Import Switching and the Impact of a Large Devaluation*

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Abstract

Using firm-level data for manufacturing firms in Colombia, we find three surprising facts related to a large devaluation. First, firms drop fewer imported inputs than in a normal period. One would expect the opposite; the number of imported varieties does fall but due to fewer adding of new imported varieties. Second, while most firms add and drop imported inputs all the time fewer do so during the devaluation; that is, there is more inaction in a devaluation. Third, within firms, adding and dropping of imported inputs are positively correlated, in both devaluation and normal periods.

These facts taken together highlight that the mechanisms by which imports adjust to a devaluation are not well understood. We propose a model where firms reorganize production and gain TFP through adding and dropping inputs over time. Firms search among suppliers who are heterogenous and, after comparing them, choose to buy the most efficient inputs. In a devaluation period, the gain from searching is lower and so firms do it less. Finally, we find further firm-level evidence consistent with the model, in particular, that imported input switching is associated with productivity gains.

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1 Introduction

In Colombia, from 1998 to 1999, during a large external shock the US to Colombia real exchange rate, RER, depreciated by 26% and import value dropped 32%. In this episode we document three surprising facts. First, since imports became more expensive during the devaluation, we would expect firms to drop more imported inputs. However, using firm-level import data for manufacturing firms, we find the opposite. To be sure, firms use less imported varieties during the devaluation but itis due to fewer adding of new imported varieties rather than more dropping. Our paper emphasizes that focusing only on changes in the net neglects an important dynamic adjustment. In an unrelated context, we find this result has the flavor of Shimer (2012), where he shows that unemployment increases are due to falling job finding rates rather than increases in job separation rates.

Second, we find most firms add and drop import varieties all the time, but fewer do so in the devaluation period. In other words, there is more inaction when imports are expensive. A popular adjustment story, namely that firms shift towards lower quality imports in a devaluation, is hard to reconcile with these facts as it would predict more switching instead of less. Naturally, we further look at firms' imported input adding and dropping behavior. We report a third fact: within firms, adding and dropping are positively correlated both during normal times and in devaluations. This rules out a composition effect explanation of our findings: an expanding firm adds more varieties than it drops whereas the opposite holds for a contracting firm. Actually, we find firms are substituting some inputs for others all the time.

The reported evidence highlights that the mechanisms by which importers adjust to devaluations are not well understood. Moreover, switching behavior has the potential to have important aggregate effects since, at the firm-level, both add and drop over total import value are around 30% on average. In order to rationalize these findings, we propose a model of production reorganization where firms choose to import an endogenous range of inputs depending on input productivity. Over time, importers decide whether to pay a search cost to be connected with a new bunch of foreign input suppliers. Each period, this process delivers new input productivity draws which are compared to those currently used. Naturally, the firm keeps the best suppliers/inputs and firm productivity gains are obtained.

Our paper is related to the recent work on the relationship between firm imports and productivity. Amiti and Konings (2007) show that reducing import tariffs leads to large productivity gains that mostly come from inputs. Halpern et al. (2011) estimate the effects of imported input use on total factor productivity for Hungarian firms. Goldberg et al. (2010), using a trade liberalization episode in India, show that reducing input tariffs induces new products. Gopinath and Neiman (2011) also use a similar production function to study the impact of the number of imported inputs on aggregate productivity. They focus on the Argentinean devaluation and show how price indices need to be adjusted to properly account for changes in the extensive margin of imports. We extend the static model of endogenous choice of imported inputs in Halpern et al. (2011), by introducing search and adjustment of imported inputs. We show that imported input switching relates to dynamic productivity gains, and that the switching behavior depends on firms' productivity and age. The price of imports, in particular through import tariffs and exchange rates, affects firms' switching behavior, and both the static and dynamic productivity gains of firms.

The dynamic model provides explanation for our empirical findings in Colombian data and in the literature. First, in the data, most firms switch imported varieties: in normal times, 50% of importers switch imported inputs and these firms have future sales growth. In the model, firms pay a search cost to be connected with a new bunch of foreign input suppliers, and shift their imported input use towards the more productive ones. Second, in the data, conditional on age, larger firms are more likely to switch. In parallel, conditional on size, older firms use more imported varieties but switch less. In the model, this is because the benefit from searching new suppliers is larger for more productive firms, so larger firms search and switch. Over time, firms use more varieties and, since finding better suppliers gets harder and harder, older firms switch less. Third, in the data we find that during the devaluation firms switch less, which seems counterintuitive. In the model, there is indeed more inaction when the import price is high, simply because the gains from searching are lower. This mechanism also explains that reducing import tariffs leads to large productivity gains and that large devaluations lead to large TFP declines. Our empirical analysis shows the productivity decline during the devaluation indeed relates to less gross switching of imported inputs.

