a risk-premium term.[4]. It is important to note, that even a risk-neutral investor, where the risk-neutral probability measure $\mathbb{Q}$ is almost everywhere equal to the physical measure $\mathbb{P}$, could have $\Theta \neq 1$ because of the possible covariance between the real exchange rate and the domestic inflation rate. On the other hand, in our application we are interested in the covariance between US inflation and, for example, the real exchange rate with Turkey. We expect this to be zero.

Taking logs of both sides, and denoting logs of uppercase variables by their lowercase,

$$e_t = p_t - p_t^* + r_t^* - r_t + q_t^E + \theta_t. \tag{1.10}$$

Finally taking differences in time we have

$$\Delta e_t = \pi_t - \pi_t^* + \Delta r_t^* - \Delta r_t + \Delta q_t^E + \Delta\theta_t, \tag{1.11}$$

where Δ is the difference between $t-1$ and t in a monthly series.

It is worth stressing that this decomposition has relied only upon the assumption of no-

[4]Specifically, $\Theta_t = 1 + \frac{1}{Q_t^E}Cov^{\mathbb{P}}\left(Q_T, \frac{\frac{d\mathbb{Q}}{d\mathbb{P}}\Pi_T}{\mathbb{E}_t^{\mathbb{P}}\left[\frac{d\mathbb{Q}}{d\mathbb{P}}\Pi_T\right]}\right)$

arbitrage. Nor have we required any assumptions about the form of the pricing measure. This is in contrast to Clarida (2012) who assumes that the pricing measure is homogeneous in the domestic price level.

1.2.7 Comparison to the literature

Clarida (2012) presents results for developed countries' exchange rates by plotting e_t versus $p_t - p_t^* + r_t^* - r_t$. He calls the latter the "risk-neutral fair value." Following from 1.10 the difference is $q_t^E + \theta_t$. Arguably, for similar, large, and economically-integrated developed countries it may be reasonable to assume that q_t^E is constant and that θ_t is significant and volatile. However, for smaller, poorer, countries that are distant to US investors, θ_t should be close to zero, and q_t^E explains the difference.

Imakubo, Kamada, and Kan extend the Clarida framework assuming investors expectations of the real exchange rate is formed as the HP-filter of historical observations. We take the opposite approach and require fewer assumptions.

1.3 Empirical strategy

In this paper, we use the US Dollar as the domestic currency and examine, as foreign currencies, the Mexican Peso, Brazilian Real, South African Rand, and Turkish Lira.[5]

The notation above used t and T for the two time periods. We will call these today, and the long-term. The long-term will be 10-20 years depending on the data. Given that the real rate yield curve is typically flat between 10 and 20 years maturities the differences are arguably of minor economic importance.[6]

[5] This sample of countries is not random; these are the only developing countries that issue inflation-linked bonds. This reflects some financial competence on the part of the debt management agency in these countries. On the other hand, they may be issuing inflation-linked bonds because investors are wary of high inflation in that currency. We acknowledge these competing selection effects may be present.

[6] Specifically, for the sample April 2008 to July 2017 the Mexican zero-coupon real yield curve slope between

The changes denoted by Δ will be interpreted to be monthly, reflecting the frequency of CPI measurement by national statistical agencies. Accordingly we will perform a variance decomposition of monthly exchange rate changes.

Exchange rates, inflation rates, and real yields from inflation-linked bonds are all easily observable. These will allow us to jointly construct a monthly series for the sum $\Delta q_t^E + \Delta\theta_t$. Disentangling those two components would require some stricter assumptions, which we forego in the interest of generality.[7]

There is a strong argument that Θ_t is close to 1, so that θ_t is near zero. This would follow if the long-term real exchange rate Q_T is independent of both the stochastic discount factor and the domestic inflation rate. The first condition holds if US investors' marginal utilities vary independently of, for example, the prospects of South African mining operations. The second condition holds if over the long term, US inflation varies little with the real economy of Brazil. Consequently, it is economically difficult to justify a large θ_t. To prove $\theta_t = 0$ follows from independence, return to (1.8) and apply the law of iterated expectations to

$$\begin{aligned} \mathbb{E}_t^{\mathbb{P}}\left[Q_T \frac{m_T \Pi_T}{\mathbb{E}_t^{\mathbb{P}}(m_T \Pi_T)}\right] &= \mathbb{E}_t\left[\mathbb{E}_t\left[Q_T \tfrac{m_T \Pi_T}{\mathbb{E}_t(m_T \Pi_T)} \mid m_T, \Pi_T\right]\right] \\ &= \mathbb{E}_t\left[Q_T \mathbb{E}_t\left[\tfrac{m_T \Pi_T}{\mathbb{E}_t(m_T \Pi_T)} \mid m_T, \Pi_T\right]\right] = \mathbb{E}_t\left[Q_T\right] \end{aligned} \tag{1.12}$$

Once we have time series for $\pi_t - \pi_t^* + \Delta r_t^* - \Delta r_t$ and for $\Delta q_t^E + \Delta\theta_t$, we can use (1.11) to decompose the variance of Δe_t as

$$Var(\Delta e_t) = Var(\pi_t - \pi_t^* + \Delta r_t^* - \Delta r_t) + Var(\Delta q_t^E + \Delta\theta_t) + 2Cov(\pi_t - \pi_t^* + \Delta r_t^* - \Delta r_t, \Delta q_t^E + \Delta\theta_t). \tag{1.13}$$

A similar decomposition applies to the nominal exchange rate as a level e_t, following from (1.10).

10 and 20 years averaged 70 basis points with a standard deviation of 37 bps. Furthermore, all results at 20 year maturity are reproduced at 10 years maturity as a robustness check in appendix A.1.

[7] One approach could be to parametrize the pricing kernel. In appendix A.2 we outline a general approach for estimating pricing kernels from observable data and prices.

A second decomposition uses the identity

$$Var(\Delta e_t) = Cov(\Delta e_t, \Pi_t - \Pi_t^* + \Delta r_t^* - \Delta r_t) + Cov(\Delta e_t, \Delta q_t^E + \Delta \theta_t) \tag{1.14}$$

and similarly in changes. When we divide through by $Var(\Delta e_t)$ (in our case we normalize it), the terms on the right hand side are like regression coefficients that must sum to 1. In this case they can be interpreted as how well Δe_t explains its constituents.

1.4 Data

Long-term real yield data for the US is collected by the Federal Reserve, cleaned with the method of Gurkaynak, Sack, and Wright (2010), and available at https://www.federalreserve.gov/econresdata/default.htm.

Real yield data for Brazil, Mexico, South Africa, and Turkey is available from Bloomberg Finance L.P. We use month end yields and spline a real-yield par curve at each date. This par curve represents the yields of coupon-paying bonds. Splining a curve is standard practice to smooth over any bond-specific idiosyncrasies. We then convert the resulting par curve to a zero curve, from which we can select a fixed maturity. Figure 1.1 shows the results of this approach for Mexican inflation-linked bonds on November 30, 2012 (the midpoint of the sample).

Exchange rates are from the St. Louis Federal Reserve's FRED database, as is US CPI.

The Brazilian CPI (called IPCA) is from the website of the Brazilian statistical agency (IBGE.) The Mexican CPI (INPC) is from Banco de Mexico. The South African CPI is from Statistics South Africa. The Turkish CPI is from the Turkish Statistical Institute. All of these consumer price indices are reported and analyzed as monthly series.

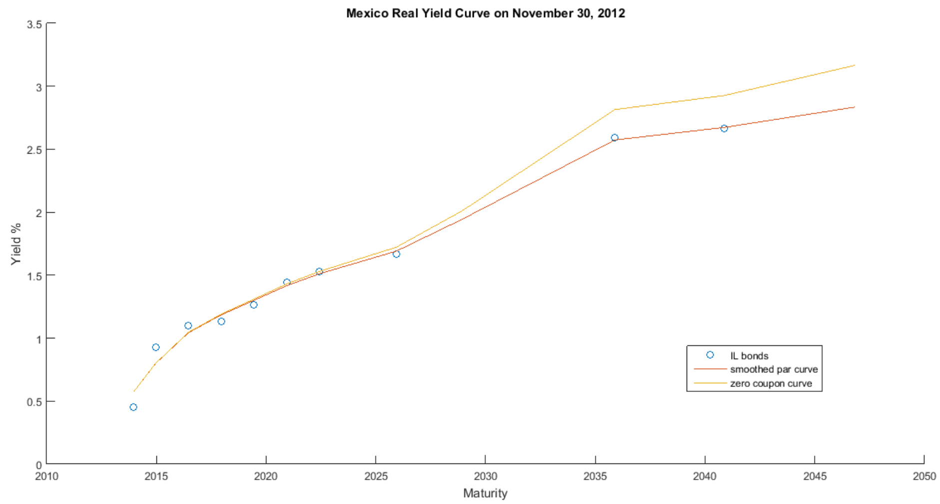

Figure 1.1: Mexican inflation-linked bond yields and smoothed par and zero real yield curves on November 30, 2012. Source: Bloomberg Finance LP and author's calculations.

1.5 Discussion of measurement

1.5.1 CPI timing

CPI for a month is measured throughout that month and then published sometime in the following month. In this paper we assume that the CPI is known by market participants at the end of the measurement month and the exchange rate is priced accordingly.

1.5.2 Inflation-linked bond timing

For settlement purposes, inflation-linked bonds trade with respect to a reference CPI, which is the CPI 3 months earlier, and interpolated between months. This means that the relevant price levels in the inflation-linked bond pricing-formula are actually mis-timed by 3 months. We can add a correction for this. We haven't done that, but it is tiny, because 3 months of inflation is small versus the future inflation over the 20 year life of the bond. Gurkaynak, Sack, and Wright (2010) ignore this when reporting expected future inflation on the Federal Reserve website. If the inflation observed since the reference CPI is the same as it is expected to be in the future, then this correction would be zero.[8]

1.5.3 Illiquidity

One possible objection to this approach is that these markets for inflation-linked bonds are relatively illiquid. However, we expect there exists a marginal investor willing to buy cheap assets. So the illiquidity objection is a rejection of the weak form of the efficient markets hypothesis. More generally, we can only ask what the market expects based on observable prices. Those expectations may be wrong ex-post or strange ex-ante.

Figure 1.2 plots the 10 year "breakeven inflation" computed as the difference between the nominal and real yields on Mexican nominal and inflation-linked government bonds versus the mean 1 year inflation expectations from Banco de Mexico's business conditions survey. The co-movement is evidence that the inflation-linked bond market tracks reported expectations. If anything, the correlation is higher than we might expect, suggesting that current inflation is assumed to last long into the future.

One possible manifestation of illiquidity could be prices that update infrequently because the bonds are not being traded on a given day. We would expect this problem to be more prevalent for 20 year maturities than for 10 year, and also to be more significant earlier in the time series because of the financial crisis of 2008. Appendix A.1 shows results for the 10 year maturities that are substantively similar to those for the 20 year maturities. Furthermore, figures 1.5 and 1.6 show similar behavior for the long-term real exchange rate plus risk premium in 2008-2009 and in 2012-2016. Consequently, we conclude that the results are not driven by stale prices on illiquid bonds.

[8] Specifically, this correction would be to the real yield, and the magnitude is the difference between expected inflation and that realized over the preceding 3 months multiplied by 3mths and divided by the maturity in months.

Figure 1.2: 20 year ”breakeven inflation” expectations for Mexico versus 1 yr inflation expectations reported by the Banco de Mexico. Data from Bloomberg, FRED, national statistical agencies, and author’s calculations.

1.5.4 Default Risk

If there were a serious possibility of default on these bonds then the yields would carry some premium. No country has defaulted on bonds issued in a currency they can print since Russia in 1998, which was a special case (the local currency debt was largely held by foreign investors, including Long Term Capital Management). The US has occasionally threatened to default in the last few years but in those episodes US bonds have actually gone up in price.

The credit default swap (CDS) market shows a probability of default for these countries, but this is somewhat technical. The CDS reflects the probability of a credit event and a recovery rate on the lowest valued deliverable security. Say for example, if Turkey defaults on a euro-denominated bond for political reasons and continues payments on its local-currency bonds. Then the buyer of protection uses the CDS to deliver the defaulted euro-denominated bond to the seller of protection. The local-currency bonds would be unaffected. Therefore the CDS market hugely overstates the probabilities of credit events in local-currency markets.

Stockman (1988) suggests that capital controls would be more likely imposed in a time of high inflation. This would lead the market to under-price inflation because full repayment is less likely in that scenario. Therefore the market-implied expected long-term real exchange rate would be lower than the true (physical measure) expectation. We admit that these “peso problems”, or unobservable risks, are possible but doubt that they are significant factors in pricing. Either way they would affect the θ_t term and not the results we present.

The key results of this paper concern the volatility and not the level of the long-term real exchange rate. If default or capital controls are more likely under high inflation, then that would slow the market from pricing high inflation. This would reduce the volatility of the long-term real exchange rate. So if these concerns are salient, our results are conservative estimates of the volatility of the long-term real exchange rate, which we will find to be dominant.

1.5.5 Inflation-floor protection

Most inflation-linked bonds have a built-in floor. This means that investors are protected in case of deflation over the life of the bond. 20 years of deflation in the developing countries we study has not happened in recent history and we assume the risk of this in the future is assessed as low by market participants. In the US, the value depends on when exactly the bond was issued. Over the long term this risk must be small. Therefore we use 20 year real yields for the US without worrying about adjusting for the possibility of 20 years of deflation.

1.6 Results

Figure 1.3 plots the log of the gross 20 year real yields for Mexico and the US, which are r and r^* in equation 1.10. Figure 1.4 plots the evolution of the price levels, or CPI, in Mexico and the US. Figure 1.5 plots the result of the decomposition, following equation 1.10, of the nominal exchange and the expected long-term real exchange rate plus its risk premium. Of note is that the latter is more volatile than the former. Furthermore, the market always expects a real depreciation

Figure 1.3: Real yields with 20 year maturity for Mexio and USA. Sample is April 2008 to July 2017. Data from Bloomberg, FRED, national statistical agencies, and author's calculations.

over the next 20 years.

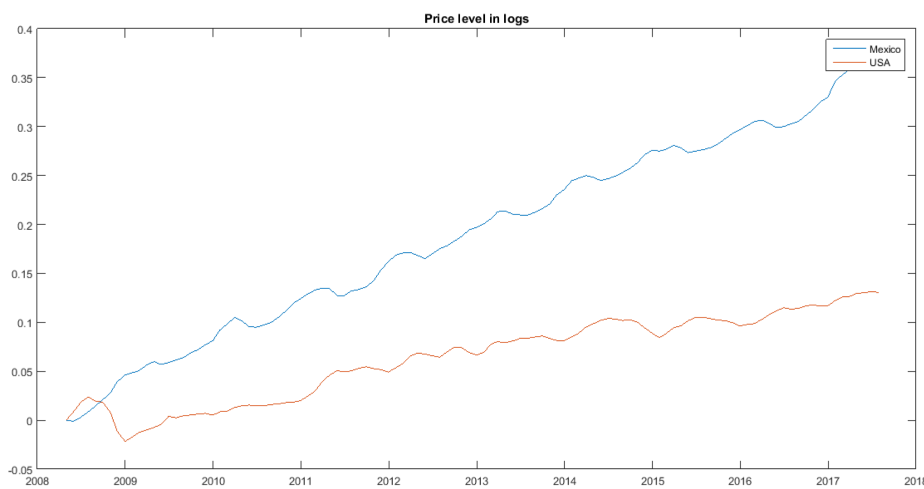

Figure 1.4: Consumer price indices for the US and Mexico, rebased so the price level starts at 1. Sample is April 2008 to July 2017. Data from FRED and national statistical agencies.

Table 1.1 reports the variance decomposition in levels and monthly changes for Mexico, Brazil, South Africa, and Turkey. The variance of the nominal exchange rate for each country has been normalized to 100 for both levels and changes. The long-term is defined as 20 years for the

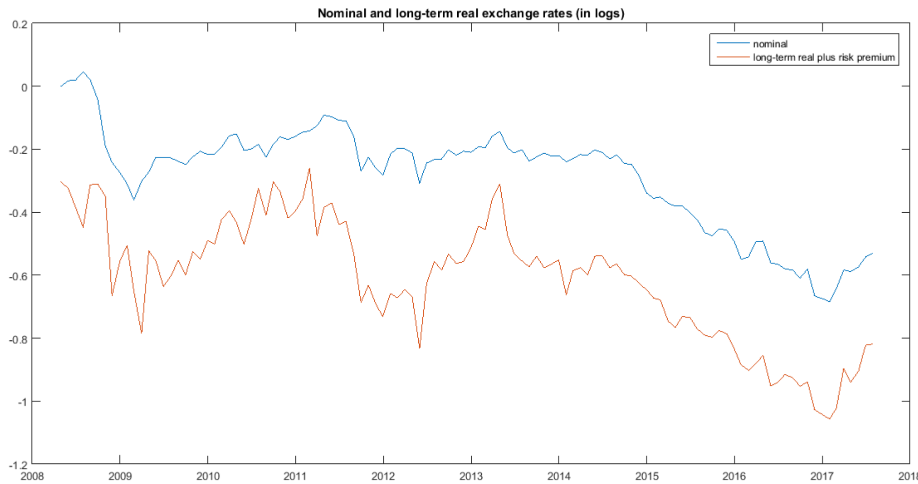

Figure 1.5: Exchange rates between Mexico and the United States, rebased so the nominal exchange rate starts at 1. Sample is April 2008 to July 2017. Data from Bloomberg, FRED, national statistical agencies, and author's calculations.

Table 1.1: Variance decomposition of nominal exchange rate for Mexico, Brazil, South Africa, and Turkey exchange rates versus the US. The long term is 20 years forward, except for Turkey where it is 10 years forward. Sample is April 2008 to July 2017 for Mexico, November 2005 to July 2017 for Brazil, September 2011 to July 2017 for South Africa, and April 2010 to July 2017 for Turkey, in all cases the sample start is determined by data availability. Data are normalized such that $var(e_t) = 100$ for each row. Data from Bloomberg, FRED, national statistical agencies, and author's calculations.

		$var(q_t^E + \theta_t)$	$var(p_t - p_t^* - r_t + r_t^*)$	$cov(q_t^E + \theta_t, p_t - p_t^* - r_t + r_t^*)$
Mexico	levels	137	21	-29
	changes	496	362	-379
Brazil	levels	117	47	-32
	changes	356	189	-222
South Africa	levels	28	36	18
	changes	208	92	-100
Turkey	levels	31	40	14
	changes	256	189	-172

first three countries and as 10 years for Turkey.

For all four countries, the long-term real exchange rate plus its risk premium is more volatile than the nominal exchange rate, where volatility is defined as the variance of the changes.

For Mexico and Brazil, $q_t^E + \theta_t$ varies more than the nominal exchange rate, e_t, in levels. For South Africa and Turkey on the other hand, $q_t^E + \theta_t$ varies less than e_t in levels, suggesting mean-reversion in the changes of the former.

Table 1.2 reports the covariance decomposition, where the two columns of course sum to the normalized variance 100. The same key facts are apparent: that the real exchange rate plus the risk premium is the dominant contributor to variance of changes (volatility) in all countries, and that South African and Turkey are qualitatively different in levels.