The supplier search mechanism modulates manufacturing TFP, not only through firms' total number of varieties, but also through reallocation within firms. Our proposed dynamic model provides guidance for our empirical analysis: Firms' adjustment choice depends on the cumulated time spent searching, firm productivity, and import prices. In the empirical section, first, we confirm the reported aggregate facts related to the devaluation at the firm-level. Second, we find further evidence consistent with our proposed mechanisms. In particular, we find that firms increase their sales after re-organizing. We also show that smaller imported inputs in terms of purchased value are more likely to be dropped. Finally, over time, and in line with their searching activity, firms use both more suppliers and imported inputs but replace them at a lower rate.

Though we use the large devaluation in Colombia as exogenous variation, our mechanism is more generally applicable than exchange rate shocks. For example, under our model, free trade agreements would reduce import prices, which would induce more firms to search for productive imported inputs, and result in larger dynamic productivity gains. In fact, Damijan et al. (2012) show that import switching is relevant for firm productivity growth using Slovenia's trade liberalization. We explain such firms' import switching behavior and provide empirical evidence on the proposed mechanism both across firms and over time. On the other hand, Bernard et al. (2010) focus on product switching on the output side. They show that US manufacturing firms use product churning as a way to reallocate their resources within the firm boundaries. Like them, we argue that focusing only on the number of imported inputs disregards an important adjustment channel. We show this process is dynamic in nature.

The remainder of the paper is structured as follows. Section 2 describes our dataset and reports key aggregate and firm-level facts during the devaluation. Section 3 spells out the model and states the proofs. Section 4 shows further evidence on firm-level switching consistent with the model predictions. Section 5 concludes.

2 Data and Empirical Evidence

We use two data sources. First, the import and export data, which comes from DIAN, the government tax authority. We have all import (export) transactions from 1994 to 2011 with data on value, quantity, HS code at 10 digits, country of origin (destination) and crucially with NIT, the tax identifier. Using the NIT we keep all manufacturing firms to avoid distributors[1]. Second, data from a manufacturing survey, is conducted by the national statistical office, DANE. The survey, called EAM (Encuesta Anual

[1] Before restricting our sample to manufacturing firms our dataset aggregates to virtually the same value as the DANE aggregate trade value statistics. Aggregate manufacturing trade closely tracks total Colombian trade and is around 50-60% of total value.

Manufacturera), is a well-known panel for which we have data for the period 1994-2011. Using a common identifier we merge both sources which results in an unbalanced panel for 1994-2011.

In Colombia, from 1998 to 1999, during a large external shock the RER depreciated by 26% [2] and import value dropped by 32% [3]. In Figure 1, we highlight dimensions on which Gopinath and Neiman (2011) did not focus, to show the relevance of gross margins for the aggregate adjustment patterns in the devaluation. We split changes in imports into 6 dimensions rather than 3: firm entry, and exit; for each continuing firm, the value of new added imported products, and the value of dropped products; the increased value of continuing products, and the decreased value for continuing products. We define dropped imported inputs as products that are never bought by the firm again, whereas added products as those that have never been bought by the firm before[4]. While results are qualitatively the same with a less restrictive definition of add and drop, using this definition, we avoid an inventory explanation as in Alessandria et al. (2010).

[2]The reported RER is US to Colombia and the change is from August 1998 to August 1999. The US is Colombia's major trading partner.

[3]The equivalent import value drop for manufacturing firms is 23%.

[4] In case of an HS code change, we use detailed documents of HS revisions to create a concordance which is available upon request. For more on this, see Section 6.2.1 in the Empirical Appendix.

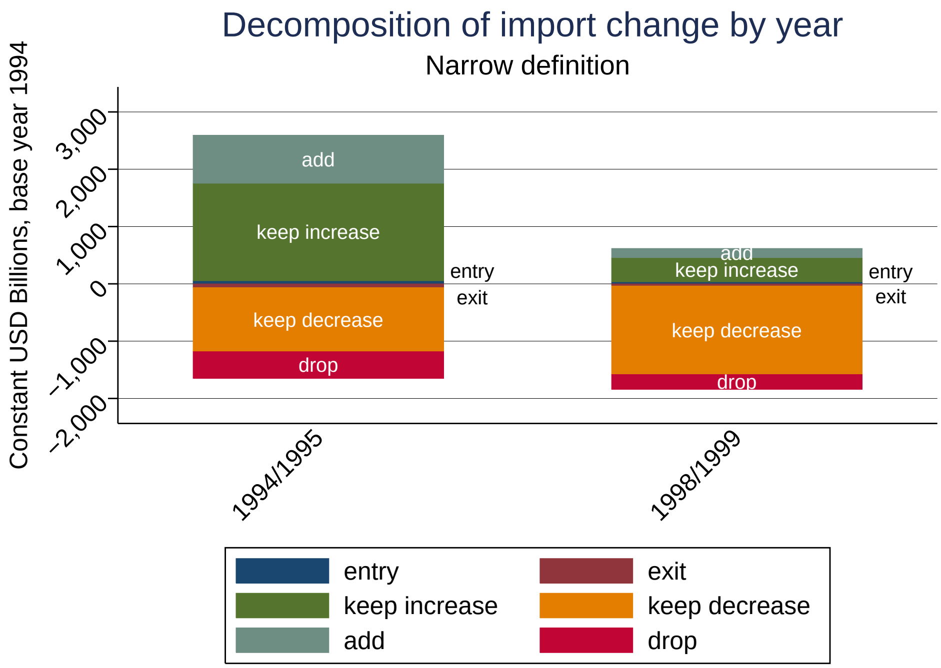

Figure 1: Decomposition of Imports Change.

In Figure 1 we report change values for our 3 pairs of adjustment modes during two different episodes: a period of aggregate import value increase, 1994/1995, and a period with a value decrease, 1998/1999. In both periods, import value of entering firms is close to those exiting. A similar pattern is obtained for the other margins. It is surprising that margins that contribute to a lower import value do not increase much during the depreciation period, 1999. In fact, import value falls mostly because two margins, added products and continuing products with increasing value, fall and not because firms dropped a larger value of imported inputs[5]. Furthermore, adjustment margins that move contrary to the net are not negligible in terms of value, e.g., there is still a large amount of adding during the devaluation and dropping during appreciation. We will show that this finding is not simply due to idiosyncratic shocks to firms and a composition effect. In particular, our story will focus on adding and dropping because of search efforts by firms.

[5] A reasonable concern is that adding and dropping values are low because import value is low. However, at the firm-level, adding and dropping values normalized by total imports fall both using a mean difference t-test and in the results reported in the firm-level regressions Section.

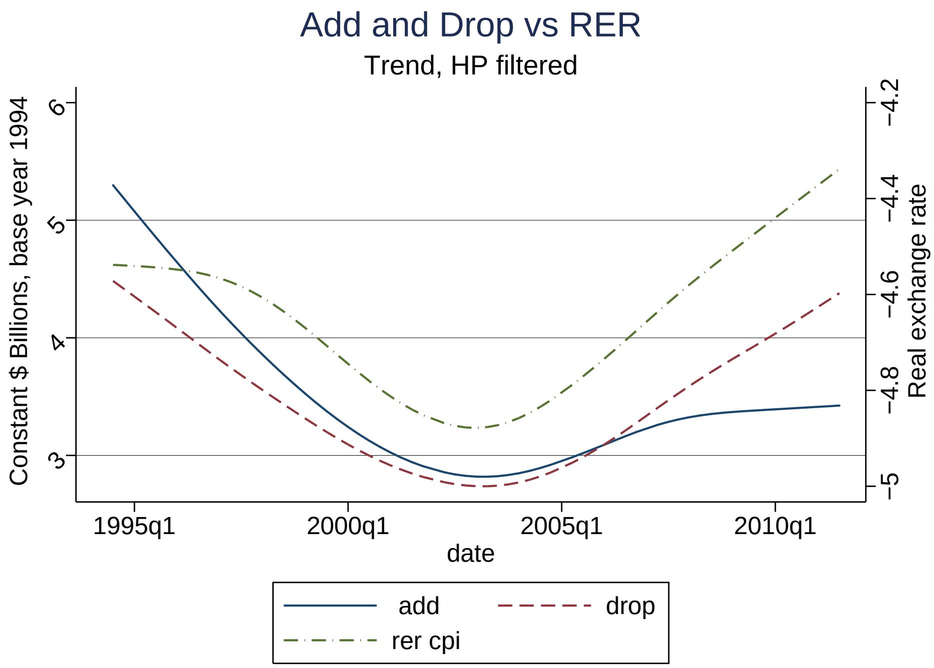

Figure 2: Aggregate Add And Drop Value Against The RER. HP Filtered Data.