Table 1.2: Covariance decomposition of nominal exchange rate for Mexico, Brazil, South Africa, and Turkey exchange rates versus the US. The long term is 20 years forward, except for Turkey where it is 10 years forward. Sample is April 2008 to July 2017 for Mexico, November 2005 to July 2017 for Brazil, September 2011 to July 2017 for South Africa, and April 2010 to July 2017 for Turkey, in all cases the sample start is determined by data availability. Data are normalized such that $var(e_t) = 100$ for each row. Data from Bloomberg, FRED, national statistical agencies, and author's calculations.

		$cov(e_t, q_t^E + \theta_t)$	$cov(e_t, p_t - p_t^* - r_t + r_t^*)$
Mexico	levels	108	-8
	changes	117	-17
Brazil	levels	85	15
	changes	134	-34
South Africa	levels	46	54
	changes	108	-8
Turkey	levels	45	55
	changes	83	17

Figure 1.6 plots the time series of the decomposition for Brazil. It is interesting to note that, for example, the depreciation of the Brazilian Real in 2015 was driven by the long-term real exchange rate. Relative to the US dollar, the currency is always (over our whole sample) expected to depreciate in real terms over the next 20 years.

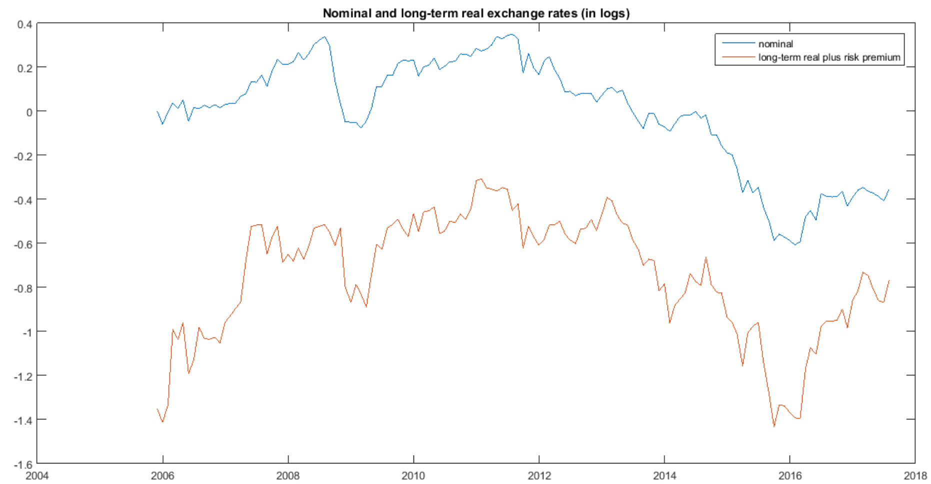

Figure 1.6: Exchange rates between Brazil and the United States, rebased so the nominal exchange rate starts at 1. Sample is November 2005 to July 2017. Data from Bloomberg, FRED, national statistical agencies, and author's calculations.

1.7 Conclusion

Real exchange rate volatility may be the fundamental puzzle of international macroeconomics (Chari, Kehoe, and McGrattan 2002.) Real exchange rates are the long-term, conceptual determinants of exchange rates outside of hyper-inflationary episodes. For the exchange rates between the United States and Brazil, Mexico, South Africa, and Turkey, the long-term real exchange rate and risk premium contribute more than double the variance to monthly changes in nominal exchange rates.

This evidence reinforces to the "exchange rate determination puzzle" in which exchange rates vary considerably more than fundamentals, and which may be explained by, for example, heterogeneity of beliefs (Bacchetta and van Wincoop 2006.) This evidence is inconsistent with the standard open economy macroeconomics explanation of sticky prices and monetary shocks. After a monetary shock, these models predict prices will adjust slowly so that the real exchange will mean revert to a level determined by fundamentals.

For monthly or shorter changes in the exchange rate market, it is not only that the expected long-term real rate is significant. It is, more nearly, that the expected long-term real exchange rate is the only thing that matters.

Chapter 2

An equity portfolio investment channel for real exchange rate volatility

2.1 Introduction

Exchange rates are volatile and move more than forecast by standard existing models (the sixth puzzle of Obstfeld and Rogoff, 2000.)[1] Accounting for inflation differentials it is variation in the real exchange rate, or the ratio of price levels between countries, that is particularly difficult to explain. In other words, relative price levels are neither stable nor mean-reverting.

In figure 2.1, we plot real exchange rates for six developing countries and the United States over a five year period (taken from the BIS and normalized to show only changes.) Table 2.1 shows the standard deviation of monthly real exchange rate changes for each country. Ignoring trends, developing countries' real exchange rates are more volatile than for the US, by roughly a factor of two. So the fundamental puzzle of real exchange rates is even more pronounced in these countries. A key distinction is that developing countries have lower productivity and price

[1] "The central puzzle in international business cycles is that fluctuations in real exchange rates are volatile and persistent." So state Chari, Kehoe, and McGrattan 2002 in the first sentence of their abstract and then again in the first sentence of their paper.

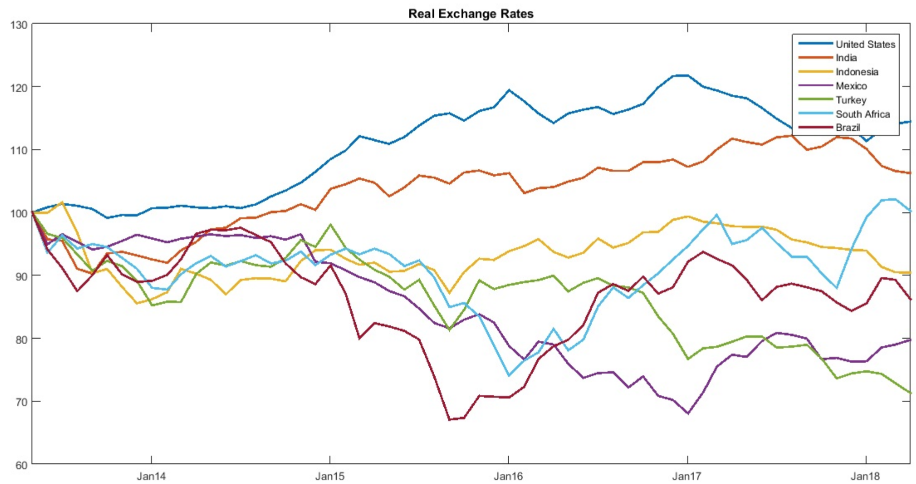

Figure 2.1: Broad Real Effective Exchange Rates, May 2013 - April 2018. Rebased to 100 at May 2013. Source: Bank for International Settlements

levels, and therefore can either catch up or fall back in relative terms to the US. The US on the other hand is near the technological frontier and makes productive advances through an entirely different mechanism.

Developing countries interact commercially with developed countries with trade in goods and with financial investment flows, both of which may facilitate changes in productivity. Financial flows dominate the discussion of economic outcomes in developing countries in the

Table 2.1: Mean and standard deviation of monthly changes in Broad Real Effective Exchange Rates, May 2013 - April 2018. Data from Bank for International Settlements and author's calculations.

	(1)	(2)
	mean	std dev
United States	0.24%	1.09%
India	0.11%	1.53%
Indonesia	-0.15%	1.97%
Mexico	-0.36%	2.25%
Turkey	-0.54%	2.41%
South Africa	0.05%	2.99%
Brazil	-0.20%	3.33%

popular and financial press. However in most international economic models prices adjust without any transactions taking place. Given the scale of financial flows and documented effects at the firm level, it is natural to investigate their importance at the country level.[2] We fill this gap by providing a real model that incorporates foreign investment, new trade, and exchange rate determination.

We use import customs data from the UN Comtrade database, classified by the Harmonized System at the 6-digit level, and international investment flow data from the IMF's Balance of Payments Database for the years 2000-2016. We document that equity portfolio investment predicts the extensive margin of imports in developing countries. We furthermore control for endogeneity of the equity portfolio investment, by instrumenting for recipient inflows with equity portfolio outflows from large developed countries, weighted by trade shares to the recipient countries, and find similar results. We use the classification of imports into Broad Economic Categories provided by the UN and find that more than 90% of the new imports predicted were intermediate or capital goods.

Then we look at older episodes of equity market liberalizations and import data classified by the SITC system at the 5-digit level. We test for a structural break in the growth rate of the extensive margin of imports and find that it increased (formally, we reject the null hypothesis that it stayed the same.) This new fact, that equity portfolio investment finances new imports at the country level forms the foundation of the model. In an appendix we also tests and confirm the already established fact that equity portfolio investment is procyclical with respect to equity returns in these countries. We use this to motivate the inclusion of a portfolio or leverage constraint in the model.

This paper presents a purely real model of the exchange rate in which foreign investment finances imports of new intermediate goods. These intermediate goods are used to make tradeable goods more productively. We don't require transport costs and therefore tradeable goods have

[2]Section 2.1 summarizes literature on portfolio investment in equities in developing countries.

one price globally. The real exchange rate is determined by the relative price of nontradeable goods, as in the Balassa-Samuelson effect (both 1964). Furthermore the real exchange rate moves with relative national incomes, known as the Penn effect. We choose to model this way in order to capture the economically beneficial effects of foreign investment.

In order to richen the dynamics we assume that foreign investors face a leverage constraint. To build an information channel into the model we assume there is an information signalling mechansim about future productivity in order to generate equity price volatility. The leverage constraint for foreign investors causes feedback from equity prices into investment, productivity, and thus the equilibrium exchange rate. The endogenous amplification of volatility explains why real exchange rates move as much as they do.

The first key test we perform is a regression of nominal exchange rates on portfolio equity investment at the quarterly frequency, where we find predictability. The second test is a regression of the real exchange rate on new varieties of imports, where we find comovement, and on lagged portfolio equity investment, where we do not reject that it is insignificant other than via new imports. We then parametrize the model and ask how important this channel is for transmiting equity price volatility to exchange rate volatility and for the effect of a rise in the world real interest rate on real exchange rates.

The contributions of this paper are to 1) document the real effects of portfolio equity investment on new imports, 2) solve a real model in which foreign investment appears explicitly in the closed form solution for the real exchange rate, and 3) illustrate the connection between equity prices and real exchange rates. This solves the puzzle that developing countries exchange rates react to the world real interest rate, and not just to interest rate differentials, as predicted by uncovered interest parity. [3]

The model is entirely real, so is distinct from mechanisms in which the central bank is at fault for all crises. Furthermore, although bad loans or other problems in the banking system

[3]Developing countries' currencies' generalized depreciations between 2013 and 2017 are largely attributed to rising US interest rates even though most EM rates rose even more.

can obviously cause a crisis, the mechanism in this paper operates independently of anything happening in a domestic banking system. The model ascribes real effects to portfolio flows, and offers a closed form expression for the real exchange rate. Several empirical facts corroborate the model's mechanisms and implications.

This paper contains elements from international trade, macroeconomics, and finance, and consequently builds upon several distinct literatures.

A long-studied question has been the relationship between trade and growth and the direction of causation. Frankel and Romer (1999) suggest that trade itself causes growth at the macro level. Both Romer (1990) and Grossman and Helpman (1991) modeled growth as the creation of new intermediate inputs, which we use to make the connection between portfolio investment and productivity via new intermediates. Feenstra and Kee (2008) examine the relationship between export variety and country productivity, whereas we flip this and think about imported input variety determining productivity.

Leverage constraints are understood as a source of amplification and contagion of falling asset prices by Pavlova and Rigobon (2008), however changing the market price of an endowment stream is a relatively small and uninteresting effect compared to understanding the large real fluctuations in those countries. We show how leverage constraints connect prices to financial flows to real outcomes.

A large literature focuses on crisis episodes in developing countries and seeks to explain the prevalence of those episodes. The first point is that borrowing in a foreign currency makes depreciations worse for the borrower, and being forced to borrow in foreign currency is typically called the "original sin" of developing countries. Eichengreen and Hausmann (1999) suggest that foreign currency borrowing creates financial fragility and can be avoided by developing deeper domestic credit markets to allow local currency borrowing. Tirole (2003), however, argues that foreign currency borrowing is optimal because it commits the country to avoid depreciation at the expense of creditors. We do not consider debt at all and target a completely distinct mechanism.

The existing literature on third-generation currency crises that arose after the Asian crisis of 1998 typically has domestic firms borrowing in foreign currency to finance production (e.g. Aghion, Bacchetta, and Banerjee 2001 or Corsetti and Pesenti 2001.) A shock to production, the interest rate, or the exchange rate can then lead to default or depreciation via a drop in domestic money demand. However, in these cases, optimal monetary policy can prevent the devaluation and the default. This is the international crisis equivalent of Friedman and Schwartz's conclusion that the Great Depression was, as Ben Bernanke put it, essentially the central bank's fault.[4] This paper argues that any less-developed country open to capital flows may experience real exchange rate volatility independent of monetary policy.

The standard explanation in small, open economy macroeconomics is illustrated in Chari, Kehoe, and McGrattan (2002.) Monetary shocks and sticky prices interact so that when the money supply increases the real exchange rate depreciates and output increases. This is the opposite correlation from our model and the Balassa-Samuelson effect. Furthermore, Blanco and Cravino (2018) find at the micro level that prices which are updated in each period do not violate relative purchasing power parity any less. In Chapter 1 we showed that the market expectation of the long term real exchange rate and its risk premium is as volatile or more volatile than the nominal exchange rate. Consequently, neither price setters nor financial markets behave as if it is sticky prices that cause the real exchange rate movement.

In distinct mechanisms, many important papers generate exchange rate movements with a selected shock or shocks. Mendoza (2010) generates a leverage cycle, including busts, with correlated shocks for total factor productivity, the world interest rate, and the price of intermediate inputs. An alternative explanation has been that foreign securities firms face destructive trading costs in equities which, coupled with a domestic collateral constraint that limits debt borrowing, make equity prices volatile and debt-deflation possible (Mendoza and Smith 2013.) Ghironi and Melitz (2005) generate real exchange rate movement via productivity shocks to heterogeneous

[4]"Regarding the Great Depression. You're right, we did it. We're very sorry." Bernanke 2002

firms that cause variety destruction.

Finally, the impossibility of controlling the exchange rate, allowing international capital mobility, and implementing independent monetary policy is well established as the "trilemma" (Obstfeld and Taylor 2004.) More recently, Rey (2015) argues for the existence of a "global financial cycle" that subsumes domestic monetary policy. Those papers primarily view capital flows as a monetary phenomenon. This chapter documents that portfolio flows have significant effects via real channels, and that country-specific factors remain important in the face of a global cycle.

One interpretation of this chapter is a contribution to explain the "global financial cycle" as operating through a specific channel of portfolio investment in equities and new imports of intermediates. However we are in contrast to Rey in showing that there are gains to international capital flows in the data and we present them as our key empirical motivating fact.

The remainder of the chapter is organized as follows. Section 2 and 3 document an empirical facts, entirely new, that portfolio equity investment predicts imports of new varieties of goods. Section 4 briefly describes the model, and then presents the full model, resulting in a few key equations for the important dynamics. Section 5 reports two regressions: the first is of the quarterly exchange rate change on lags of equity price changes, portfolio flows, and the exchange rate change, confirming that portfolio equity investment predicts the exchange rate; the second is of the annual real exchange rate on imports of new varieties of goods in that year and on the previous year's foreign equity investment inflows, confirming that new varieties comove with the real exchange rate and finding no other statistically significant effect of the preceding years' foreign investment inflows. In section 6 we ask what plausible magnitudes the model explains and apply the parametrized model to explain the "taper tantrum" and excess exchange rate volatility. Section 7 concludes.

2.2 Portfolio equity investment

2.2.1 Literature on real effects of portfolio investment

Many studies have found that foreign portfolio investment relaxes domestic financial constraints and frictions. Henry (2007) summarized "(a)ll the evidence we have indicates that countries derive substantial benefits from opening their equity markets to foreign investors." Claessens and Rhee (1994) found that stock markets in which it was easier to invest had higher P/E ratios. Levine and Zervos (1998) showed that stock market liquidity and banking development positively predict growth. Henry (2000) found that stock market liberalizations in developing countries were followed by positive excess stock returns. This shows that foreign investors provide additional productive capital for a lower expected return at the margin. Sensitivity of small firms' investment to cash flow fell 80% after financial liberalizations in a panel of firms from 13 countries (Laeven 2002.) Edison, Klein, Ricci, and Sløk (2004) and Bekaert, Haney, and Lundblad (2005) found that financial liberalizations spurred growth, or in other words that financing market failures inhibited productive investment. Forbes (2007) found that the Chilean "encaje" tax on capital flows caused financial constraints for small firms. So access to foreign capital did finance investment that would otherwise not happen. After equity market liberalizations, firms in sectors more dependent on external finance increased exports more (Manova 2008.) Taken together, these results suggest that portfolio equity investment provides financing for productive investment that would not otherwise occur.

A separate literature supports the notion that foreign ownership improves productivity, including in linked firms, and makes exporting more likely, including in neighboring firms. Mexican manufacturing firms with some foreign investor were more likely to export and other firms near them were too (Aitken, Hanson, Harrison 1997.) Small Venezuelan firms between 1976 and 1980 showed a positive correlation between foreign ownership and productivity (Aitken and Harrison 1999.) Javorcik (2004) examined foreign ownership of Lithuanian firms and found "backward linkages", or improved productivity in other sectors. Foreign ownership was correlated with productivity, and the foreign ownership variable had a mean of 7.8% and a standard deviation of 23%, indicating that this effect was about portfolio investment and not direct investment. Ramondo (2009) found "foreign-owned" plants in Chile are more productive, where "foreign-owned" is defined as 10% or more foreign share of ownership. Bloom (2019b) examines the same plants and finds that the beneficial effects of foreign ownership occur at levels of ownership associated with portfolio investment, and finds no evidence that direct investment is more important. From these studies, we can expect portfolio equity investment to improve productivity in recipient firms.

Finally there is evidence that listed firms are better managed and that free advice improves productivity. Listed firms were better managed than private or family firms, and privatized firms were better managed than government-owned (Bloom and Van Reenen 2010.) Free consulting on management practices at Indian firms improved productivity by 11% (Bloom, Eifert, Mahajan, McKenzie, and Roberts 2013.) And we know that investors impart knowledge of best-practices to firms' management via roadshows and earnings conference calls (Jung, Wong, and Zhang 2018 or Call, Sharp, and Shohfi 2018.) Together this implies that portfolio equity investment can improve productivity in recipient firms via advice and recommendations from foreign investors.

2.2.2 Traded varieties and portfolio investment

The extensive margin of imports

In this section we document a new fact, that equity portfolio flows predict imports of new varieties of goods, or the extensive margin of international trade. We furthermore show that these new varieties of goods are primarily intermediate inputs and capital goods.

Import data is available from UN Comtrade. We use the 1996 Harmonized System of classification at the 6 digit level. We examine 18 developing countries in the years 2000-

2016 (because before 2000, some imports are unclassified and reported as a residual outside of classification.)[5] These constitute the largest less-developed countries that are relatively open to foreign portfolio investment.[6]

Each country reports its own customs data to UN Comtrade, however very small flows are not recorded, and the cutoff for reporting is not consistent across countries. Therefore, we want to count small flows and zeros similarly, to avoid inconsistencies, and consider them all sparsely-traded. This follows Kehoe and Ruhl (2013) in their definition of the extensive margin of trade (their paper title refers to the "new goods margin"). Earlier work on the extensive margin such as Hummels and Klenow (2005) or Broda and Weinstein (2006) followed Feenstra (1994) in only considering zero recorded imports as non-traded when measuring the extensive margin. Kehoe and Ruhl (2013) document that their method is more robust and behaves as expected around events like trade liberalizations.

Imports are ranked by traded value in US dollars, and the first set comprising 90% of imports by value are mainly-traded goods that sum to $M_t^{(t)}$ in US dollars.[7] The remaining goods, sparsley-traded, sum to $S_t^{(t)}$. The superscript indicates when the goods are ordered, and the subscript indicates when the imported values are summed. So we have that $Imports_t = M_t^{(t)} + S_t^{(t)}$,

[5] Argentina, Brazil, Chile, Colombia, India, Indonesia, Malaysia, Mexico, Nigeria, Peru, Philippines, Poland, Russia, South Africa, Thailand, Turkey, Venezuela, Vietnam.

[6] Largest means that each has GDP greater than 195bn USD in 2016, less-developed means GDP per capita less than 16k USD in 2016 , and relatively open means that the average level of the Chinn-Ito Financial Openness Index from 1990-2015 is greater than -1.2. Bangladesh and Egypt are excluded because they are missing some recent years' import data in the UN Comtrade database.

[7] The definition of the extensive margin of imports as the 10% least traded goods follows Kehoe and Ruhl (2013.) Appendix B.1 shows a robustness check by redoing Table 2.3 with a 5% threshold and finds very similar results.

and that import growth can be decomposed as the weighted average of each group's growth:

$$\begin{aligned}\frac{Imports_{t+1}}{Imports_t} &= \frac{M_{t+1}^{(t)}+S_{t+1}^{(t)}}{M_t^{(t)}+S_t^{(t)}}\\ &= \frac{M_t^{(t)}}{M_t^{(t)}+S_t^{(t)}}\frac{M_{t+1}^{(t)}}{M_t^{(t)}}+\frac{S_t^{(t)}}{M_t^{(t)}+S_t^{(t)}}\frac{S_{t+1}^{(t)}}{S_t^{(t)}}\\ &= 0.9\times\frac{M_{t+1}^{(t)}}{M_t^{(t)}}+0.1\times\frac{S_{t+1}^{(t)}}{S_t^{(t)}}.\end{aligned}$$

OLS regression

To test the mechanism for new varieties growth, we are interested in absolute growth in the goods below the sparsely-traded threshold, $S_{t+1}^{(t)}-S_t^{(t)}$. The dependent variable in the regression is this divided by GDP in year t. This represents the margin of import growth to GDP attributable to the goods in the $S_t^{(t)}$ category:

$$\frac{Imports_{t+1}-Imports_t}{GDP_t}=\frac{M_{t+1}^{(t)}-M_t^{(t)}}{GDP_t}+\frac{S_{t+1}^{(t)}-S_t^{(t)}}{GDP_t}.$$

We will refer to this as both the extensive margin of imports and as new varieties of imported goods, although strictly speaking they may already be imported in small values.

The independent variables of foreign investment inflows come from the IMF Balance of Payments Database. They record net incurrence of liabilities for each country in each year, classified as foreign direct or portfolio investment. We plot direct investment and portfolio investment as fractions of GDP in figures 2.2 and 2.3 respectively.

The estimating equation is

$$\left(\frac{S_{t+1}^{(t)}-S_t^{(t)}}{GDP_t}\right)_i=\alpha_i+\delta_t+\beta\left(\frac{Inflows}{GDP}\right)_{i,t}+\gamma Controls_{i,t}+\varepsilon_{i,t+1}.$$

Regression results are shown in table 2.2. The preferred specification regresses new

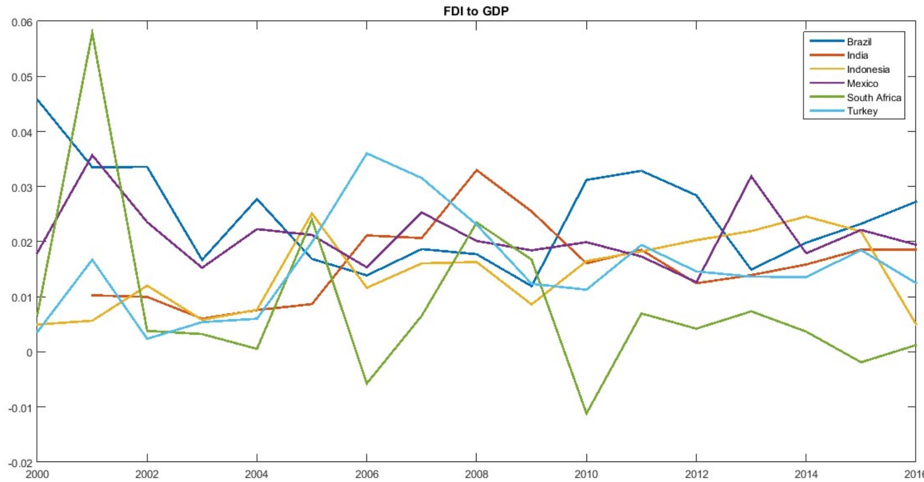

Figure 2.2: Foreign direct investment to GDP for select countries 2000-2016. The series is the net incurrence of liabilities in equity securities from the IMF Balance of Payments Database.

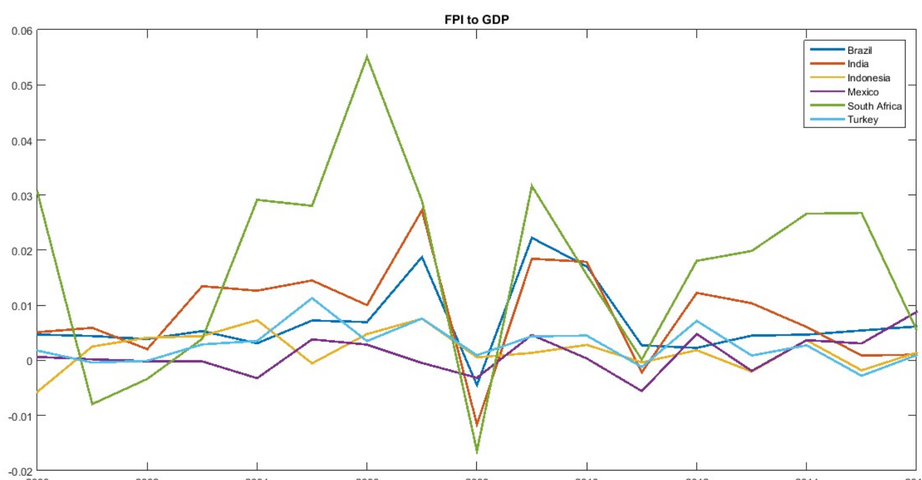

Figure 2.3: Foreign portfolio investment to GDP for select countries 2000-2016. The series is the net incurrence of liabilities in equity securities from the IMF Balance of Payments Database.

varieties imported on lagged portfolio investment. It is remarkable that foreign direct investment has no significant effect. Portfolio investment, however, has predictive power at the 1% significance level. Because all specifications include country fixed effects, we do not cluster standard errors by country, in agreement with Abadie, Athey, Imbens, and Wooldridge (2017). [8]

Table 2.2: Regression of extensive margin of imports on investment inflows and lag of the dependent variable. The final column means that an extra 1000 USD of portfolio investment predicts 89.6 USD of extra imports of new varieties. All variables are expressed as fractions of GDP. Data cover 2001 to 2015. Data from IMF, World Bank, and Federal Reserve. Standard errors in brackets. *** p<0.01, ** p<0.05, * p<0.1

	(1)	(2)	(3)	(4)	(5)	(6)
			new varieties imported			
lag portf eq invt	0.211***	0.213***	0.214***	0.0956***	0.0902***	0.0896***
	[0.0388]	[0.0373]	[0.0371]	[0.0361]	[0.0347]	[0.0345]
lag direct eq invt	-0.00322	0.00551		-0.0174	-0.0150	
	[0.0356]	[0.0327]		[0.0306]	[0.0285]	
lag new imports	0.044			-0.056		
	[0.061]			[0.061]		
country f.e.	yes	yes	yes	yes	yes	yes
year f.e.	no	no	yes	yes	yes	
Observations	252	266	267	252	266	267
R-squared	0.510	0.508	0.508	0.686	0.685	0.685

The Rey hypothesis for a global financial cycle finds some confirmation in the significance of the year fixed effects. Clearly portfolio flows are synchronized across countries and imports of new varieties are also, so the coefficient on portfolio flows is smaller when year fixed effects are included. However, the results with year fixed effects show that within-year variation is important too. Therefore within the global financial cycle, country differences matter.

Table 2.3 repeats the regression adding two lags of GDP growth as a control. GDP is expressed in US dollars, so local currency appreciation appears in this control. If portfolio equity investment is driven by news that also causes new imports in the following year, that news should

[8]Columns 1 and 4 suffer from dynamic panel, or Nickell (1981), bias because they include both country fixed effects and a lag of the dependent variable.

also increase current GDP and appreciate the local currency. Therefore, if this news channel is significant, adding the control of dollar local GDP growth should decrease the estimated effect of portfolio equity investment on new imports. Table 2.3 reports estimates nearly identical to table 2.2, suggesting that the news channel is not a primary causal mechanism for the new imports.

Table 2.3: Regression of extensive margin of imports on investment inflows and lag of the dependent variable with added controls. The final column means that an extra 1000 USD of portfolio investment predicts 88.7 USD of extra imports of new varieties. GDP growth is year-on-year change in each country's GDP expressed in US dollars. All other variables are expressed as fractions of GDP. Data cover 2001 to 2015. Data from IMF, World Bank, and Federal Reserve. Standard errors in brackets. *** p<0.01, ** p<0.05, * p<0.1

	(1)	(2)	(3)	(4)	(5)	(6)
	new varieties imported					
lag portfolio eq invt	0.207***	0.205***	0.205***	0.0944***	0.0894**	0.0887**
	[0.0385]	[0.0371]	[0.0369]	[0.0362]	[0.0346]	[0.0345]
lag direct equity invt	0.00405	0.00349		-0.0223	-0.0192	
	[0.0356]	[0.0326]		[0.0310]	[0.0287]	
lag new imports	-0.0354			-0.0470		
	[0.0697]			[0.0630]		
two lags gdp growth	yes	yes	yes	yes	yes	yes
country fixed effects	yes	yes	yes	yes	yes	yes
year fixed effects	no	no	no	yes	yes	yes
Observations	252	266	267	252	266	267
R-squared	0.521	0.521	0.521	0.688	0.688	0.688

Instrumental variables

We cannot yet claim that the portfolio equity investment is causing the new imports in these countries because of endogeneity. This endogeneity consists of "push" factors such as global monetary conditions and global growth, and "pull" factors such as news of investment opportunities in the recipient country. We can eliminate the latter by instrumenting for portfolio equity inflows to a country with a Bartik-like (1991) instrument that interacts portfolio equity outflows from the USA, UK, Japan, and Euro area with the recipient countries' share of imports by the developed country in the year 2005 and a measure of ease of trading in the recipient stock market.

This instrument is also in the style of the gravity model of financial flows from Portes and Rey (2005), however here we considered both positive and negative flows, instead of estimated sums of inflows and outflows in absolute value. Portes and Rey found that the magnitude of inflows could be well-estimated by $\ln | inflows_{i,t} | = \beta \ln | outflows_{j,t} | + \delta \left[X_{ij}\right] + \varepsilon_{i,t}$ where X_{ij} are controls, such as distance or shared language, between countries i and j. To adapt this to our problem, with positive and negative flows, we take the exponent and fit a non-linear model by least squares.

The estimating equation for the first-stage of the instrumental variables regression is

$$\begin{aligned} \frac{Inflows_{i,t}}{GDP_{i,t}} = \quad & \alpha_i + \delta_t + \beta_{USA} \frac{Outflows_{USA,t}}{GDP_{i,t}} Tradeshare_{i,USA}^{\gamma_1} Openness_{i,t}^{\gamma_2} \\ & + \beta_{EUR} \frac{Outflows_{EUR,t}}{GDP_{i,t}} Tradeshare_{i,EUR}^{\gamma_1} Openness_{i,t}^{\gamma_2} \\ & + \beta_{UK} \frac{Outflows_{UK,t}}{GDP_{i,t}} Tradeshare_{i,UK}^{\gamma_1} Openness_{i,t}^{\gamma_2} \\ & + \beta_{JPN} \frac{Outflows_{JPN,t}}{GDP_{i,t}} Tradeshare_{i,JPN}^{\gamma_1} Openness_{i,t}^{\gamma_2} + controls_{i,t} + \varepsilon_t. \end{aligned} \tag{2.1}$$

The idea is to approximate what fraction of developed countries' outflows would go to each destination country. This should depend on how linked the two countries are by trade in physical goods. It should also depend on the easy of trading in that market. The "openness" index used is the IMF's Financial Market Access index. The tradeshare is the balance of payments counterpart to the financial account flow. Specifically it is the share of the developed country's imports that come from the developing country. The coefficients γ_1 and γ_2 are chosen jointly to minimize the sum of squared errors in the non-linear first stage.[9]

This instrument is valid if the weighted shares are orthogonal to the innovations in the

[9]The estimated equation for the first stage of column 6, for example, of table 2.4 uses $\beta_{USA} = \underset{(0.21)}{-0.15}$, $\beta_{EUR} = \underset{(0.57)}{0.33}$, $\beta_{UK} = \underset{(1.48)}{1.20}$, $\beta_{JPN} = \underset{(0.70)}{-0.74}$, $\gamma_1 = \underset{(0.27)}{0.57}$, and $\gamma_2 = \underset{(0.62)}{2.00}$.

extensive margin of imports. A threat to identification could be that in a year following, for example, large US foreign portfolio investment, the US exports new things to countries it already trades with heavily. A further threat to identification could be if the IMF's Financial Market Access index reflects reforms in a year that lead to a growth in trade the following year. However, the index is largely static across the sample period so we suspect this is unlikely.

Table 2.4 reports the results for the instrumental variables regression. The first stage F statistics confirm the relevance of the instruments for the portfolio equity inflows. Where direct investment appears in the regression, it is instrumented in exactly the same way. Appendix B.2 shows that the model from section 3 would expect 0.35 for the first regression coefficient in these tables.

Table 2.4: Instrumental variables regression of extensive margin of imports on investment inflows and lag of the dependent variable. The final column means that an extra 1000 USD of portfolio investment predicts 230 USD of extra imports of new varieties. GDP growth is year-on-year change in each country's GDP expressed in US dollars. All other variables are expressed as fractions of GDP. Data cover 2001 to 2015. Data from IMF, World Bank, and Federal Reserve. Standard errors in brackets. *** $p<0.01$, ** $p<0.05$, * $p<0.1$

	(1)	(2)	(3)	(4)	(5)	(6)
	new varieties imported					
lag portfolio eq invt	0.442***	0.443***	0.453***	0.267***	0.267***	0.230***
	[0.0916]	[0.0897]	[0.0827]	[0.101]	[0.0976]	[0.0856]
lag direct equity invt	0.151	0.0776		-0.175*	-0.144*	
	[0.131]	[0.110]		[0.100]	[0.0870]	
lag new imports	-0.128			-0.0503		
	[0.0894]			[0.0690]		
two lags gdp growth	yes	yes	yes	yes	yes	yes
country fixed effects	yes	yes	yes	yes	yes	yes
year fixed effects	no	no	no	yes	yes	yes
Observations	252	266	267	252	266	267
R-squared	0.405	0.428	0.434	0.621	0.628	0.665
first stage F-stat	12.7	13.3	13.4	7.2	7.8	7.9

Intermediate inputs and capital goods

Table 2.5 replaces the dependent (LHS) variable with those least-traded new imports that are likely to be used as intermediate inputs and capital goods. The UN provides a concordance between the HS1996 trade data and the system of Broad Economic Classification. The results show that of the new imports predicted by portfolio equity investment, more than 90% are categorized by the BEC as intermediate inputs or capital goods. Consequently, we expect these to affect productivity in the recipient country, and not just utility from consumption variety.

Table 2.5: Regression of extensive margin of intermediate input imports on investment inflows and a lag of the dependent variable. The final column means that an extra 1000 USD of portfolio investment predicts 83 USD of extra imports of new intermediates. GDP growth is year-on-year change in each country's GDP expressed in US dollars. All other variables are expressed as fractions of GDP. Data cover 2001 to 2015. Data from IMF, World Bank, and Federal Reserve. Standard errors in brackets. *** $p<0.01$, ** $p<0.05$, * $p<0.1$

	(1)	(2)	(3)	(4)	(5)	(6)
	new intermediates imported					
lag port eq invt	0.185***	0.183***	0.184***	0.0865***	0.0836***	0.0830***
	[0.0319]	[0.0309]	[0.0307]	[0.0230]	[0.0289]	[0.0287]
lag direct eq invt	0.00207	0.00307		-0.0200	-0.0153	
	[0.0296]	[0.0271]		[0.0257]	[0.0239]	
lagged new inputs	-0.0308			-0.0303		
	[0.0730]			[0.0677]		
2 lags gdp growth	yes	yes	yes	yes	yes	yes
country f.e.	yes	yes	yes	yes	yes	yes
year f.e.	yes	yes	yes	yes	yes	yes
Observations	252	266	267	252	266	267
R-squared	0.512	0.512	0.512	0.683	0.682	0.682

Table 2.6 duplicates the instrumental variables approach from the previous section, and applies it to new varieties of imports that are likely to be used as intermediate inputs and capital goods.

Table 2.6: Instrumental variables regression of extensive margin of intermediate input imports on investment inflows and a lag of the dependent variable. The final column means that an extra 1000 USD of portfolio investment predicts 190 USD of extra imports of new intermediates. GDP growth is year-on-year change in each country's GDP expressed in US dollars. All other variables are expressed as fractions of GDP. Data cover 2001 to 2015. Data from IMF, World Bank, and Federal Reserve. Standard errors in brackets. *** p<0.01, ** p<0.05, * p<0.1

	(1)	(2)	(3)	(4)	(5)	(6)
			new intermediates imported			
lag portfolio eq invt	0.374***	0.378***	0.388***	0.213***	0.213***	0.190***
	[0.0777]	[0.0750]	[0.0689]	[0.0813]	[0.0788]	[0.0707]
lag direct equity invt	0.149	0.0845		-0.115	-0.0879	
	[0.112]	[0.0920]		[0.0800]	[0.0703]	
lag new inputs	-0.125			-0.0372		
	[0.0951]			[0.0705]		
two lags gdp growth	yes	yes	yes	yes	yes	yes
country fixed effects	yes	yes	yes	yes	yes	yes
year fixed effects	no	no	no	yes	yes	yes
Observations	252	266	267	252	266	267
R-squared	0.381	0.412	0.424	0.638	0.643	0.663
first stage F-stat	12.7	13.3	13.4	7.1	7.8	7.9

2.3 Structural breaks after equity market liberalizations

A completely different way of asking this question examines the effect of equity market liberalizations on the extensive margin of imports. Henry (2000) documents 12 episodes when countries opened their equity markets to foreign investors. Here we examine the 10 for which there are UN trade data.[10] Imports are categorized according to the SITC1 system a the 5 digit level (because the HS system was not introduced until 1988.) The definition of the extensive margin is otherwise identical to the preceding.

The extensive margin growth for each country i is regressed on a constant, a time trend, and lagged Dollar GDP growth, with a break after the country's liberalization in year T_i. The estimated equations is

$$\left(\frac{S_{t+1}^{(t)} - S_t^{(t)}}{GDP_t}\right)_i = \alpha_i + \delta_1 t + \delta_2 \Delta GDP_{i,t} + \beta_1 \mathbf{1}(t \geq T_i) + \beta_2 t \mathbf{1}(t \geq T_i) + \beta_3 \Delta GDP_{i,t} \mathbf{1}(t \geq T_i) + \varepsilon_{i,t+1}. \quad (2.2)$$

The results for the β coefficient estimates and standard errors are reported in table B.3. We can see that there is on average more growth in the extensive margin after the liberalization with a smaller time trend.