To further understand the role of the RER, we plot it together with aggregate add and drop values[6]. We do so by filtering quarterly values of both margins and RER data to then focus on the trend[7]. We do this because in Section 3 our explanation of aggregate patterns is about technology choice by firms[8]. Figure 2 shows that the value of added and dropped products by continuing firms comoves positively with the exchange rate; falls in aggregate volumes of adding and dropping are observed with a depreciation[9]. This pattern is essentially the same when replicating the analysis for the average number of added and dropped products across firms. These two figures refuse a simple explanation where the net value of imports fall because firms drop more imports as they become more expensive.

[6] RER_t is the US-Colombia rate, with base year 1992, so uses nominal rate as dollars per peso.

[7] More precisely, we take logs first and then apply the HP filter using the conventional value of 1600 for lambda. The results are similar when we look at the cycle.

[8] In the case of Colombia, the RER depreciated a 50% from 1996 to 2003 before going back to its 1996 value by 2008.

[9] A similar pattern appears for the remaining 4 margins, entry and exit, and keep increase and decrease.

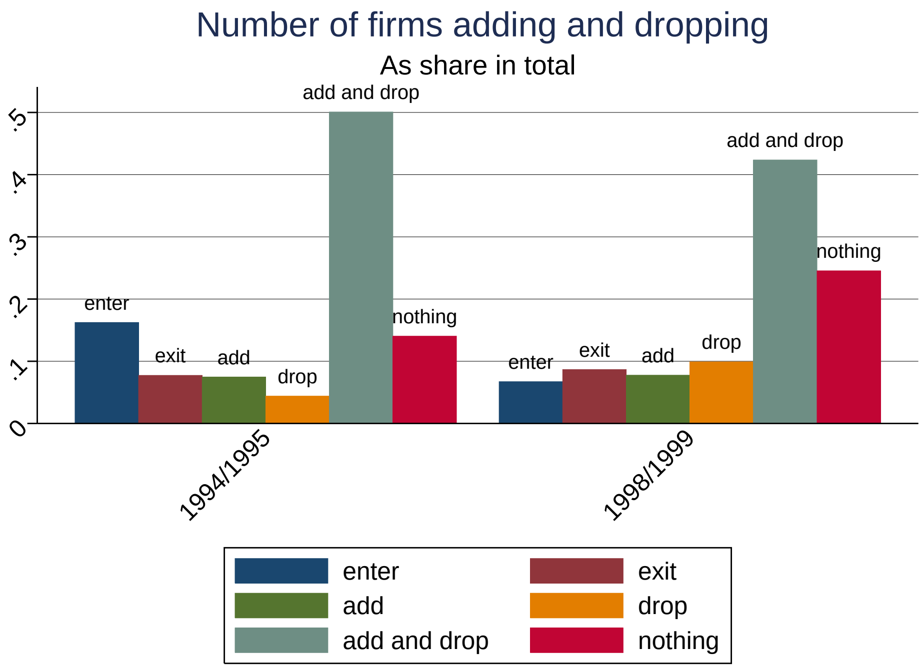

Figure 3: Number Of Firms By Adjustment Mechanism as Share in Total Number of Firms.

Next, we show the fraction of firms using each adjustment mode. In Figure 3 we show the fraction of firms that use a given adjustment mechanism between 1994/1995 and 1998/1999. Two features are worth noticing. First, most firms add and drop imported products at the same time. Second, during the devaluation there is more inaction, i.e., fewer firms do input switching. It is hard to reconcile this figure with the story of firms buying less quality imports in a devaluation. Many firms are acting against a conventional economic intuition of adjustment to a RER change. Moreover, these margins are particularly relevant if one wants to understand aggregate adjustment value, for which the entry and exit margins contribute marginally.