The test that the β's are jointly zero yields a Wald statistic of 3.02. The associated p-value is 0.03. Therefore we conclude that opening equity markets to foreigners preceded an increase in new trade. It is of course possible that these equity market liberalizations were timed coincidentally with other changes in economic policy that drove these results.

An appendix confirms the established fact that portfolio investment is pro-cyclical, or responds positively price changes.

This new fact, that portfolio investment predicts the extensive margin of imports, and that

[10] Argentina 1989, Brazil 1988, Chile 1987, Colombia 1991, Korea 1987, Malaysia 1987, Mexico 1989, Philippines 1986, Thailand 1988, Venezuela 1990 are included. India and Taiwan do not have UN trade data for that period.

Table 2.7: Regression of extensive margin on post-liberalization indicator interactions. Data cover 10 years up to and after stock market liberalization. Data from World Bank and Henry (2000). Standard errors in brackets. *** p<0.01, ** p<0.05, * p<0.1

post liberalization	extensive margin to GDP
constant	0.594**
	[0.275]
time trend	-0.000296***
	[0.000138]
GDP growth	-0.00334
	[0.00280]
country fixed effects	yes
Observations	200
R-squared	0.52

these new imports are likely productive intermediates is at the core of the model we build, and has important real economic implications.

2.4 Model

2.4.1 Preview of model

Because the model involves several components, we summarize it here first before fully presenting it in the next subsection. The model builds on the empirical fact just established: that equity portfolio flows finance new varieties of imports. First we will describe two economies in general equilibrium with different levels of technology and solve for the real exchange rate. Then we will introduce foreign investment in partial equilibrium and show how it alters the real exchange rate.

There are two countries that produce and consume two final goods, tradeables and non-tradeables.[11] The tradeable final good is a composite of tradeable intermediate inputs. Trade

[11] Non-tradeable goods here are distinct from the sparsely-traded goods in the preceding section.

is assumed to be costless, so there is one global price for tradeables. We use tradeables as our numeraire and normalize the price to one. The relative price of non-tradeables in each economy thus determines the real exchange rate.

Labor moves freely between sectors, so there is one wage in each country. For simplicity, nontradeables are produced using purely labor. Tradeables production uses both labor and intermediate inputs. These assumptions are partly motivated by the Baumol effect (1966), in this case productivity in nontradeables is static and in tradeables is dynamic.

The two countries are different in the number of varieties of intermediate inputs available, and also because of an exogenous productivity factor for tradeables production. The poorer country is assumed to have fewer varieties of intermediate inputs, and a tradeables productivity factor less than one. The number of varieties is intended to capture countries' differences in technology and the productivity factor can capture institutional factors.[12]

These assumptions alone allow us to derive a real exchange rate in terms of technology and productivity differences. The two economies are in general equilibrium.

Moving to partial equilibrium, portfolio investment from the richer country is used to finance imports of new varieties of intermediate inputs into the poorer country. This follows from a contracting story, that intermediate input producers in the richer country will not export unless they have an investment in place in the poorer country. An alternative rationale is an impatience story, by which different discount rates prompt agents in the richer and more patient country to provide the intermediate inputs. A third interpretation is an information channel by which domestic tradeables producers only learn about the availability of foreign intermediate inputs if they have received foreign portfolio investment. The intermediate inputs are sold monopolistically for tradeables production.

[12]In reality these intermediate inputs could be intangibles like management practices, or they could be actual physical goods. The framework here is the same one Paul Romer (1990) used for ideas to explain endogenous growth which in turn used a model first employed for expiring patents (Judd 1985.) Imports are of course recorded and therefore we have evidence that the model does apply in the case of physical goods. Naturally, when a foreign investor buys a portion of the equity in a domestic firm, they likely also seek to improve the management practices.

These assumptions create the link from foreign investment to technology and therefore to the real exchange rate.

Foreign investments from the richer country constitute a portfolio of equities. We assume that this portfolio is leveraged, but a number of portfolio constraints, such as a value-at-risk limit, would behave similarly. This leverage creates an accelerator effect whereby price changes precipitate portfolio changes. Investors receive noisy signals about future tradeables productivity which create exogenous variation in equity prices.

These assumptions generate dynamics for equity prices and consequently for portfolio investment and in turn the real exchange rate.

2.4.2 Preferences, demands, prices, and the real exchange rate

We have two countries called "USA" and "Mexico" producing and consuming two goods, tradeables Y_T and non-tradeables Y_N. In what follows, we suppress the country superscripts whenever the equation applies to both countries.

The law of one price holds and there are no transport costs, so we can normalize the price of the traded good in both countries to $P_T = 1$.

Preferences are characterized by instantaneous Cobb-Douglas utility[13]

$$U_s = C_{T,s}^{\gamma} C_{N,s}^{1-\gamma} \tag{2.3}$$

and intertemporal objective function $U_t = \sum_{s=t}^{\infty} \beta^{s-t} U_s$. The corresponding ideal price index is

$$P = P_N^{1-\gamma}, \tag{2.4}$$

[13] We use Cobb-Douglas utility to ensure the resulting closed-form expression for the real exchange rate. With Cobb-Douglas utility, the budget shares on each good are constant fractions, γ and $(1-\gamma)$ respectively. This means constant fractions of the labor force produce tradeable and nontradeable goods. With more general CES preferences, the budget share may be increasing or decreasing in the price of the non-tradeable good, depending on the elasticities. The fundamental resulting dynamics do not depend, however, on the particular functional form used to represent preferences.

given the optimal consumption index $C = C_T^{\gamma} C_N^{1-\gamma}$, and demands are given by $C_T = \gamma PC$ and $C_N = (1-\gamma)(P/P_N)C$.

The real exchange rate is therefore

$$q = \frac{P^{MEX}}{P^{USA}} = \left(\frac{P_N^{MEX}}{P_N^{USA}}\right)^{1-\gamma}. \tag{2.5}$$

A higher value of q corresponds to a relatively higher price level in Mexico. An increase in q corresponds to an appreciation of the real exchange rate for Mexico.

2.4.3 Production and the market for intermediate inputs

Labor moves freely between sectors so $L = L_T + L_N$ in each country.

Production of the non-traded good uses only labor so $Y_N^{MEX} = A_N^{MEX} L_N^{MEX}$ and $Y_N^{USA} = A_N^{USA} L_N^{USA}$

Production of the traded good uses intermediates goods $x(v)$ which come in a number N^{MEX} and N^{USA} of varieties, where $N^{USA} > N^{MEX}$. Traded goods are produced as

$$Y_T^{USA} = \frac{1}{\alpha}\left(\int_0^{N^{USA}} x^{\alpha}(v)dv\right)\left(L_T^{USA}\right)^{1-\alpha} \tag{2.6}$$

and as

$$Y_T^{MEX} = \tilde{A}^{1-\alpha}\frac{1}{\alpha}\left(\int_0^{N^{MEX}} x^{\alpha}(v)dv\right)\left(L_T^{MEX}\right)^{1-\alpha}, \tag{2.7}$$

where $\tilde{A} < 1$ captures institutions relatively less conducive to efficient production. The tilde on $\tilde{A}$ is used to convey that it is a random variable, following a stochastic process. Each input $x(v)$ is produced each period at a marginal cost α (using the freedom in the units of N) and fully used up in production that period.

The tradeables producers face a cost $p(v)$ for each variety of input and a wage w for labor, so their profit maximization yields input demands

$$L_T = (1-\alpha)\frac{Y_T}{w} \tag{2.8}$$

for labor, and for intermediate inputs

$$x^{USA}(v) = p^{USA}(v)^{\frac{1}{\alpha-1}}\,(1-\alpha)\,Y_T^{USA}/w^{USA} \tag{2.9}$$

and

$$x^{MEX}(v) = \tilde{A}\,p^{MEX}(v)^{\frac{1}{\alpha-1}}\,(1-\alpha)\,Y_T^{MEX}/w^{MEX} \tag{2.10}$$

.

The intermediate inputs producers are monopolists maximizing $\pi(v) = (p(v)-\alpha)x(v)$ which yields uniform prices $p(v) = 1$. So demanded quantities are

$$x^{USA}(v) = x^{USA} = L_T^{USA}, \tag{2.11}$$

$$x^{MEX}(v) = x^{MEX} = \tilde{A}L_T^{MEX}. \tag{2.12}$$

and intermediate producers' profits are

$$\pi^{MEX}(v) = \pi^{MEX} = \tilde{A}(1-\alpha)L_T^{MEX}. \tag{2.13}$$

2.4.4 Market-clearing

For simplicity, we impose zero net profit for the Mexican intermediates producers. This means we don't have to consider where their profits go in the market-clearing for tradeables. We assume they pay a sunk cost $F\tilde{A}L_T$ for entry and are forced to exit with probability ϕ. Zero profit follows if $\phi F = (1-\alpha)$. This is true both in expectation and each period, because there are a continuum of intermediates producers so the law of large numbers applies.

Mexico's market-clearing for nontradeables is $Y_{NT}^{MEX} = C_{NT}^{MEX}$ and for tradeables is $Y_T^{MEX} = C_T^{MEX} + X$, where

$$X = xN^{MEX} = \tilde{A} L_T^{MEX} N^{MEX} \tag{2.14}$$

. Production simplifies to

$$Y_T^{MEX} = \tilde{A} \frac{N^{MEX}}{\alpha} L_T^{MEX} \tag{2.15}$$

.

2.4.5 Equilibrium

Mexican wages are $w = \tilde{A} \frac{1-\alpha}{\alpha} N^{MEX}$, so

$$P_N^{MEX} = \tilde{A} \frac{1-\alpha}{\alpha} \frac{N^{MEX}}{A_N^{MEX}} \tag{2.16}$$

.

Labor allocations are $L_T = \gamma L$ and $L_{NT} = (1-\gamma)L$.

If we equalize non-tradeables productivity $A_N^{MEX} = A_N^{USA}$, we get

$$\bar{q} = (\frac{N^{MEX}}{N^{USA}})^{1-\gamma} \tilde{A}^{1-\gamma}. \tag{2.17}$$

The real exchange rate is less than one because of lower Mexican productivity in tradeables, and therefore lower wages, and finally a lower non-tradeables price. This is a classic Balassa-Samuelson motivation for the real exchange rate. This new closed-form expression for the real exchange rate separates the effects of differences in technology use, as captured by the number of intermediate varieties used in production, and differences in more general productivity factors like institutions.

2.4.6 Foreign investment

Now we introduce foreign investment into Mexico. Foreign investors can buy and sell an equity which corresponds to ownership of an importing firm in Mexico. Each firm can import a unique variety of intermediate input from the USA at marginal cost α and sell it to Mexican tradeable goods producers at a price of 1. The number of these firms therefore corresponds to the number of imported intermediate inputs, and we call it N_t. The value, or price, of each equity or firm we call V_t. Total investment in Mexico is of course $N_t V_t$.[14]

2.4.7 The real exchange rate

Tradeables production uses both domestic varieties and varieties owned by foreign investors (they add equivalently in the definite integral in (2.7)). So Mexican wages are

$$w_t = \tilde{A}_t \frac{1-\alpha}{\alpha}(N^{MEX} + N_t) \tag{2.18}$$

and the price of non-tradeables is

$$P_{N,t}^{MEX} = \tilde{A}_t \frac{1-\alpha}{\alpha} \frac{(N^{MEX} + N_t)}{A_N^{MEX}}. \tag{2.19}$$

Finally, the real exchange rate, assuming $A_N^{MEX} = A_N^{USA}$, is

$$q_t = (\frac{N^{MEX} + N_t}{N^{USA}})^{1-\gamma} \tilde{A}_t^{1-\gamma}. \tag{2.20}$$

Here we have a real exchange rate that depends in closed form upon general productivity, local technology, and foreign technology financed by capital flows.[15]

[14]When a US investor buys a new firm or equity, the payment is made in tradeable goods, which then become the working capital of the new firm. Future profits are remitted to the investor, or added to working capital, in the form of tradeables also.

[15]Amiti and Konings (2007) found that lowering tariffs on imported inputs raised productivity in Indonesian manufacturing, just as imported inputs function in this model.

2.4.8 Equities valuation

Foreign investors own the right to sell new varieties of intermediate inputs to Mexican tradeables producers. Unlike domestic Mexican intermediates producers, they face no sunk cost and forced-exit risk. They earn a profit $(1-\alpha)$ for each input sold. Foreign investors are risk-neutral, therefore each equity is worth

$$V_t(v) = E_t\left[\sum_{s=t+1}^{\infty}(\frac{1}{1+r})^{s-t}\pi_t(v)\right] = (1-\alpha)\gamma L^{MEX}E_t\left[\sum_{s=t+1}^{\infty}\frac{\tilde{A}_s}{(1+r)^{s-t}}\right]. \tag{2.21}$$

2.4.9 Productivity and signal

The log of productivity is assumed to be a random walk with a normally-distributed innovation, so

$$z_{t+1} = z_t + \varepsilon_{t+1}$$

where $\varepsilon_{t+1} \sim N(0, \sigma_\varepsilon^2)$ and $\tilde{A}_t = e^{z_t}$.

There is also a visible signal of next period's productivity $\tilde{B}_t$, whose log, s_t, has an uncorrelated normally-distributed error

$$s_t = z_{t+1} + u_t$$

where $u_t \sim N(0, \sigma_u^2)$.

The minimum mean squared error estimator of $z_{t+1}$is therefore

$$\frac{\sigma_u^2}{\sigma_u^2+\sigma_\varepsilon^2}z_t + \frac{\sigma_\varepsilon^2}{\sigma_u^2+\sigma_\varepsilon^2}s_t.$$

The exponential of this can be written as

$$\tilde{A}_t^{\frac{\sigma_u^2}{\sigma_u^2+\sigma_\varepsilon^2}}\tilde{B}_t^{\frac{\sigma_\varepsilon^2}{\sigma_u^2+\sigma_\varepsilon^2}}.$$

This is a slightly biased estimator of $\tilde{A}_{t+1}$, but that can be corrected by the factor $e^{-\frac{\sigma_u^2\sigma_\varepsilon^2}{\sigma_u^2+\sigma_\varepsilon^2}}$

Given this process and this signal, the variety's expected profit and therefore firm value can be calculated as

$$V_t(v) = (1-\alpha)\gamma L^{MEX}\frac{e^{\sigma_\varepsilon^2}}{1+r-e^{\sigma_\varepsilon^2}}e^{-\frac{1}{2}\frac{\sigma_u^2\sigma_\varepsilon^2}{\sigma_u^2+\sigma_\varepsilon^2}}\tilde{A}_t^{\frac{\sigma_u^2}{\sigma_u^2+\sigma_\varepsilon^2}}\tilde{B}_t^{\frac{\sigma_\varepsilon^2}{\sigma_u^2+\sigma_\varepsilon^2}}. \tag{2.22}$$

2.4.10 Foreign investors

Investors start with initial capital K_t and can leverage at a cost r, up to a factor $\Gamma > 1$ times the book value of their assets.

Investors fully leverage to $\Gamma K_t = V_t N_t$. Changes in the price of varieties may be due to either signals about productivity or changes in true productivity. These price changes impact investor's capital as

$$\pi_{t+1} = (V_{t+1} - V_t)N_t - r(\Gamma - 1)K_t. \tag{2.23}$$

Or in percentage terms as

$$\frac{\Delta K_{t+1}}{K_t} = \frac{\pi_{t+1}}{K_t} = \Gamma\frac{V_{t+1}-V_t}{V_t} - r(\Gamma-1). \tag{2.24}$$

In the case of a price fall, in order to meet the margin call and satisfy the leverage constraint, varieties must be sold.[16] In the case of a capital gain, investors are able to buy more varieties, up to the constraint $\Gamma K_{t+1} = V_{t+1}N_{t+1}$ determining N_{t+1}. The dynamics for varieties are

$$\frac{\Delta N_{t+1}}{N_t} = (\Gamma-1)\frac{\Delta V_{t+1}}{V_{t+1}}, \tag{2.25}$$

[16] Appendix B.4 derives these relations for asset sales in response to price falls in the presence of a leverage constraint in more detail.

where the interest cost has been subsumed into the definition of ΔV_{t+1}as returns in excess of interest rates.

To offset these capital flows, the import/export firm is assumed to have a working capital requirement of $\frac{1-\alpha}{r}\tilde{A}\gamma L^{MEX}$, which is also redeemed when the firm is closed.

This leverage constraint is identical to a Value-at-Risk constraint, and behaves similarly to a broader class of portfolio constraints. The key feature is that total investments are a multiple Γ of investor capital, which is impacted by the performance of those investments. In the case of Value-at-Risk, Γ is some multiple of the standard deviation of the equity price, but a constant nonetheless. The constraint is well known in the monetary policy literature for creating the "financial accelerator (Bernanke et al 1996,) in the macro-finance literature for exacerbating financial cycles (Adrian and Shin 2014), and in international finance for explaining contagion in crises (Pavlova and Rigobon 2008.)

2.4.11 Key equations

The key dynamics now are that bad news about productivity causes stock prices to fall. The financial accelerator of leverage causes equity flows out of the country. These equity flows destroy technology, reducing productivity. This is turn decreases the real exchange rate. Portfolio equity investment in the balance of payments data corresponds to $V_t\Delta N_t$ in this model.

Mexican wages are

$$w_t = \tilde{A}_t \frac{1-\alpha}{\alpha}(N^{MEX} + N_t). \tag{2.26}$$

The price of non-tradeables is

$$P_{N,t}^{MEX} = \tilde{A}_t \frac{1-\alpha}{\alpha}\frac{(N^{MEX} + N_t)}{A_N^{MEX}}. \tag{2.27}$$

Prices of import/export firm equities are

$$V_t(v) = (1-\alpha)\gamma L^{MEX} \frac{e^{\sigma_\varepsilon^2}}{1+r-e^{\sigma_\varepsilon^2}} e^{-\frac{1}{2}\frac{\sigma_u^2\sigma_\varepsilon^2}{\sigma_u^2+\sigma_\varepsilon^2}} \tilde{A}_t^{\frac{\sigma_u^2}{\sigma_u^2+\sigma_\varepsilon^2}} \tilde{B}_t^{\frac{\sigma_\varepsilon^2}{\sigma_u^2+\sigma_\varepsilon^2}}. \tag{2.28}$$

Varieties evolve as

$$\frac{\Delta N_{t+1}}{N_t} = (\Gamma - 1)\frac{\Delta V_{t+1}}{V_{t+1}}. \tag{2.29}$$

The real exchange rate, assuming $A_N^{MEX} = A_N^{USA}$, is

$$q_t = (\frac{N^{MEX} + N_t}{N^{USA}})^{1-\gamma} \tilde{A}_t^{1-\gamma}. \tag{2.30}$$

So even false signals about productivity cause changes in technology and therefore the real exchange rate. A change in r, $\tilde{A}$, or $\tilde{B}$ changes V in equation (2.26), which in turn changes N via equation (2.27), which finally impacts the real exchange rate q in equation (2.28).

2.5 Empirical support

2.5.1 Quarterly portfolio investment and the nominal exchange rate

The key equations of the model specify that portfolio investment is predicted to have a positive effect on the real exchange rate because it finances access to additional varieties of intermediate inputs which improve productivity in tradeables. In this section we examine the relationship between inward portfolio investment in equities by foreigners and the log-change in the exchange rate (all expressed versus the US dollar) for the 18 developing countries examined in section 2.2.

The model predicts equity portfolio investment will finance new imports of intermediate inputs which will in turn appreciate the exchange rate. To test this we regress the quarterly appreciation of the exchange rate on lagged portfolio investment and other lagged variables

Table 2.8: Regression of change in log exchange rate (appreciation) on lag of inward equity portfolio investment and lag appreciation. Portfolio investment is expressed as a fraction of GDP. The last columns implies that an increase of portfolio equity investment equal to 1% of GDP predicts an appreciation of about 2% in the subsequent quarter. Data cover 18 countries from Q3 1994 to Q4 2018. Data from IMF, World Bank, and Federal Reserve. Standard errors in brackets. *** p<0.01, ** p<0.05, * p<0.1

	(1) appreciation	(2) appreciation	(3) appreciation	(4) appreciation
lagged portfolio investment	0.0187***	0.0158**	0.0167***	0.0194***
	[0.00650]	[0.00644]	[0.00630]	[0.00626]
lagged appreciation	0.104***	0.0651**	0.0605**	0.0890***
	[0.0271]	[0.0270]	[0.0266]	[0.0276]
lagged fed funds	yes	yes	no	no
lagged gdp growth	yes	yes	yes	yes
country fixed effects	yes	yes	yes	yes
year fixed effects	no	yes	yes	no
quarterly fixed effects	no	no	no	yes
Observations	1,284	1,284	1,343	1,343
R-squared	0.058	0.130	0.128	0.245

detailed in Table 2.8. The last columns implies that an increase of portfolio equity investment equal to 1% of GDP predicts an appreciation of about 2% in the subsequent quarter.

We can be sure with 99% confidence that according to the best linear forecast, increased portfolio investment in a quarter will increase the forecast appreciation in the following quarter.

This may be because equity investors have some timing skill and know which economies will grow more in the future. Nonetheless it is confirmation that portfolio flows procyclically predict exchange rates, as predicted in the model. This result is distinct from the known in-sample correlations between equity flows, prices, and exchange rates attributed to portfolio rebalancing, as in e.g. Hau and Rey (2004.)

Exchange rates are notoriously difficult, if not impossible, to predict. Therefore this result is remarkable, suggesting that the model has some use in explaining the dynamics of these countries.

The counterargument would be that equity flows to these countries for the same reasons that their exchange rates subsequently appreciate. This implies that equity investors have special knowledge that foreign exchange traders do not, and argues that foreign exchange markets are inefficient. As unrealistic as this argument may be a priori, we aim to rule it out empirically. It is possible to instrument as before in section 2.2 for developing inflows with developed outflows.

The estimating equation for the first-stage of the instrumental variables regression is

$$\begin{aligned} \frac{Inflows_{i,t}}{GDP_{i,t}} &= \alpha_i + \beta_{Japan}\frac{Outflows_{Japan,t}}{GDP_{i,t}}Indexshare_i \\ &+ \beta_{UK}\frac{Outflows_{UK,t}}{GDP_{i,t}}Indexshare_i + \beta_{USA}\frac{Outflows_{USA,t}}{GDP_{i,t}}Indexshare_i + \varepsilon_t. \end{aligned}$$

The sample includes periods before and after the creation of the Euro, so we use only the UK to represent flows from Europe. The idea is to approximate what fraction of outflows would go to each destination country. This should depend on the destination's share in a global equity index. This share is calculated from the World Bank data on total equity market capitalization. Outflows are portfolio acquisition of all portfolio equities in the developed countries' financial accounts. Data are quarterly. Inflows are equity portfolio investment as before.

In Table 2.9 we report the results of the instrumental variables regression. First stage F-statistics confirm relevance of the instruments. The results are imprecise in some specifications, but those that are statistically significant strongly confirm the sign of the effect. The third column can be interpreted to say that an extra 1% of GDP of equity portfolio inflows predicts a 10% appreciation in the subsequent quarter.

Table 2.9: Instrumental variables regression of change in log exchange rate (appreciation) on lag of inward equity portfolio investment and lag appreciation. Portfolio investment is expressed as a fraction of GDP. Data cover 18 countries from Q3 1994 to Q4 2018. The third column can be interpreted to say that an extra 1% of GDP of equity portfolio inflows predicts a 10% appreciation in the subsequent quarter. Data from IMF, World Bank, and Federal Reserve. Standard errors in brackets. *** $p<0.01$, ** $p<0.05$, * $p<0.1$

	(1) appreciation	(2) appreciation	(3) appreciation	(4) appreciation
lagged portfolio investment	-0.0482	0.0898*	0.0987**	-0.0256
	[0.0515]	[0.0473]	[0.0443]	[0.135]
lagged appreciation	0.223***	0.0646	0.0582	0.183**
	[0.0520]	[0.0481]	[0.0469]	[0.0825]
lagged fed funds	yes	yes	no	no
lagged gdp growth	yes	yes	yes	yes
country fixed effects	yes	yes	yes	yes
year fixed effects	no	yes	yes	no
quarterly fixed effects	no	no	no	yes
Observations	1,112	1,112	1,112	1,112
R2	0.0221	0.0369	0.0363	0.1479
First-stage F statistic	8.45	7.12	11.6	9.58

2.5.2 Real exchange rates and new varieties

To investigate the model's mechanism more directly, we look at the long-term empirical relationship between the real exchange rate and new varieties of imports for 21 developing countries[17]. Changes in log real exchange rates (with the price level corresponding to household and government consumption) come from the Penn World Tables (Feenstra, Inklaar, and Timmer 2014) for the years 1984-2014. We have to use the SITC1 system for import classification to go this far back in time, meaning there are only 838 categories. Portfolio and direct equity investment data again come from the IMF Balance of Payments database.

Table 2.10: Regression of log real exchange rate change on extensive margin of imports and investment inflows. Data cover 1984 to 2014. GDP growth is expressed in US dollars. New varieties imported and equity investment are expressed as a fraction of GDP. The final column can be interpreted to say that an extra 1% of GDP of new imports is expected to coincide with a 10% real appreciation. Data from Penn World Table, IMF, World Bank, and Federal Reserve. Standard errors in brackets. *** p<0.01, ** p<0.05, * p<0.1

	change in real exchange rate					
new varieties imports	0.163***	0.161***	0.149***	0.118***	0.121***	0.103***
	[0.020]	[0.019]	[0.017]	[0.024]	[0.023]	[0.019]
lag portfolio eq invt	0.350	0.363		-0.114	-0.096	
	[0.560]	[0.555]		[0.592]	[0.588]	
lag direct equity invt	0.353			0.519		
	[0.423]			[0.465]		
lagged GDP growth	yes	yes	yes	yes	yes	yes
Fed Funds and lag	yes	yes	yes			
country fixed effects	yes	yes	yes	yes	yes	yes
year fixed effects				yes	yes	yes
R2	0.54	0.53	0.31	0.59	0.58	0.36
observations	410	421	561	410	421	561

Table 2.10 shows regressions of the change in real exchange rate on new varieties of imports (as a fraction of GDP), with and without year fixed effects. There is strong statistical evidence that a country importing more new goods is likely to experience a real appreciation. Column 6 can be interpreted to say that an extra 1% of GDP of new imports is expected to coincide with a 10% real appreciation.

In columns 2 and 5, we ask if lagged portfolio equity investment has a statistically significant additional effect on the real exchange rate, and find that it does not. This means we do

[17] Argentina, Bangladesh, Brazil, Chile, Colombia, Egypt, India, Indonesia, Malaysia, Mexico, Nigeria, Pakistan, Peru, Philippines, Poland, Russia, South Africa, Thailand, Turkey, Venezuela, and Vietnam.

not reject the hypothesis that the new imports channel is how portfolio equity investment affects the real exchange rate.

2.6 Parametrization and magnitudes

In this section, we parametrize the model and ask approximately how important this channel is. Table 2.11 contains the minimum parametrization necessary for the applications that follow. This exercise is not a rigorous calibration, but rather an approximation to possible magnitudes. This portfolio investment channel can explain the majority of excess real exchange rate volatility compared to developed countries. The parametrized model also explains approximately 20% of the real depreciations seen in the "taper tantrum."

2.6.1 Parameters

Stockman and Tesar (1995) found $\gamma = 0.5$, the share of consumption spent on tradeable goods. Engel (1999) found estimates between 0.22 and 0.64 for the share of non-tradeable consumption in developed countries, so this parameter is clearly subject to much uncertainty and depends on the precise definition and method of estimation. We use $\gamma = 0.4$ to reflect that these countries consume relatively more simple products. We further assume the capital share in tradeables production $\alpha = 0.35$.

Table 2.11: Parameters for estimation of magnitudes. Author's calculations.

parameter	description	value
γ	tradeables share in consumption	0.4
α	intermediates share in tradeables production	0.35
$\frac{xN_t}{P_Y Y}$	intermediate input imports to GDP	0.21
$\Gamma - 1$	positive feedback from prices to flows	0.05

Average real exchange rates for the countries in the sample gives q_t. Penn World Tables (Feenstra, Inklaar, and Timmer 2014) for 2011 report an average q_t (for consumption) of 0.55.

Hall and Jones (1999) instrument for social infrastructure and find a range for $\widetilde{A}_t$ between 0.27 and 0.93. I will assume 0.8. The closed form expression for the real exchange rate (2.30) was

$$q_t = (\frac{N^{MEX} + N_t}{N^{USA}})^{1-\gamma} \tilde{A}_t^{1-\gamma} \tag{2.31}$$

. This then estimates

$$\frac{N^{MEX} + N_t}{N^{USA}} = 0.46 \tag{2.32}$$

for the ratio of varieties available in Mexico to those in the USA.

Market clearing in tradeables was

$$Y_T^{MEX} = C_T^{MEX} + x(N^{MEX} + N_t). \tag{2.33}$$

This implied

$$x(N^{MEX} + N_t) = \frac{\alpha}{1-\alpha} C_T. \tag{2.34}$$

Dividing by GDP yields

$$\frac{x(N^{MEX} + N_t)}{C_T + P_N C_N} = \frac{\alpha}{1-\alpha} \frac{C_T}{C_T + P_N C_N} = \frac{\alpha}{1-\alpha} \gamma \tag{2.35}$$

from the γ budget-share in tradeables resulting from the Cobb-Douglas preferences.

The first term from equation (2.35), $\frac{xN_t}{C_T + P_N C_N}$, is intermediate input imports to GDP. The ratio of imports to GDP is 35% on average across the previous 18 countries as reported by the World Bank. Furthermore, Johnson (2014) reports 60% of world trade is in intermediate imports. Therefore we combine these as

$$\frac{xN_t}{GDP} = \frac{imports}{GDP} \frac{intermediates}{imports} = 0.35 * 0.6 = 0.21. \tag{2.36}$$

These first 3 parameters from Table 2.11 thus determine all of the N ratios: $\frac{N^{MEX}}{N^{USA}}$, $\frac{N_t}{N^{USA}}$, and $\frac{N_t}{N^{MEX}}$.

The dependence of the real exchange rate on imported varieties (2.30) was

$$q_t = \left(\frac{N^{MEX} + N_t}{N^{USA}}\right)^{1-\gamma} \tilde{A}^{1-\gamma} \tag{2.37}$$

.

Differencing gives

$$\frac{\Delta q_t}{q_t} = (1-\gamma)\frac{\Delta N_t}{N_t + N^{MEX}}, \tag{2.38}$$

which shows the percent change in the real exchange rate as a function of the change in foreign equity holdings. Furthermore

$$\frac{\Delta N_t}{N_t + N^{MEX}} = \frac{N_t}{N_t + N^{MEX}} \frac{\Delta N_t}{N_t}. \tag{2.39}$$

Combining the above estimates, we calculate

$$\frac{\Delta q_t}{q_t} = 0.59 \frac{\Delta N_t}{N_t}. \tag{2.40}$$

Finally we need to make use of (2.29)

$$\frac{\Delta N_t}{N_t} = (\Gamma - 1)\frac{\Delta V_t}{V_{t+1}}. \tag{2.41}$$

What fraction of foreign equities are sold in response to a 1% price drop? Previous studies track individual portfolios to measure the magnitudes of positive feedback trading. Froot, O'Connell, and Seasholes (2001) report 0.05 for $(\Gamma - 1)$ over 3 months after a price change. Kaminsky, Lyons, and Schmukler (2004) found 0.025 and Raddatz and Schmukler (2012) found similar. We will use 0.05.

There also exists a theoretical literature on international macroeconomic linkages that use an equivalent estimate of $(\Gamma - 1)$ between 2 and 5 (for example Aiyagari and Gertler 1999 or Devereux and Yetman 2010.) This is motivated either by a 25% margin requirement at exchanges or by a similar recovery rate in the event of default, in the style of Kiyotaki and Moore (1997.) A parameter of this magnitude in this model would make this channel hugely important.

Putting it all together we get

$$\frac{\Delta q_t}{q_t} = 0.029 \frac{\Delta V_t}{V_t}. \tag{2.42}$$

2.6.2 Interest Rate Shock

In 2013, the US Federal Reserve hinted that they would taper their purchases of government bonds and mortgage-backed securities. The resulting rise in yields, and spillover effects were dubbed the "taper tantrum." Figure 2.4 plots the real interest rate on a Treasury Inflation-Protected Security with 30 years to maturity.

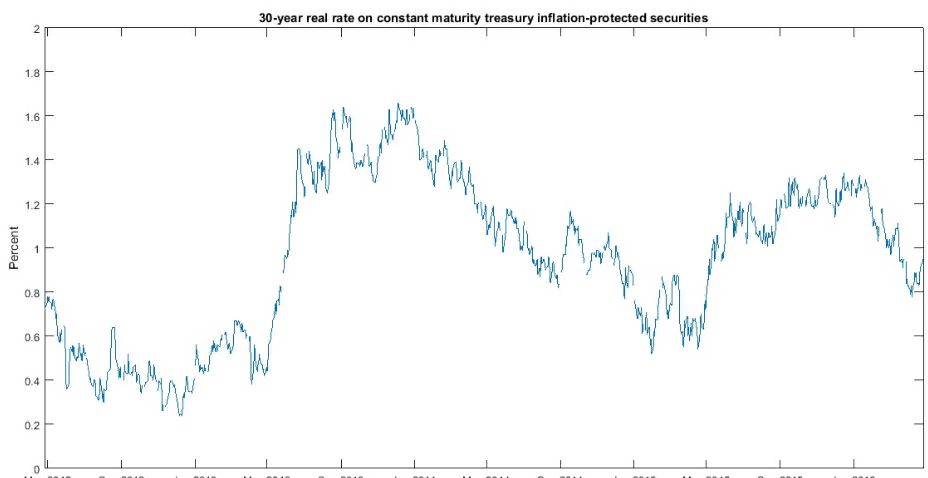

Figure 2.4: 30yr constant maturity real yields. Constructed by the Board of Governors of the Federal Reserve from treasury inflation-protected securities.

Previous literature on this episode are limited to an event study by Chari, Stedman, and

Lundblad (2017) which identified monetary policy shocks from treasuries futures data and showed that developing countries' equity prices were sensitive to US interest rates.

Here we ask what our model would imply from the taper tantrum. Suppose the risk-adjusted real interest rate used for discounting equities' cashflows increases from 0.5% to 1.5%. From equation for equity prices we find $\frac{\Delta V}{V} = -67\%$.

Now from equation (2.42), we calculate $\frac{\Delta q}{q} = -2.0\%$. Figure 1 showed real exchange rates in 2013 which depreciated on average by around 10%.

A key result here is that developing countries' exchange rates are affected by the world interest rate through a channel distinct from uncovered interest parity. For example, the Mexican central bank maintained a constant interest rate differential to the US during the relevant period and still the Mexican peso depreciated considerably. The model developed in this paper can explain this via the equity valuation and portfolio investment channel.

2.6.3 Volatility

We now return to the question of excess volatility with which we began. The model illustrates the channel that transmits equity price volatility to real exchange rate volatility, via portfolio constraints and the real effects of portfolio equity investment. The calibrated model, and equation (2.42) specifically, means that all else constant

$$\sigma(q_t) = 0.029\sigma(V_t).$$

Stock market indices for these 18 countries have a dollar price standard deviation $\sigma(V_t)$ of about 30%. Schiller (1981) estimated that 80% of volatility in the S&P 500 was not justified by volatility in dividends. If we consider this estimate as non-fundamental noise, we have 24% excess volatility $\sigma(V_t)$ for stock prices. This calibrated model implies that this would contribute 0.7% to the standard deviation of the real exchange rate. Returning to table 2.1, we saw that most real exchange rates had an excess volatility of less than 1.4% compared to the US real exchange rate.

We suggest that this equity portfolio channel explains a significant part, perhaps a majority, of excess exchange rate volatility in developing countries.

2.7 Conclusion

This paper has detailed a new channel of real exchange rate volatility for developing countries importing foreign technology. Constrained portfolios of equities held by foreign investors finance access to new technology. This investment can reverse in the case of bad news and therefore equity price falls. The fall in productivity in tradeables production generates a real exchange rate depreciation.

The mechanism in this paper is purely real and does not point to suboptimal monetary policy decisions. The amplification of volatility is endogenous to the model. The expression for the real exchange rate is in closed form, and shows clearly the role of foreign portfolio flows.

We establish a new fact, that portfolio flows, and not direct investment flows, facilitate imports of new varieties of goods. We incorporate this fact into a full model of portfolio flows and the real economy.

Turning to quarterly data, we confirm that the exchange rate responds positively to lagged equity portfolio investment in concurrence with the key equations of the model. This combined with the existence of portfolio constraints contributes to explaining the endogenous volatility of real exchange rates.

Furthermore, we find that over a 30 year period, real exchange rates appreciate when more new goods are imported. The previous year's portfolio equity investment does not significantly additionally affect the real exchange rate, suggesting that the new imports channel is important.

Chapter 3

Foreign ownership and productivity of Chilean manufacturers

3.1 Introduction

Purchases of equity stakes in firms by foreign investors are categorized in the balance of payments as either foreign direct investment (FDI) or foreign portfolio investment (FPI.) Foreign direct investment and portfolio investment are differentiated by a 10% control threshold, such that purchasing the first 9% of a firm's equity constitutes portfolio investment, for example, and then purchasing an additional 2% constitutes direct investment. FDI has been considered generally beneficial for recipient countries and governments in both developing and industrialized countries go to great lengths to attract those investments. Portfolio investment, also called "hot money", is regarded more warily.

Alburquerque (2003) documents many facts comparing FDI and FPI. FDI is lumpy in the sense that investments are mostly large, and persistent through downturns. Portfolio investment is fluid in the sense that it can be of any size, and transient in the sense that it can quickly reverse.

Thank you to Natalia Ramondo for kindly sharing data and code.

Portfolio investment has persistently grown in magnitudes relative to FDI over the past 10 years. Specifically in the IMF Balance of Payments Database, total direct investment is always positive, whereas total portfolio investment was negative in 2008 and has since grown to exceed direct investment in both 2017 and 2018.[1]

Whilst the beneficial impacts of foreign investors have been well documented, it remains unknown at what level of foreign ownership these effects matter. We investigate the marginal impacts of additional foreign ownership in Chilean manufacturing plants in the years 1998 to 2001. This question is important because the answer may imply real outcomes from portfolio investment and affects optimal policy.