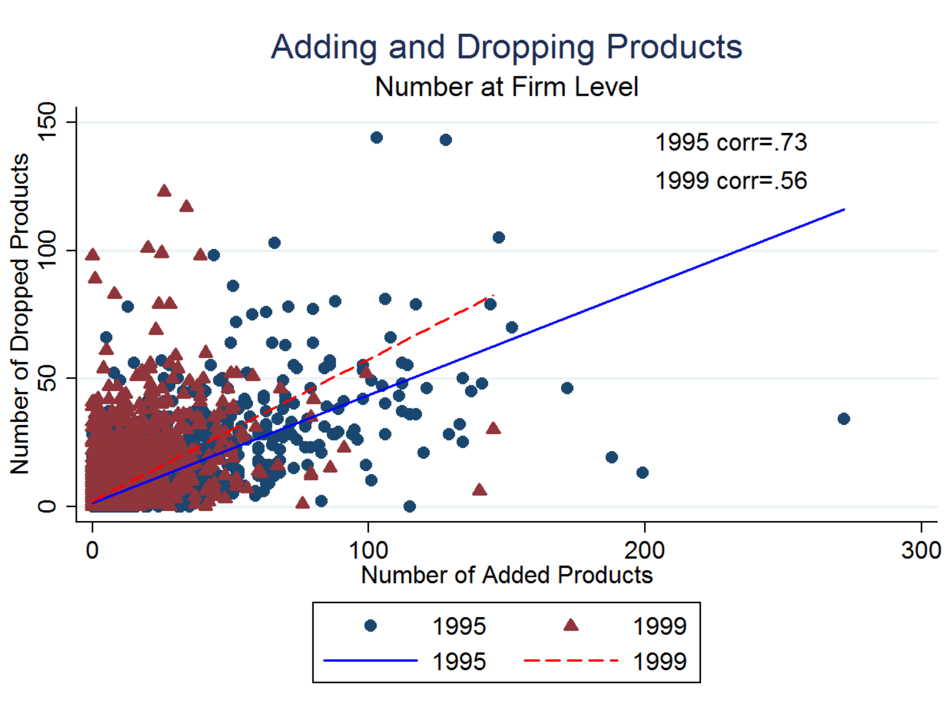

Figure 4: Number Of Imported Inputs Added And Dropped.

Motivated by the large pool of firms add and drop imported inputs simultaneously, on Figure 4 we plot the number of imported products added and dropped by each firm. The strong positive correlation found provides evidence that these firms add just as many products as they drop. With this evidence we rule out an explanation where our results are due to a composition effect, where firms that expand (contract) mostly add (drop) imported inputs. Contrary to such scenario, what we find is that firms are substituting some imported inputs for others.

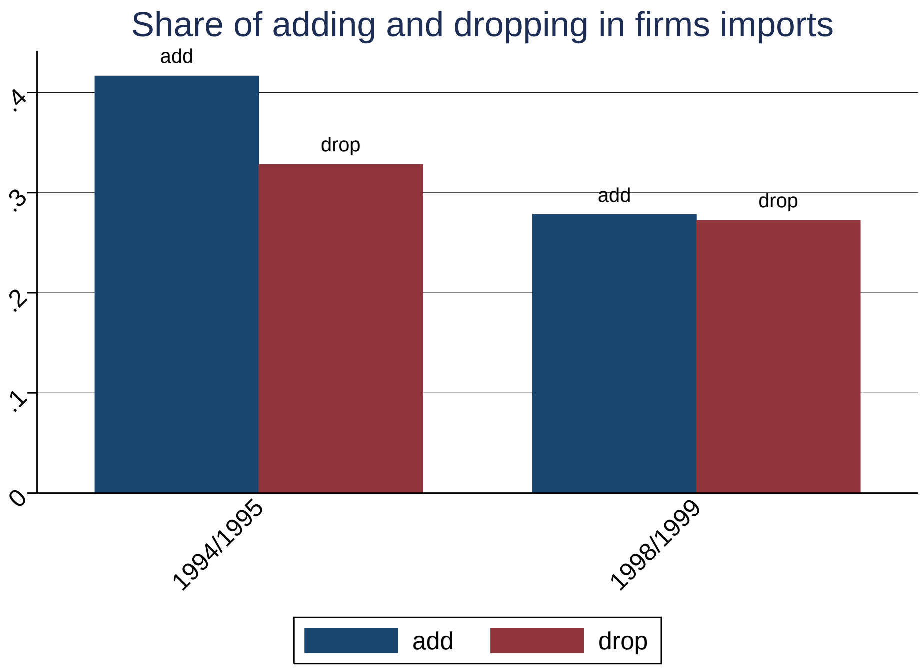

Figure 5: Firm Level Add And Drop Values As Fraction Of Total Import Value.