We find significant effects of foreign ownership on (log) total factor productivity (TFP) in levels, changes, and also when controlling for endogeneity between the investment and the recipient plants' productivity, using an instrumental variables approach.

All forms of foreign investment allow introduction of foreign technologies, which are believed to be a significant source of growth. For example, Eaton and Kortum (1999) estimate that half of US productivity growth comes from foreign technology. We expect an even greater fraction in smaller and less developed countries.

One widely studied channel is that foreign firms' new imports have related technology effects (Keller 2002.) Spillover productivity effects within industries were documented in the UK (Haskel, Pereira, Slaughter 2004 and Girma and Wakelin 2001), the US (Keller and Yeaple 2002), and Chile (Ramondo 2009.) Our contribution is to examine the level of foreign ownership that matters for beneficial effects.

Goldstein and Razin (2006) compare principal-agent differences between FDI and FPI. Contracting and monitoring problems would cause a preference for FDI, which indicates control. Portfolio investment may involve transfer of management practices, although this important channel has not been stressed in the literature. Investors meet with management and give

[1] The specific series examined are called "Net incurrence of liabilities in equity and investment fund shares" for both direct and portfolio investment.

recommendations during earnings conference calls (). And free advice is known to improve productivity (). But we know of no literature that combines these facts to conclude that portfolio investmnet affects management practices and, in turn, productivity.

Differences between foreign owned and domestic firms are long-studied. Caves (1974) finds majority foreign owned firms in Canada and Australia were more profitable. Blomström (1986) shows that sectors with higher foreign ownership produce more value added per worker. Aitken, Harrison, and Lipsey (1996) show that foreign firms pay higher wages in Mexico, Venezuela, and the United States. Aitken and Harrison (1999) regress output on inputs and foreign ownership and report positive effects for levels of foreign ownership. Our contribution, in contrast, is to look at TFP with respect to a continuous measure of foreign ownership and to ask if low levels are significant and therefore if portfolio investment is important for productivity.

There is much literature on FDI, and less on portfolio investment, but some literature on FDI may be relevant to portfolio investment. For example, Javorcik (2004) studies foreign ownership of Lithuanian firms and although the paper predominantly refers to FDI, the ownership variable has a mean of 7.8% and a standard deviation of 23%, indicating that a considerable portion of the foreign investment flow was portfolio investment and not direct investment. Javorcik finds increased productivity in recipient firms and their suppliers.

Manova (2008) showed that portfolio investment after equity market liberalizations facilitated increased exporting for credit constrained firms. This additional access to capital is a distinct channel from the total factor productivity that we examine.

We examine the relationship between the level of foreign ownership and the log of TFP, first by ordinary least squares and then with a local linear regression. We find TFP increases with foreign ownership, especially at lower levels of the foreign ownership share. We then show that increases in foreign ownership coincide with increases in TFP. This is true even when restricting the sample to low levels of initial foreign ownership and to small increases, for example a less than 10% initial share and an increase of less than 10%. Next we control for endogeneity in the foreign investment decision by instrumenting with total portfolio outflows from high-income countries interacted with initial plant size and industry dummies and confirm that the relationship remains. Finally we ask if plants with partial foreign ownership produce differently and show that the share of intermediate inputs imported increases in foreign ownership.

The rest if this paper is organized as follows. Section 2 discusses productivity measurement, from the basic problem identified by Marschak and Andrews (1944) to more recent solutions. Section 3 discusses the econometrics of kernel regression. Section 4 discusses the data and how it is analyzed. Section 5 presents the main empirical results. Finally section 6 concludes.

3.2 Productivity measurement

3.2.1 Production

Consider a plant panel with plants i, over time periods t, with a Cobb-Douglas value-added production functions

$$Y_{it} = A_{it} K_{it}^{\alpha} L_{it}^{\beta} \tag{3.1}$$

where observable capital input is K, labor input L, and unobservable productivity A. In logs the production function becomes

$$y_{it} = a_{it} + \alpha k_{it} + \beta l_{it} \tag{3.2}$$

where the capital share α and labor share β now appear as if regression coefficients. If we were to try to run a regression of the form

$$y_{it} = \bar{a} + \alpha k_{it} + \beta l_{it} + \varepsilon_{it} \tag{3.3}$$

then consistency would require $\mathbb{E}[\varepsilon_{it} | k_{it}, l_{it}] = 0$. However, since profit maximizing plants would choose to employ more capital and labor in response to positive productivity changes, this conditional mean independence is certainly violated and OLS estimates are biased. This problem has been known and discussed since at least Marschak and Andrews (1944.)

3.2.2 Tornqvist and Malmqvist productivity indices

If markets for capital and labor are competitive, plants will employ factors such that marginal revenue products equal marginal costs. These first order conditions in the Cobb-Douglas case are $\alpha = {}^{rK}/_{Y}$ and $\beta = {}^{wL}/_{Y}$ for capital costs r and wages w. In both cases the numerator is total cost of the factor in each period (and of course in the special case of constant returns to scale, $\alpha + \beta = 1$ and total cost equals output, for zero profits). The log production function (3.2) can be time differenced as

$$a_{it} - a_{it-1} = y_{it} - y_{it-1} + \alpha(k_{it} - k_{it-1}) + \beta(l_{it} - l_{it-1}) \tag{3.4}$$

to measure changes in total factor productivity.

The Bureau of Labor Statistics follows this method and uses what is called the Tornqvist index to measure TFP changes by industry, with cost shares averaged over both periods (BLS 2015).

Christensen, Caves, and Diewert (1982) show that an average of Malmqvist indices for input and output is equivalent to a Tornqvist index under constant returns to scale. The Malmqvist index compares the minimum inputs required to produce a fixed output or the maximum output producible from a fixed input. These notions of distances in efficiency become useful when examining input-output data without prices (e.g. Färe, Grosskopf, Norris, and Zhang 1994).

Rather than assume a production function, Christensen et al. assume a parametric form of the production possibility frontier. This translog PPF is a local second-order approximation to any production function and is more flexible than the well known production functions with constant elasticities of substitution and transformation (Christensen Jorgensen Lau 1973).

In our data, we do not see payments to capital. Therefore we have two ways of calculating a Tornqvist index. We can assume constant returns to scale, in which case the shares sum to one and α is inferred from the other shares. Or we can assume that the user cost of capital is steady with real interest rates and depreciation both approximately 10%, so $\alpha = {}^{0.2K}/_{Y}$. Both methods yield similar results and are shown as robustness checks in Appendix C.2. [2]

3.2.3 The Levinsohn-Petrin approach

Levinsohn and Petrin (2004, henceforth LP) assume that plants are unable to adjust labor inputs at impact in response to within-period productivity shocks. LP assume that plants do adjust usage of intermediate inputs at impact, and therefore use an intermediate input to control for productivity shocks observable to the plant. Their method was adapted from that of Olley and Pakes (1997) who used investment instead, but in a similar way. The advantage of intermediates over investment is that intermediates are more plausibly smooth and monotonically increasing in productivity, both of which are necessary for invertibility.

We assume that productivity is composed of a component, observable to the plant, governed by a Markov process, and an unobservable mean-zero error term

$$a_{it} = \omega_{it} + \eta_{it}, \tag{3.5}$$

where $\mathbb{E}[\eta_{it}|k_{it}, l_{it}, \omega_{it}] = 0$ and $\omega_{it} = \mathbb{E}[\omega_{it}|\omega_{it-1}] + \nu_{it}$. Because capital k_{it} and intermediates m_{it} are assumed to be increasing in the observable-to-the-plant productivity ω_{it}, that relation can be inverted and we can write $\omega_{it} = p(k_{it}, m_{it})$, some polynomial function of arbitrary degree.

[2] The Tornqvist productivity changes are calculated from gross output, with intermediates in the Cobb-Douglas production function. For the other productivity measures we will use intermediates as instruments and productivity will be calculated from value-added in production.

Substituting into 3.2, we can write

$$y_{it} = \alpha k_{it} + \beta l_{it} + \omega_{it} + \eta_{it}, \tag{3.6}$$

and then

$$y_{it} = \alpha k_{it} + \beta l_{it} + p(k_{it}, m_{it}) + \eta_{it}, \tag{3.7}$$

where p is a polynomial of arbitrary degree. Now the labor share β can be estimated to give a $\hat{\beta}$ by OLS with this specification, including polynomial terms in k_{it} and m_{it}.

The next step is to solve for observable productivity ω_{it} and the unobservable error as a function of the capital share α, from (3.6)

$$(\widehat{\omega_{it} + \eta_{it}}) = y_{it} - \hat{\alpha} k_{it} - \hat{\beta} l_{it}. \tag{3.8}$$

Now for the correct $\hat{\alpha}$, this series was assumed to be Markov, so we write

$$(\widehat{\omega_{it} + \eta_{it}}) = \tilde{p}((\omega_{it-1} \widehat{+ \eta}_{it-1}); \hat{\alpha}) + \hat{\xi}_{it}, \tag{3.9}$$

again some new polynomial $\tilde{p}$ of arbitrary degree, for each $\hat{\alpha}$, and $\mathbb{E}[\xi_{it} | k_{it-1}, l_{it-1}, \omega_{it-1}] = 0$. $\hat{\beta}$ has already been estimated, and for any possible $\hat{\alpha}$, there is a corresponding $\tilde{p}(\cdot; \hat{\alpha})$ and $\hat{\xi}_{it}$. This procedure ultimately leads to

$$\hat{\alpha} = argmin(\sum_{it} \hat{\xi}_{it}^2). \tag{3.10}$$

The idea of the algorithm is that each $\hat{\alpha}$ generates a corresponding polynomial $\tilde{p}$, which in turn generates a series of innovations $\hat{\xi}_{it}$. The intuition is that the Levinsohn-Petrin estimator jointly minimizes the errors in the production function and in the plants' forecasts of their next period productivity.

Olley and Pakes (1997) specifically model entry and exit. They find the effect insignificant and consequently, Levinsohn and Petrin omit this selection effect and we follow their example. In aggregate, we expect plant selection endogeneity to bias down the the capital coefficient because plants with more invested capital are less likely to exit when productivity is low. Van Beveren (2007) reviews these issues and point to the irrelevance of selection in the case of Belgian firms.

3.2.4 The Ackerberg-Caves-Frazer approach

Ackerberg, Caves, and Frazer (2015, henceforth ACF) show that if labor does adjust to capital and plant-observable productivity then the labor share β is not identified in (3.7). ACF begin with the same model, but at (3.6) they do not keep the $\hat{\beta}$ as the labor share. Instead they estimate

$$y_{it} = \alpha k_{it} + \beta l_{it} + p(k_{it}, l_{it}, m_{it}) + \eta_{it}, \tag{3.11}$$

yielding $\hat{\beta}'$ and some polynomial $\hat{p}$. This then defines a new polynomial p' from

$$y_{it} = \hat{\beta}' l_{it} + p'(k_{it}, l_{it}, m_{it}) + \eta_{it}. \tag{3.12}$$

From this and (3.6) we can write

$$\widehat{\omega_{it} + \eta}_{it} = p'(k_{it}, l_{it}, m_{it}) - \alpha k_{it}.$$

Now we use the Markov property again to define a third polynomial

$$(\widehat{\omega_{it} + \eta_{it}}) = \tilde{p}((\omega_{it-1} \widehat{+ \eta}_{it-1})) + \xi_{it} = \tilde{p}(p'(k_{it-1}, l_{it-1}, m_{it-1}) - \alpha k_{it-1}) + \xi_{it}.$$

Finally, to estimate this $\tilde{p}$, jointly with $\hat{\beta}$ and $\hat{\alpha}$, we return to (3.6) and estimate

$$y_{it} = \alpha k_{it} + \beta l_{it} + \tilde{p}(p'(k_{it-1}, l_{it-1}, m_{it-1}) - \alpha k_{it-1}) + \xi_{it}. \tag{3.13}$$

This ACF estimate of productivity is used in Appendix C.3 as a robustness check.

3.2.5 GMM framework

Wooldridge (2009) showed how these productivity measures can all be estimated in a GMM framework. From (3.6), we had

$$y_{it} = \alpha k_{it} + \beta l_{it} + \omega_{it} + \eta_{it}, \tag{3.14}$$

and we assume $\omega_{it} = g(k_{it}, m_{it})$ and the Markov property $\omega_{it} = \mathbb{E}[\omega_i|\omega_{it-1}] + \xi_{it}$ or $\omega_{it} = f(g(k_{it-1}, m_{it-1})) + \xi_{it}$. This yields

$$y_{it} = \alpha k_{it} + \beta l_{it} + \mathbb{E}[\omega_i|\omega_{it-1}] + \xi_{it} + \eta_{it}. \tag{3.15}$$

Or substituting in functions to be estimated the innovations are

$$\eta_{it} = y_{it} - \alpha k_{it} - \beta l_{it} - g(k_{it}, m_{it}), \tag{3.16}$$

and

$$\xi_{it} + \eta_{it} = y_{it} - \alpha k_{it} - \beta l_{it} - f(g(k_{it-1}, m_{it-1})). \tag{3.17}$$

.

The moment conditions for ACF are

$$\mathbb{E}\left[\eta_{it}\begin{pmatrix} k_{it} \\ l_{it} \\ m_{it} \end{pmatrix}\right] = 0. \tag{3.18}$$

and

$$\mathbb{E}\left[(\xi_{it}+\eta_{it})\begin{pmatrix} k_{it} \\ k_{it-1} \\ l_{it-1} \\ m_{it-1} \end{pmatrix}\right]=0. \tag{3.19}$$

Additional lags of the regressors can be added to both moment conditions to identity the coefficients on the polynomials which estimate $\hat{f}$ and $\hat{g}$. The difference between ACF and LP is that LP includes l_{it} with the second moment condition (3.19).

There are of course additional approaches to plant productivity estimation. For example, we could imagine including foreign ownership directly in this step. However, we choose to follow these traditional approaches for comparability to the literature on FDI and productivity.

3.3 Estimation strategy

3.3.1 Ordinary Least Squares

We begin by showing that foreign owned plant are more productive and look simply at levels of log TFP with regressions of the form

$$a_{ijrt}=\beta\, foreign_{ijrt}+\alpha_j+\alpha_r+\alpha_t+\varepsilon_{ijrt} \tag{3.20}$$

where plant i is in industry j, region r, at year t. Industries are listed in appendix C.1. Standard errors are clustered by plant. Estimation of changes in log TFP are of the form

$$\Delta a_{ijrt}=\beta_1\,\Delta foreign_{ijrt}+\beta_2\, size_{ijr,t-1}+\beta_3\, a_{ijr,t-1}+\alpha_j+\alpha_r+\alpha_{t-1}+\varepsilon_{ijrt} \tag{3.21}$$

again with standard errors clustered by plant. The notation Δ_t represents the change between years $t-1$ and t.

3.3.2 Local linear regressions

In this paper, we investigate at what levels foreign ownership and its changes become important. Consequently we are interested in the shape of the curve when we plot, for example, productivity versus foreign ownership. The natural tool here is a nonparametric regression.

Suppose we start with data generated by a non-linear function of independent variables x_i, as

$$y_i = g(x_i) + \varepsilon_i, \tag{3.22}$$

with $\mathbb{E}[\varepsilon_i|x_i] = 0$. Consequently $\mathbb{E}[y_i|x_i] = g(x_i)$.

The local linear regression method developed by Cleveland (1979) fits a weighted linear regression at each observation x_i, so

$$g_i(x) = \alpha_i + \beta_i(x - x_i). \tag{3.23}$$

One nice feature of this model is that $\widehat{g'(x_i)} = \widehat{\beta}_i$ estimates $\frac{\partial \mathbb{E}[y|x]}{\partial x}|_{x_i}$.

The local parameters $\hat{\alpha}_i$ and $\hat{\beta}_i$ are chosen to solve the weighted least squares problem

$$\min \sum_{j=1}^{n} \{y_j - \alpha_i - \beta_i(x_j - x_i)\}^2 K(x_j, x_i; h), \tag{3.24}$$

where K is a kernel function to weight nearer observations more heavily, and h is a bandwidth parameter determining how severely to overweight nearer observations relative to farther ones. In this paper we use cross-validation to determine the bandwidth parameter. This means that we minimize, over bandwidth, the sum of squared residuals h

$$\hat{h} = \underset{h}{argmin} \sum_{i=1}^{n} (y_i - \hat{g}_i(x_i))^2 \tag{3.25}$$

where $\hat{g}_i$ is the non-linear function fit from the $n-1$ data points excluding observation i (this is called “leave one out” cross-validation.) Li and Racine (2004) show convergence and asymptotic normality of this method in the case with both continuous and discrete regressors, as we have in our setting.

We employ this method because we are interested in the response of the dependent variable, log TFP, at quantiles of the independent variable, foreign ownership. So this is like the converse of quantile regression that examines the response of quantiles of the dependent variable to a continuous independent variable.

3.4 Data

The plant level data comes from the Encuesta Nacional Industrial Annual, or yearly country-wide manufacturing census published by Chile’s national statistics institute. This survey provides us with plant’s own reporting of total revenues, wage expenditures, intermediate input costs, investment, the value of fixed assets, and the 4-digit ISIC industry classification. This dataset was used by Liu (1992) and Tybout, DeMelo, and Corbo (1991) to study productivity in these plants, especially around trade liberalizations, and Pavcnik (2002) who modeled plant entry and exit to study those industry productivity dynamics.

The raw data is analyzed following Ramondo (2009).. Value-added is calculated as the difference between total revenues and total expenditures on raw materials (intermediate inputs and energy.) All variables are real, deflated with 1996 as a base year. Total revenues are deflated by the 3-digit industry price deflator. A corresponding national price deflator is used for each of national and imported raw materials. Finally, electricity and fuels are deflated by the national intermediate inputs deflator.

The labor employed is measured by the total wage payments because our dataset does not contain the preferred measure of total hours worked. This follows Javorcik (2004) who calls these labor "efficiency units." The capital stock of each plant is calculated by the perpetual inventory method. Capital is tracked by starting with reported book-value in 1992, and then following a standard law of motion for capital. Depreciation is assumed to be constant. Investment is deflated by an investment price deflator.

We restrict the sample to ISIC2 industries between 310 and 399, which corresponds to manufacturing. We will consider industries at the 3-digit level, so we have 27 distinct industries. These industries and their frequency in our data are listed in Appendix C.1.

We use electricity as the intermediate inputs to instrument for plant productivity with the Levinsohn-Petrin method, where the production function is estimated at the 2-digit ISIC2 level. Then we generate $\hat{a}_{it}$, or log TFP for each plant.

Table 3.1: Summary statistics for manufacturing plants in Chile 1998-2001. TFP is calculated by the Levinsohn-Petrin method with electricity use as proxy for plant-observed productivity. Plant level data from ENIA published by INE.

	Observations	Mean	Std. Deviation	Min	Max
foreign	15,454	0.0492	0.204	0	1
Δ foreign	10,178	-0.00012	0.0985	-1	1
log TFP	14,423	2.0165	1.1150	-7.5464	7.8215
Δ log TFP	9,366	-0.0173	0.7146	-5.2290	8.5335
import_share	15,404	0.0482	0.111	0	1

The 10,178 observations with a change in foreign ownership represent 4096 distinct manufacturing plants. Of these, the majority (over 90%) are entirely domestic in all years. There are 304 plants with some foreign ownership. These plants provide the variation that will determine our key results. The wholly domestic plants only provide more precise estimates of the average productivity by region, year, and industry. Our results contrast the foreign owned plants against these averages.