We complete the evidence related to adjustment in the devaluation by showing that this adding and dropping is not a small value at the firm-level. Figure 5 presents the average value that firms add(drop) as a fraction of their total imports. These shares are large at around 30% for both margins[10]. Also note that during the devaluation period, both shares fall but more intensely so for adding which is consistent with the previous evidence[11].

Overall, these findings suggest that firms select their imported varieties and suppliers, and reorganize their imported inputs and production over time. During the devaluation, firms not only use less imported varieties, but also do less churning of imported inputs. In the following section we present a theory of endogenous input selection, where firms search for imported inputs suppliers and reorganize their inputs usage over time.

[10]This is the most conservative value, i.e., defining add (drop) as products never used by the firm before (anymore). Using a broader definition, the value is around 50%.

[11]In Table 14 in the Empirical Appendix, we show that reporting this fact as number of imported inputs provides a similar view. It further shows how adding and dropping activities are related to firm size. Larger firms do more adding and also more dropping. See Section 4 for a regression version of this results.

3 Model

In this section, we build a simple model to understand firms imported inputs switching behavior, and provide guidance for our empirical analysis in Section 4. We extend the static model of endogenous choice of imported inputs by Gopinath and Neiman (2011) and Halpern et al. (2011), introduce searching for imported inputs and inputs adjustment over time. We show that imported inputs switching relates to dynamic productivity gains, and that switching behavior depends on firms' productivity, age and the price of imports.

3.1 Production and Imported Inputs

The demand quantity, $q(i)$, firm i can sell is inversely related to the price it sets, $p(i)$ [12]:

$$q\left(i\right)=Dp\left(i\right)^{-\rho}.$$

where ρ is the elasticity of demand and D is a demand shifter. Each firm i has a TFP given by A_i and produces a single good using labor, L, and intermediate inputs, X

$$Y_i=A_iL_i^{1-\alpha}X_i^{\alpha}.$$

Intermediate inputs consist of a bundle of intermediate goods indexed by $j\in[0,1]$ and aggregated according to a Cobb-Douglas technology:

$$X_i=\exp\left[\int_0^1\ln X_{ij}dj\right].$$

For each type j of intermediate goods, there are two varieties: home, H, and foreign, M,

$$X_{ij}=\left[H_{ij}^{\frac{\sigma-1}{\sigma}}+\left(b_{ij}M_{ij}\right)^{\frac{\sigma-1}{\sigma}}\right]^{\frac{\sigma}{\sigma-1}},$$

where σ is the elasticity of substitution between the home and foreign varieties in the production function. $b_{ij}>1$ measures the productivity advantage of the foreign varieties j in producing i.

[12]We use a partial equilibrium framework to focus on why firms constantly switch imported inputs, and how switching behavior is different across firms and time.

Firms' productivity A does not change over time. Furthermore, to import n varieties firms need to pay a fixed cost of $n^{\eta}F$ units of labor. We assume $\eta > 1$ so the cost function is convex on the number of varieties as in Gopinath and Neiman (2011). Unlike them, each input productivity has a distribution $f(b)$, with support over $(1, \infty)$. Firms decide their input bundle knowing the productivity of each input. Given this setup, firm i would use all the home inputs, and some foreign inputs which depend on the trade-off between the productivity gains induced by foreign inputs and the convex cost of importing. Assume home varieties have price p_H and all foreign varieties have the same price p_F/ε, where ε is the exchange rate. We focus on the imported input decision and ignore firms entry and exit[13].

Before describing in more detail the static part of our model, let us briefly introduce the dynamic aspects. Every period importers will decide whether to pay a searching fixed cost. Paying it will allow them to find new suppliers for the measure one of inputs. Having compared the current suppliers' input productivities to the new productivity draws, firms choose from which supplier to source, and finally the range of imported inputs given the convex cost of importing. We will fully introduce the dynamic aspects in section 3.3.