3.5 Results

3.5.1 OLS in levels

We begin with levels to establish basic facts about the data. Table 3.2 reports results of regressions of log TFP of the form

$$a_{ijrt} = \beta foreign_{ijrt} + \alpha_j + \alpha_r + \alpha_t + \varepsilon_{ijrt}. \tag{3.26}$$

Standard errors are clustered by plant. The first column shows that productivity is increasing in foreign ownership. The second column shows that the square of foreign ownership is not statistically significant. This lack of clear non-linearity is evidence against the idea that only large fractions of foreign ownership are important.

Table 3.3 shows results of regressions with an identical specification, however on restricted samples. In column 1 the sample is restricted to plants that report foreign ownership less than 10%, in column 2 we restrict to plants with less than 20% ownership, and so on. The result shows that log TFP is increasing in levels of foreign ownership, even at low levels of that foreign ownership.

3.5.2 Local linear regressions

In this section we fit local linear regressions of the form

$$a_{ijrt} = g(foreign_{ijrt}) + \alpha_j + \alpha_r + \alpha_t + \varepsilon_{ijrt}. \tag{3.27}$$

Table 3.2: Regression of log TFP on foreign ownership with fixed effects by year, region, and 3-digit ISIC industry code. Data from INE covering 1998-2001. Robust standard errors clustered by plant in brackets. *** p<0.01, ** p<0.05, * p<0.1.

	(1) TFP_LP	(2) TFP_LP
foreign	0.417***	0.704
	[0.064]	[0.432]
$foreign^2$		-0.303
		[0.443]
Observations	14,423	14,423
R-squared	0.541	0.541

Table 3.3: Regression of log TFP on foreign ownership with fixed effects by year, region, and 3-digit ISIC industry code. Columns 1-5 restrict the sample to those plants with foreign ownership less than 10%, 20%, 30%, 40%, and 50% respectively. Data from INE covering 1998-2001. Robust standard errors clustered by plant in brackets. *** p<0.01, ** p<0.05, * p<0.1.

	for<10% (1) TFP_LP	for<20% (2) TFP_LP	for<30% (3) TFP_LP	forn<40% (4) TFP_LP	for<50% (5) TFP_LP
foreign	6.212	3.969**	2.867***	1.830***	0.906***
	[3.813]	[1.581]	[0.741]	[0.475]	[0.270]
Observations	13,585	13,619	13,658	13,695	13,791
R-squared	0.546	0.546	0.547	0.547	0.545

We aim to explore in a non-parametric specification, precisely which levels of foreign ownership are associated with higher productivity.

Table 3.4 reports conditional means of log TFP for different levels of foreign ownership, as well as the conditional derivatives $g'(foreign)$. Standard errors are computed by bootstrap with 200 replications and we believe have converged because look indistinguishable from a run of 100 replications. The number of observations as well as many discrete covariates as fixed effects makes this computationally intensive.

We note that the differential level effect of foreign ownership is greatest at low levels of foreign ownership. Furthermore, total factor productivity peaks around 40\% foreign ownership in this specification.

Table 3.4: Local linear regression of log TFP on foreign ownership. Fixed effects by year, region, and 3-digit ISIC industry code. Data from INE covering 1998-2001. Standard errors computed by bootstrap with 200 replications. *** p<0.01, ** p<0.05, * p<0.1.

margin of foreign ownership	conditional mean TFP	conditional derivative
0%	1.998***	0.445***
	[0.009]	[0.060]
10%	2.214***	0.443***
	[0.097]	[0.060]
20%	2.339***	0.441***
	[0.180]	[0.059]
40%	2.594***	0.438***
	[0.115]	[0.059]
60%	2.438***	0.436***
	[0.258]	[0.059]
80%	1.930***	0.433***
	[0.432]	[0.059]
Observations	14,423	
R-squared	0.585	

3.5.3 OLS in changes

Table 3.5 reports results of regressions of the form

$$\Delta a_{ijrt} = \beta_1 \Delta foreign_{ijrt} + \beta_2\, size_{ijr,t-1} + \beta_3\, a_{ijr,t-1} + \alpha_j + \alpha_r + \alpha_{t-1} + \varepsilon_{ijrt}. \tag{3.28}$$

Standard errors are clustered by plant. The first column shows that increases in foreign ownership coincide with increases in total factor productivity. The final column shows that the square of the change in foreign ownership is not statistically significant. This is consistent with the idea that large ownership shares do not carry additional importance for productivity improvements.

Table 3.5: Change in log TFP on change in foreign ownership. Fixed effects by year, region, and 3-digit ISIC industry code. Data from INE covering 1998-2001. Robust standard errors clustered by plant in brackets. *** p<0.01, ** p<0.05, * p<0.1.

	(1) Δ TFP_LP	(2) Δ TFP_ACF	(3) Δ TFP_TQV	(5) Δ TFP_LP
Δ foreign	0.259***	0.130	0.123	0.261***
	[0.096]	[0.101]	[0.192]	[0.095]
TFP_−1	-0.504***	-0.512***	-0.014***	-0.504***
	[0.019]	[0.019]	[0.001]	[0.019]
$size_{-1}$	0.111***	0.031***	-0.012*	0.110***
	[0.016]	[0.009]	[0.007]	[0.016]
$(\Delta \text{ foreign})^2$				0.166
				[0.117]
Observations	9,366	9,366	6,899	9,366
R-squared	0.307	0.277	0.241	0.307

Next, we restrict the sample of plants in order to investigate for which plants these effects remain significant. Table 3.6 restricts the sample to plants that report foreign ownership less than 10%-50% in the previous year in columns 1-5 respectively.

Table 3.7 restricts the sample to plants that report less than 10% in the previous period, and then restricts the sample further to plants who reported changes in foreign ownership less than

Table 3.6: Change in log TFP on change in foreign ownership. Columns 1-5 correspond to restricting to levels of lagged foreign ownership less than 10%, 20%, 30%, 40%, and 50%. Fixed effects by year, region, and 3-digit ISIC industry code. Data from INE covering 1998-2001. Robust standard errors clustered by plant in brackets. *** p<0.01, ** p<0.05, * p<0.1.

	for_{-1} <10%	for_{-1} <20%	for_{-1} <30%	$forn_{-1}$ <40%	for_{-1} <50%
	(1)	(2)	(3)	(4)	(5)
	Δ TFP_LP	Δ TFP_LP	Δ TFP_LP	Δ TFP_LP	Δ TFP_LP
Δ foreign	0.428**	0.430**	0.453***	0.421**	0.406**
	[0.174]	[0.173]	[0.173]	[0.168]	[0.159]
TFP_{-1}	-0.498***	-0.498***	-0.498***	-0.496***	-0.497***
	[0.020]	[0.019]	[0.019]	[0.019]	[0.019]
$size_{-1}$	0.138***	0.136***	0.129***	0.126***	0.123***
	[0.025]	[0.023]	[0.020]	[0.019]	[0.018]
Observations	8,834	8,855	8,877	8,902	8,957
R-squared	0.303	0.303	0.302	0.301	0.301

10%-50% in columns 1-5 respectively. We draw particular attention to table 3.7, column 1, where we see that for plants with less than 10% foreign ownership that receive an increase in foreign ownership less than 10%, total factor productivity increases in a magnitude that is both relatively large and statistically significant. Specifically, we find that for the firms in this subsample, a 1% increase in foreign ownership is expected to coincide with an extra 3.8% increase in total factor productivity.

Table 3.8 restricts the sample to plants who reported a change in foreign ownership less than 10%, and then restricts the sample further to plants who reported lagged levels of foreign ownership less than 10%-50% in columns 1-5 respectively. This restriction, by construction, renders the first columns of tables 3.7 and 3.8 identical.

Table 3.7 is replicated in appendix C.2 with the ACF and Tornqvist productivity measures as a robustness check.

Table 3.7: Change in log TFP on change in foreign ownership. Sample is restricted to plants with a level of lagged foreign ownership below 10%. Columns 1-5 correspond to restricting to changes of foreign ownership less than 10%, 20%, 30%, 40%, and 50%. Fixed effects by year, region, and 3-digit ISIC industry code. Data from INE covering 1998-2001. Robust standard errors clustered by plant in brackets. *** p<0.01, ** p<0.05, * p<0.1.

	Δfor<10%	Δfor<20%	Δfor<30%	Δfor<40%	Δfor<50%
	(1)	(2)	(3)	(4)	(5)
	Δ TFP_LP	Δ TFP_LP	Δ TFP_LP	Δ TFP_LP	Δ TFP_LP
Δ foreign	3.794**	-0.495	3.264**	2.429**	1.179
	[1.706]	[3.206]	[1.348]	[0.993]	[0.770]
TFP_{-1}	-0.496***	-0.496***	-0.497***	-0.497***	-0.497***
	[0.020]	[0.020]	[0.020]	[0.020]	[0.020]
$size_{-1}$	0.143***	0.143***	0.141***	0.142***	0.145***
	[0.026]	[0.026]	[0.026]	[0.026]	[0.027]
Observations	8,763	8,768	8,776	8,779	8,793
R-squared	0.304	0.303	0.305	0.304	0.302

Table 3.8: Change in log TFP on change in foreign ownership. Sample is restricted to plants with a change in foreign ownership below 10%. Columns 1-5 correspond to restricting to levels of lagged foreign ownership less than 10%, 20%, 30%, 40%, and 50%. Fixed effects by year, region, and 3-digit ISIC industry code. Data from INE covering 1998-2001. Robust standard errors clustered by plant in brackets. *** p<0.01, ** p<0.05, * p<0.1.

	for_{-1} <10%	for_{-1} <20%	for_{-1} <30%	$forn_{-1}$ <40%	for_{-1} <50%
	(1)	(2)	(3)	(4)	(5)
	Δ TFP_LP	Δ TFP_LP	Δ TFP_LP	Δ TFP_LP	Δ TFP_LP
Δ foreign	3.794**	1.101	6.027*	0.370	0.159
	[1.706]	[1.626]	[3.150]	[1.557]	[0.577]
TFP_{-1}	-0.496***	-0.496***	-0.495***	-0.494***	-0.495***
	[0.020]	[0.020]	[0.020]	[0.019]	[0.019]
$size_{-1}$	0.143***	0.141***	0.134***	0.130***	0.126***
	[0.026]	[0.025]	[0.022]	[0.020]	[0.019]
Observations	8,763	8,782	8,801	8,823	8,877
R-squared	0.304	0.304	0.304	0.302	0.302

Lagged changes in foreign ownership

In table 3.9 we report results for the regression specification

$$\begin{aligned}\Delta a_{ijrt} =&\beta_0 \Delta foreign_{ijr,t} + \beta_1 \Delta foreign_{ijr,t-1} + \beta_2 \Delta foreign_{ijr,t-2} \\ &+ \beta_3\, size_{ijr,t-1} + \beta_4\, a_{ijr,t-1} + \alpha_j + \alpha_r + \alpha_{t-1} + \varepsilon_{ijrt}\end{aligned} \tag{3.29}$$

both with and without the first term. With only data covering 4 years, this specification can only be run for one year of the dependent variable.

Without the first term, estimates of β_1 and β_2 are not statistically significant, but point estimates offer some suggestive confirmation that foreign ownership leads to improving log TFP in future years.

Table 3.9: Change in log TFP on lags of changes in foreign ownership. Fixed effects by year, region, and 3-digit ISIC industry code. Data from INE covering 1998-2001. Robust standard errors clustered by plant in brackets. *** p<0.01, ** p<0.05, * p<0.1.

	(1)	(2)
	Δ TFP_LP	Δ TFP_LP
Δ foreign	0.269**	
	[0.135]	
Δ foreign$_{-1}$	0.358**	0.225
	[0.180]	[0.177]
Δ foreign$_{-2}$	0.224	0.130
	[0.224]	[0.235]
TFP$_{-1}$	-0.517***	-0.516***
	[0.027]	[0.027]
size$_{-1}$	0.111***	0.110***
	[0.019]	[0.019]
Observations	2,602	2,602
R-squared	0.379	0.378

3.5.4 Instrumental variables

An endogeneity concern in the preceding results is that foreign investors have some knowledge about which plants will see their productivity increase. This endogeneity would not necessarily violate the efficient markets hypothesis because the future productivity increase could already be priced into these firms' equities. However the potential endogeneity alters the interpretation of the estimates. Here we address this possible endogeneity.

The regressor, change in foreign ownership, is influenced by plant-specific factors and therefore may be correlated with the error term. By employing a global instrument, we try to isolate the causal factors apart from the plant-specific factors.

Productivity levels

We assume that foreign investors are more likely to invest in larger plants, and we use the total real value of production for each plant from the preceding year as a preceding interaction variable to make the instrument plant-specific. Foreign capital is more plentiful in some years, and we can measure a relevant part of the global supply of capital with total outward portfolio investment in equities from the US, UK, Euro area, and Japan. Lastly, we assume that some industries are more appealing to foreign investors. So to instrument for changes in foreign ownership, we interact total developed outflows with lagged plant size and with industry dummies. The first stage estimating equation is

$$\Delta foreign_{ijrt} = \beta_j size_{ijr,t-1} outflows_t + \beta_0 size_{ijr,t-1} + \alpha_j + \alpha_r + \alpha_t + \varepsilon_{ijrt} \tag{3.30}$$

for a plant i, in industry j, at year t. This follows the empirical strategy of Keller and Yeaple (2009). Interacting with industry dummies is equivalent to running the first stage industry by industry, and pooling.

Instruments that assume shocks will be distributed according to some pre-existing shares originate with Bartik (1991.) They are the subject of several recent analyses (Borusyak, Hull, and Jaravel 2018 and Goldsmith-Pinkham, Sorkin, and Swift 2018.) The key question is if the shares are correlated with the error term, in which case the endogeneity problem remains. To address this in our case, we add lagged size as a control in both stages of the instrumental variables (IV) regression.

We run an IV regression with the second stage

$$a_{ijrt} = \beta_1 \Delta \hat{foreign}_{ijrt} + +\beta size_{ijr,t-1} + \alpha_j + \alpha_r + \alpha_t + \varepsilon_{ijrt}$$

and report results in table 3.10.

Table 3.10: Instrumental variables regression of log TFP level on change in foreign ownership. Fixed effects by year, region, and 3-digit ISIC industry code. Data from INE covering 1998-2001. Standard errors in brackets. *** p<0.01, ** p<0.05, * p<0.1.

	(1) TFP_LP
Δ foreign	0.908***
	[0.347]
$size_{-1}$	0.217***
	[0.007]
Observations	9,547
First stage F stat	7.14
R-squared	0.578

Productivity changes

Here we aim to run second stage regressions identical to equation (3.21). Our first stage takes the form

$$\Delta foreign_{ijrt} = \beta_j size_{ijr,t-1} outflows_t + \beta_0 size_{ijr,t-1} + \beta_1 a_{ijr,t-1} + \alpha_j + \alpha_r + \alpha_t + \varepsilon_{ijrt}. \quad (3.31)$$

The results, in table 3.11, show statistical significance at the 5% level.

Table 3.11: Instrumental variables regression of change in log TFP on change in foreign ownership. Fixed effects by year, region, and 3-digit ISIC industry code. Data from INE covering 1998-2001. Standard errors in brackets. *** p<0.01, ** p<0.05, * p<0.1.

	(1) Δ TFP_LP
Δ foreign	0.633**
	[0.293]
TFP_{-1}	-0.503***
	[0.008]
$size_{-1}$	0.112***
	[0.006]
Observations	9,366
First stage F-stat	7.29
R-squared	0.304

Next we duplicate table 3.6, and restrict to levels of lagged foreign ownership less than 10%, 20%, 30%, 40%, and 50% in columns 1-5, respectively, of table 3.12.

3.5.5 Share of inputs imported

OLS in levels

In this section, we ask if foreign ownership changes how plants operate. One possibility could be that foreign investors impart knowledge of foreign technology and links to foreign suppliers. Our data includes imports of foreign inputs, so here we investigate if foreign owned plants use more imported inputs.

Our dependent variable is what fraction of inputs are imported. The estimating equation is

$$imported\,input\,share_{ijrt} = \beta_1 foreign_{ijrt} + \alpha_j + \alpha_r + \alpha_t + \varepsilon_{ijrt}. \tag{3.32}$$

Table 3.12: Instrumental variables regression of change in log TFP on change in foreign ownership. Columns 1-5 correspond to restricting to levels of lagged foreign ownership less than 10%, 20%, 30%, 40%, and 50%. Fixed effects by year, region, and 3-digit ISIC industry code. Data from INE covering 1998-2001. Standard errors in brackets. *** p<0.01, ** p<0.05, * p<0.1.

	for_{-1} <10%	for_{-1} <20%	for_{-1} <30%	$forn_{-1}$ <40%	for_{-1} <50%
	(1)	(2)	(3)	(4)	(5)
	Δ TFP_LP	Δ TFP_LP	Δ TFP_LP	Δ TFP_LP	Δ TFP_LP
Δ foreign	1.190***	1.220***	1.520***	1.333***	1.325***
	[0.414]	[0.409]	[0.409]	[0.383]	[0.376]
TFP_{-1}	-0.498***	-0.497***	-0.497***	-0.496***	-0.496***
	[0.009]	[0.009]	[0.009]	[0.009]	[0.009]
$size_{-1}$	0.132***	0.130***	0.122***	0.120***	0.118***
	[0.009]	[0.009]	[0.008]	[0.008]	[0.008]
Observations	8,834	8,855	8,877	8,902	8,957
First-stage F stat	3.62	3.59	3.88	4.18	4.3
R-squared	0.298	0.297	0.291	0.293	0.292

The results, in table 3.13, show that wholly domestic plants import less. Furthermore, it is the presence of any foreign ownership, and not large levels, that implies a plant will import inputs.

This evidence that plants with low levels of foreign ownership employ economically significantly more imported inputs suggests that portfolio investment may involve transfer of information, management pratices, or technology to the recipient plants. This would have real effects in the context of the model presented in chapter 2 or in Keller (2002) where technology takes the form of differentiated intermediate inputs.

Instrumental Variables

We remploy the same instrument with a first stage as in equation (3.30). The estimating equation takes the form

$$imported\,input\,share_{ijrt} = \beta\Delta\widehat{foreign}_{ijrt} + \beta_0\,size_{ijr,t-1} + \alpha_j + \alpha_r + \alpha_t + \varepsilon_{ijrt}.$$

Table 3.13: Regression of share of inputs imported on foreign ownership. Column 1 represents the full sample. Columns 2-6 restrict the sample to plants with less than 10%-50% foreign ownership respectively. Fixed effects by year, region, and 3-digit ISIC industry code. Data from INE covering 1998-2001. *** p<0.01, ** p<0.05, * p<0.1.

	(1) imp share	for<10% (2) imp share	for<20% (3) imp share	for<30% (4) imp share	for<40% (5) imp share	for<50% (6) imp share
foreign	0.087***	0.934	0.352***	0.325***	0.242***	0.169***
	[0.009]	[0.888]	[0.125]	[0.064]	[0.050]	[0.037]
Obs	15,404	14,462	14,499	14,539	14,580	14,686
R2	0.154	0.123	0.124	0.126	0.128	0.128

We find that the IV estimate for the effect of the change on foreign ownership on the share of inputs imported is significant at the 1% level.

Table 3.14: Instrumental variables regression of share of inputs imported on foreign ownership. Fixed effects by year, region, and 3-digit ISIC industry code. Data from INE covering 1998-2001. *** p<0.01, ** p<0.05, * p<0.1.

	(1) import_share
Δ foreign	0.163***
	[0.053]
$size_{-1}$	1.894***
	[0.096]
Observations	10,144
First stage F-stat	6.29
R-squared	0.140

3.6 Conclusion

In plant-level data from Chilean manufacturers, foreign ownership increases total factor productivity. This effect is evident at low levels of foreign ownership. In other words, foreign portfolio investment also has positive effects on productivity. One channel seems to be a shift of the recipient of foreign capital towards the increased use of foreign intermediate goods.

Increases in foreign ownership coincide with increases in total factor productivity, and this effect is maintained for small levels of foreign owmership and small increases in it. Previous literature had focused on FDI, which requires a larger ownership stake. Our results suggest that it is the initial, small foreign stake that matters most, as evidenced for example by the conditional derivative of log TFP estimated to be decreasing in foreign ownership.

This matters because foreign portfolio investment flows have exploded in recent decades. Our evidence that foreign ownership improves productivity implies increased transference of international technology and management practices.

The policy implication of this result is that foreign portfolio investment is beneficial for recipient plants. Therefore persistent FPI should be encouraged where possible.

Appendix A

Appendices to Chapter 1

A.1 Illiquidity, robustness to maturity

Here we duplicate table 1.1 using 10 year maturities instead of 20 years. We argue that the similarity of the results shows that illiquidity or stale prices do not drive the main conclusions.

Table A.1: Nominal exchange rate variance decomposition for Mexico. The long term is 10 years forward. Sample is April 2008 to July 2017.

	$var(q_t^E + \theta_t)$	$var(p_t - p_t^* + r_t^* - r_t)$	$cov(q_t^E + \theta_t, p_t - p_t^* + r_t^* - r_t)$
levels	79.9	9.9	5.1
changes	154	70.3	-62.3

Table A.1 reports the variance decomposition in levels and monthly changes for Mexico.

Table A.2: Nominal exchange rate variance decomposition for Brazil. The long term is 10 years forward. Sample is November 2005 to July 2017.

	$var(q_t^E + \theta_t)$	$var(p_t - p_t^* + r_t^* - r_t)$	$cov(q_t^E + \theta_t, p_t - p_t^* + r_t^* - r_t)$
levels	63.3	32.3	2.19
changes	175	47.3	-61.0

Table A.2 reports the variance decomposition in levels and monthly changes for Brazil.

Table A.3: Nominal exchange rate variance decomposition for South Africa. The long term is 10 years forward. Sample is September 2011 to July 2017.

	$var(q_t^E + \theta_t)$	$var(p_t - p_t^* + r_t^* - r_t)$	$cov(q_t^E + \theta_t, p_t - p_t^* + r_t^* - r_t)$
levels	35.8	20.6	21.8
changes	136	29.5	-32.6

Table A.3 reports the variance decomposition in levels and monthly changes for South Africa.

A.2 A general approach to the stochastic discount factor

Here we outline a general approach to estimating the stochastic discount factor relying on a few assumptions regarding distributions and functional forms.

The observable state variables relevant for risk, utility, asset prices, and anything else relevant are contained in a vector X_{t+1} (n x 1). These variables are assumed to depend on their past in some general way plus normally distributed innovations u_{t+1} (n x 1). So the data generating process is

$$X_{t+1} = F(X_{t-s})_{\{s \geq 0\}} + u_{t+1},\; u_{t+1} \sim N(0,\Sigma).$$

The function $F(X_{t-s})_{\{s\geq 0\}}$ may be a vector auto-regression of order p, or some nonlinear function of the past variables. The typical case will be $X_{t+1} = \Phi X_t + u_{t+1}$, where Φ (n x n) is the VAR(1) coefficient matrix.

Prices of risk take the "essentially-affine" form introduced by Duffee (2002)

$$\underset{nx1}{\lambda_t} = \underset{nx1}{\lambda_0} + \underset{nxn}{\Lambda_1}\underset{nx1}{X_t}.$$

Constant prices of risk, $\Lambda_1 = 0$ will generate Fama-MacBeth regressions for pricing.

The stochastic discount factor, whose expectation must equal 1, takes the form

$$m_{t+1} = e^{\lambda_t' u_{t+1} - 1/2\lambda_t'\Sigma\lambda_t}.$$

Finally, discounted, or excess returns for an asset with price a_t are defined as $z_{t+1} = \frac{a_{t+1}}{a_t e^{r_t}}$. Their uncertainty is also assumed to captured by the factors and takes the form $z_{t+1} = e^{\delta_t' X_{t+1}}$. δ_t (n x 1) may be time-varying, but it is known at time t.

From these assumptions we use the fact that $\mathbb{E}_t[m_{t+1}z_{t+1}] = 1$ to get

$$1 = \mathbb{E}_t[e^{\lambda_t' u_{t+1} - 1/2\lambda_t'\Sigma\lambda_t + \delta_t'(F(X_{t-s})_{\{s\geq 0\}} + u_{t+1})}].$$

Evaluating the expectation and taking logs we have

$$\delta_t'\Sigma\lambda_t = -\delta_t' F(X_{t-s})_{\{s\geq 0\}} - 1/2\delta_t'\Sigma\delta_t.$$

Left-multiplying both sides by $\Sigma^{-1}(\delta_t\delta_t')^{-1}\delta_t$ and taking the transpose solves for λ_t:

$$\lambda_t' = -F(X_{t-s})'_{\{s\geq 0\}}\Sigma^{-1} - 1/2\delta_t'.$$

Right-multiplying by $X_{t+1}$and rearranging yields

$$\delta_t' X_{t+1} = -2\lambda_t' X_{t+1} - 2F(X_{t-s})'_{\{s\geq 0\}}\Sigma^{-1}X_{t+1}.$$

The left-hand side of this are the excess returns. If we allow for return pricing errors ε_{t+1} we can write this as a linear regression

$$-F(X_{t-s})'_{\{s\geq 0\}}\Sigma^{-1}X_{t+1} - \frac{1}{2}\ln z_{t+1} = (\lambda_0 + \Lambda_1 X_t)' X_{t+1} + \varepsilon_{t+1}.$$

The factors X_t and excess returns z_{t+1} are observable. The data-generating process $F(X_{t-s})$ can be estimated. Therefore the price of risk factors λ_0 and $\Lambda_1$enter this equation as n and $n \times n$ regression coefficients to be estimated by ordinary least squares.

Given the vector λ_0 and matrix Λ_1, combined with the factors X_t, the stochastic discount factor m_{t+1} is estimated. This allows calculation of the relevant covariance in the risk premium term.

Appendix B

Appendices to Chapter 2

B.1 Robustness of extensive margin

In table B.1 we redo the first stylized fact using a 5% threshold for the new imports margin.

Table B.1: Regression of extensive margin of imports on investment inflows and lag of the dependent variable, using a 5% threshold. The final column means that an extra 1000 USD of portfolio investment predicts 42.5 USD of extra imports of new varieties. All variables are expressed as fractions of GDP. Data cover 2001 to 2015. Data from IMF, World Bank, and Federal Reserve. Standard errors in brackets. *** p<0.01, ** p<0.05, * p<0.1

	new varieties imported					
lagged portfolio eq inv	0.0981**	0.0977**	0.0984**	0.0492	0.0431	0.0425
	(0.0321)	(0.0307)	(0.0306)	(0.0335)	(0.0322)	(0.0321)
lagged direct eq invest	0.0158	0.0145		-0.0169	-0.0183	
	(0.0287)	(0.0261)		(0.0282)	(0.0261)	
lagged new imports	-0.026			-0.112		
	(0.063)			(0.061)		
two lags of GDP growth	yes	yes	yes	yes	yes	yes
country fixed effects	yes	yes	yes	yes	yes	yes
year fixed effects				yes	yes	yes
R2	0.70	0.70	0.70	0.76	0.76	0.75
observations	233	247	248	233	247	248

In table B.2 we redo the first stylized fact, weighting countries by their GDP.

Both sets of regression demonstrate the robustness of the stylized fact.

B.2 Portfolio constraints

In this section we document evidence of portfolio constraints in portfolio investment in equities. This fact is already well established in the literature on "contagion." We examine 10 developing countries. Equity data comes from the Global Financial Database and portfolio investment comes from the IMF Balance of Payments Database. [1] Data is quarterly for Q4 1997

[1]The countries examined are Brazil, India, Indonesia, Malaysia, Mexico, Philippines, Russia, South Africa, Thailand, and Turkey. The respective equity indices are the Dow Jones Brazil, India S&P/Crisil-500, Dow Jones Indonesia, ow Jones Malaysia, Dow Jones Mexico, Dow Jones Philippines, Russia MICEX Composite, Dow Jones South Africa, Dow Jones Thailand, and Istanbul SE All-share.

Table B.2: Regression of extensive margin of imports on investment inflows and lag of the dependent variable. The final column means that an extra 1000 USD of portfolio investment predicts 103 USD of extra imports of new varieties. Countries are weighted by their GDP (or equivalently, the elements of the regression are not normalized by GDP). Data cover 2001 to 2015. Data from IMF, World Bank, and Federal Reserve. Standard errors in brackets. *** p<0.01, ** p<0.05, * p<0.1

	new varieties imported					
lagged portf eq inv	0.185***	0.185***	0.189***	0.101***	0.101***	0.103***
	(0.0322)	(0.0309)	(0.0306)	(0.0320)	(0.0309)	(0.0306)
lagged direct eq inv	-0.00663	0.00107		-0.0107	-0.00815	
	(0.0209)	(0.0188)		(0.0204)	(0.0192)	
lagged new imports	0.017			-0.010		
	(0.076)			(0.076)		
two lags GDP growth	yes	yes	yes	yes	yes	yes
country fixed effects	yes	yes	yes	yes	yes	yes
year fixed effects				yes	yes	yes
R2	0.59	0.58	0.58	0.70	0.70	0.70
observations	233	247	248	233	247	248

to Q3 2016.

Portfolio investment in equities is expressed as a fraction of GDP. Results are presented in table B.4.

Portfolio flows are seen to be statistically persistent. The evidence for portfolio constraints is that flows are positively correlated with lagged returns, at 5% significance. With a normal downward sloping demand curve for assets, the sign would be negative. This suggests that price falls cause sales, precisely the amplification mechanism in our model. Therefore portfolio constraints are binding for the marginal investor, or at least they behave as if they are.

B.3 Firms' use of external capital

Tradeables producers' output is $Y_T^{MEX} = \tilde{A}^{1-\alpha}\frac{1}{\alpha}\left(\int_0^{N^{MEX}} x^{\alpha}(v)dv\right)\left(L_T^{MEX}\right)^{1-\alpha}$.

Demand for intermediate inputs are $x^{MEX} = \tilde{A}L_T^{MEX}$.

Wages are $w = \tilde{A}\frac{1-\alpha}{\alpha}N^{MEX}$.

Table B.3: Regression of portfolio equity investment on lagged equity returns. Data cover Q4 1997 to Q3 2016. Dynamic panel (Nickell 1981) bias is neglible because the time dimension is much greater than the cross-sectional. Data from IMF and World Financial Database. Standard errors in brackets. *** $p<0.01$, ** $p<0.05$, * $p<0.1$

	portfolio equity investment
lagged equity investment	0.23***
	[0.036]
lagged equity returns	0.0028**
	[0.0012]
lagged fed funds	0.00018
	[0.00010]
lagged fed funds change	0.0011***
	[0.00052]
lagged returns * abs(returns)	-0.00022*
	[0.00010]
country fixed effects	yes
R2	0.095
observations	752

Tradeables producers' intermediate input cost is $X = xN = \tilde{A}L_T^{MEX}N$.

Their wage cost is $wL_T = \tilde{A}\frac{1-\alpha}{\alpha}N^{MEX}L_T$.

Their total cost is $\frac{1}{\alpha}\tilde{A}L_T N$.

So as varieties increase, intermediate input costs increase by α of total cost. If we assume a standard capital share, $\alpha = 0.35$, we would expect new financing of \$1mm to lead to \$350k of imported varieties.

B.4 Dynamics of flows under leverage constraint

The foreign investor has financial capital K_s at the start of period s. Full leverage to a factor Γmeans choosing to borrow $(\Gamma - 1)K_s$ in debt. These two together constitute the liability side of the investor's balance sheet. The assets are foreign equities, specifically a quantity N_s at a price V_s. Equality between assets and liabilities yields

$$\Gamma K_s = V_s N_s. \tag{B.1}$$

Profit earned between periods comes from equity price changes and interest costs:

$$\pi_{t+1} = (V_{s+1} - V_s)N_s - r(\Gamma - 1)K_{s.} \tag{B.2}$$

Financial capital changes with the profit, so

$$K_{s+1} = K_s + \pi_{t+1}. \tag{B.3}$$

Subsequently, the investor chooses N_{s+1} to meet the leverage constraint

$$\Gamma K_{s+1} = V_{s+1} N_{s+1}. \tag{B.4}$$

Combining B.3 and B.4 we get

$$V_{s+1}N_{s+1} = \Gamma(K_s + V_{s+1}N_s - V_s N_s - r(\Gamma - 1)K_s). \tag{B.5}$$

Using B.1 we can rewrite

$$V_{s+1}N_{s+1} = V_s N_s + \Gamma V_{s+1} N_s - \Gamma V_s N_s - r(\Gamma - 1)V_s N_s). \tag{B.6}$$

Rearranging produces

$$\frac{N_{s+1} - N_s}{N_s} = (\Gamma - 1)\frac{(V_{s+1} - (1+r)V_s)}{V_{s+1}}. \tag{B.7}$$

Defining portfolio flows $\Delta N_{s+1} = N_{s+1} - N_s$ and excess price changes $\Delta V_{s+1} = V_{s+1} - (1+r)V_s$, we arrive at the key equation for portfolio flows' response to price changes

$$\frac{\Delta N_{s+1}}{N_s} = (\Gamma - 1)\frac{\Delta V_{s+1}}{V_{s+1}}. \tag{B.8}$$

Clearly price volatility is much larger than interest costs, so the r term is negligible.

Appendix C

Appendices to Chapter 3

C.1 Industry details

Table C.1: Industry classifications in ENIA dataset. Source: INE.

ISIC2	Frequency	Description
311	4,297	Food manufacturing (a)
312	267	Food manufacturing (b)
313	320	Beverage industries
321	989	Manufacture of textiles
322	827	Manufacture of wearing apparel, except footwear
323	121	Manufacture of leather and products of leather, leather substitutes and
324	402	Manufacture of footwear, except vulcanized or moulded rubber
331	1,134	Manufacture of wood and wood and cork products, except furniture
332	443	Manufacture of furniture and fixtures, except primarily of metal
341	298	Manufacture of paper and paper products
342	634	Printing, publishing and allied industries
351	241	Manufacture of industrial chemicals
352	598	Manufacture of other chemical products
354	60	Manufacture of miscellaneous products of petroleum and coal
355	195	Manufacture of rubber products
356	784	Manufacture of plastic products not elsewhere classified
361	36	Manufacture of pottery, china and earthenware
362	82	Manufacture of glass and glass products
369	517	Manufacture of other non-metallic mineral products
371	125	Iron and steel basic industries
372	96	Non-ferrous metal basic industries
381	1,475	Manufacture of fabricated metal products, except machinery
382	674	Manufacture of machinery except electrical
383	215	Manufacture of electrical machinery apparatus, appliances and supplies
384	332	Manufacture of transport equipment
385	93	Manufacture of professional and scientific, and measuring and controlli
390	199	Other Manufacturing Industries

C.2 Robustness to productivity measure

Here we duplicate table 3.7 using the ACF and Tornqvist TFP measures.

Table C.2: Change in log TFP on change in foreign ownership with ACF measure of TFP. Sample is restricted to plants with a level of lagged foreign ownership below 10%. Columns 1-5 correspond to restricting to changes of foreign ownership less than 10%, 20%, 30%, 40%, and 50%. Fixed effects by year, region, and 3-digit ISIC industry code. Data from INE covering 1998-2001. Robust standard errors clustered by plant in brackets. *** p<0.01, ** p<0.05, * p<0.1.

	(1) Δ TFP_ACF	(2) Δ TFP_ACF	(3) Δ TFP_ACF	(4) Δ TFP_ACF	(5) Δ TFP_ACF
Δ foreign	3.025*	0.008	0.236	0.139	0.704
	[1.797]	[3.261]	[1.218]	[0.826]	[0.769]
TFP_{-1}	-0.503***	-0.503***	-0.503***	-0.503***	-0.503***
	[0.018]	[0.018]	[0.018]	[0.018]	[0.018]
$size_{-1}$	0.027*	0.028*	0.028*	0.028*	0.030**
	[0.015]	[0.015]	[0.015]	[0.015]	[0.015]
Observations	8,763	8,768	8,776	8,779	8,793
R-squared	0.273	0.273	0.273	0.273	0.271

Table C.3: Change in log TFP on change in foreign ownership with Tornqvist measure of TFP. Sample is restricted to plants with a level of lagged foreign ownership below 10%. Columns 1-5 correspond to restricting to changes of foreign ownership less than 10%, 20%, 30%, 40%, and 50%. Fixed effects by year, region, and 3-digit ISIC industry code. Data from INE covering 1998-2001. Robust standard errors clustered by plant in brackets. *** p<0.01, ** p<0.05, * p<0.1.

	(1) Δ TFP_TQV	(2) Δ TFP_TQV	(3) Δ TFP_TQV	(4) Δ TFP_TQV	(5) Δ TFP_TQV
Δ foreign	1.277	1.633**	1.582*	0.231	-0.077
	[1.225]	[0.720]	[0.826]	[0.597]	[0.404]
TFP_{-1}	-0.015***	-0.015***	-0.015***	-0.015***	-0.015***
	[0.001]	[0.001]	[0.001]	[0.001]	[0.001]
$size_{-1}$	-0.022	-0.021	-0.021	-0.020	-0.020
	[0.014]	[0.014]	[0.013]	[0.013]	[0.013]
Observations	6,400	6,403	6,406	6,409	6,420
R-squared	0.238	0.238	0.238	0.238	0.238

C.3 Robustness to outliers

Our data may contain plants that face extreme shocks such as labor disputes or fires, for example. Our analysis would measure close to zero TFP in some cases. Here we exlude TFP outliers to show that our results are not driven by outliers.

Here we duplicate table 3.7, first removing all observations where the dependent variable is more than 4 standard deviations from the mean.

Table C.4: Change in log TFP on change in foreign ownership with Tornqvist measure of TFP. Sample is restricted to plants with a level of lagged foreign ownership below 10%. Columns 1-5 correspond to restricting to changes of foreign ownership less than 10%, 20%, 30%, 40%, and 50%. Fixed effects by year, region, and 3-digit ISIC industry code. Data from INE covering 1998-2001. Robust standard errors clustered by plant in brackets. *** $p<0.01$, ** $p<0.05$, * $p<0.1$.

	(1) Δ TFP_LP	(2) Δ TFP_LP	(3) Δ TFP_LP	(4) Δ TFP_LP	(5) Δ TFP_LP
Δ foreign	3.733**	-0.695	2.559*	1.867**	0.053
	[1.560]	[3.128]	[1.333]	[0.929]	[0.348]
TFP_{-1}	-0.406***	-0.405***	-0.406***	-0.406***	-0.406***
	[0.016]	[0.016]	[0.016]	[0.016]	[0.016]
$size_{-1}$	0.118***	0.118***	0.117***	0.118***	0.119***
	[0.028]	[0.028]	[0.027]	[0.028]	[0.028]
Observations	8,686	8,691	8,698	8,701	8,713
R-squared	0.237	0.236	0.237	0.236	0.236

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