3.2 Firms Static Problem

A firm with productivity A, after the imported input productivity is realized, decides which foreign inputs to use by minimizing its total cost:

$$\min_{L,\Omega,\{H_j,M_j\}} \left\{ wL + \int_0^1 p_H H_j dj + \int_\Omega \frac{p_F}{\varepsilon} M_j dj + |\Omega|^{\eta} wF \right\}$$

subject to:

$$Y = AL^{1-\alpha}X^{\alpha}$$

$$X = \exp\left[\int_0^1 \ln X_j dj\right] \tag{1}$$

$$X_j = \left[H_j^{\frac{\sigma-1}{\sigma}} + (b_j M_j)^{\frac{\sigma-1}{\sigma}}\right]^{\frac{\sigma}{\sigma-1}} \tag{2}$$

where $|\Omega|$ is the number of foreign inputs purchased. In our model, firms' total

[13] This considerably simplifies the model. The extensive margin contribution to the aggregate adjustment is small in any case.

cost is composed of compensation to workers and spending on domestic and foreign intermediate inputs, as well as the convex cost of importing.

To solve this problem, first we guess the solution is that firms use imported inputs with productivity larger than b^*. By the law of large numbers, there is a $f(b)$ fraction of inputs with productivity equal to b, and the measure of inputs firm would use is $\int_{b^*}^{\infty} f(b)\,db$. Given b^*, the price index for intermediate inputs, P, is

$$P = p_H \exp\left[\int_0^1 \left(\ln\left[1 + I(im)\left(b_j \frac{\varepsilon p_H}{p_F}\right)^{\sigma-1}\right]^{\frac{1}{1-\sigma}}\right) dj\right] =$$
$$= p_H \exp\left[\int_{b^*}^{\infty} \ln\left[1 + \left(b \frac{\varepsilon p_H}{p_F}\right)^{\sigma-1}\right]^{\frac{1}{1-\sigma}} f(b)\,db\right].$$

where $I(im)$ is an indicator function that takes value 1 if input j is imported and zero otherwise. Solving the firm problem[14], we can express his unit cost, λ, as

$$\lambda = \frac{C}{A} G(b^*)^{-\alpha}.$$

where

$C = \left(\frac{w}{1-\alpha}\right)^{1-\alpha}\left(\frac{p_H}{\alpha}\right)^{\alpha}$, $G(b^*) = \exp\left[\int_{b^*} (\ln B) f(b)\,db\right]$ and $B = \left[1 + \left(b \frac{\varepsilon p_H}{p_F}\right)^{\sigma-1}\right]^{\frac{1}{\sigma-1}}$. That is, the unit cost depends on firms' productivity A, the home country factor costs C, and the benefit from using more productive foreign inputs $G(b^*)$. Notice that a larger measure of foreign inputs, implied by a lower cutoff, reduces the marginal production cost.

If the firm uses an $m(b^*)$ measure of inputs, and produces output Y, his total cost is,

$$\lambda Y + m(b^*)^{\eta} w F,$$

and the firm maximizes net profits:

$$\max_{Y,b^*} \left(\frac{Y}{D}\right)^{-\frac{1}{\rho}} Y - \lambda Y - m(b^*)^{\eta} w F$$

[14]See Theoretical Appendix for a detailed derivation of the model.

where $m(b^*) = \int_{b^*} f(b)\, db$.

From the two first order conditions, we have that the marginal input[15] b^* satisfies,

$$\alpha D \left(\frac{\rho-1}{\rho}\right)^{\rho} \left(\frac{C}{A}\right)^{1-\rho} G(b^*)^{\alpha(\rho-1)} \ln B^* = \eta m(b^*)^{\eta-1} wF. \tag{3}$$

Adding more imports, i.e., a smaller b^*, increases the benefit from using more productive foreign inputs $G(b^*) = \exp\left[\int_{b^*} (\ln B) f(b)\, db\right]$, hence the unit cost is lower. Moreover this way the firm faces higher demand. On the other hand, using more imports implies an increasing importing cost.

3.3 Imported Input Switching

At period 2, importers decide if they want to pay a searching cost F_s to be connected with a new bunch of foreign input suppliers[16]. If they pay the searching cost, they get a new draw (from a new supplier) for each input produced in the foreign country. Then for each input, firms choose to import from the more productive supplier. Define the set of optimal inputs used by firm i as $\Omega_i(1)$ at time 1 and $\Omega_i(2)$ at time 2. If an input j is used at time 1 by firm i, we will write $b_{ij}(1) \in \Omega_i(1)$.

The possibilities for adding and dropping between periods are as follows. Firm i may add a variety j at $t = 2$, if $b_{ij}(1) \notin \Omega_i(1)$ and $b_{ij}(1) \in \Omega_i(2)$[17] or $b_{ij}(2) \in \Omega_i(2)$. The firm may also keep a variety if $b_{ij}(1) \in \Omega_i(1)$ and $b_{ij}(1)$ or $b_{ij}(2) \in \Omega_i(2)$, he may drop a variety if $b_{ij}(1) \in \Omega_i(1)$ and $b_{ij}(1) \notin \Omega_i(2), b_{ij}(2) \notin \Omega_i(2)$.

We assume $f(b)$, the suppliers' productivity distribution for each input is a Frechet distribution, which will give us closed-form solutions[18],

$$F(b) = \exp\left(-T(b-1)^{-\theta}\right)$$

The maximum productivity of two draws for an input has a Frechet distribution with parameter $2T$. Letting a denote the measure of suppliers a firm has met, then the distribution of the productivity of inputs would be $f_a(b)$ with parameter aT.

[15] There is a unique b^* if the second order condition is negative. See the Theoretical Appendix for the parameter restriction required.
[16] Firms are born in period 1.
[17] This will never be the case as it is not optimal.
[18] The model can be simulated for more general distributional assumptions.

Firms have two options: either paying the fixed searching cost and being connected with a new bunch of suppliers, or not searching. Then the Bellman equation of a firm with productivity A is,

$$V\left(a,A\right)=\max_{\{\text{search},\text{not search}\}}\left\{\pi\left(a+1,A\right)-wF_s+\beta V\left(a+1,A\right),\pi\left(a,A\right)+\beta V\left(a,A\right)\right\},$$

the firm would pay to search for new draws only when

$$\pi\left(a+1,A\right)-wF_s+\beta V\left(a+1,A\right)>\pi\left(a,A\right)+\beta V\left(a,A\right),$$

which rearranging in terms of gains from switching versus the cost of switching becomes

$$\pi\left(a+1,A\right)-\pi\left(a,A\right)+\beta\left(V\left(a+1,A\right)-V\left(a,A\right)\right)>wF_s.$$

We will prove in Proposition 4 in the next subsection that the value of searching increases with firm productivity A.

To summarize, a firm with productivity A and supplier measure a, uses inputs that have productivity larger than cutoff b_a^* that satisfies,

$$\alpha D\left(\frac{\rho-1}{\rho}\right)^{\rho}\left(\frac{C}{A}\right)^{1-\rho}G(b_a^*)^{\alpha(\rho-1)}\ln B_a^*=\eta m(b_a^*)^{\eta-1}wF, \tag{4}$$

and search for new draws if $A>\bar{A}\left(a\right)$, and $\bar{A}\left(a\right)$ satisfies:

$$\pi\left(a+1,\bar{A}\left(a\right)\right)-\pi\left(a,\bar{A}\left(a\right)\right)+\beta\left(V\left(a+1,\bar{A}\left(a\right)\right)-V\left(a,\bar{A}\left(a\right)\right)\right)=wF_s \tag{5}$$

Note that given parameters $\left(\alpha,C,\rho,\sigma,\eta,w,F,F_s,\frac{\varepsilon p_H}{p_F},T,\theta\right)$, for each firm A, we can solve the optimal imports cutoff b_a^*, and the decision rule for the firm to search or not, for every $a=1,2,3....$

3.4 Propositions

In this section we state the main propositions that are obtained from the model which we will connect with the evidence in Section 4. The first theoretical proposition highlights the well established fact, also present in our data, that more productive firms use more imported inputs.

Proposition 1 *Given age, more productive firms use more imported inputs.*

Proof. See Theoretical Appendix in Section 6.1.2.

$$\frac{db_a^*}{dA} < 0,$$

so when firm productivity increases, the input cutoff decreases and the firm uses more inputs as $m(b^*) = \int_{b^*} f(b)\, db$. Intuitively, more productive firms gain more from having more inputs and hence are able to overcome a larger convex cost. ■

One of the key features we find in the data is that firms are simultaneously adding and dropping imported inputs. Our model generates such behavior by combining search of better inputs with the possibility of dropping those that are less productive. The next proposition shows this feature of the model analytically.

Proposition 2 *If firms pay the search costs to find new suppliers, they will add and drop varieties simultaneously.*

Proof. See Theoretical Appendix in Section 6.1.3. $\frac{db^*}{da} > 0$, searching new suppliers raises the cutoff, hence some original inputs should be dropped. However, the measure of imported inputs increases, as $\frac{dm(b^*)}{da} > 0$ [19]. So if firms paid the search cost, they add and drop imported inputs simultaneously. Searching allows the firm to access a better input distribution. Some previously not imported inputs have a much more productive new supplier, in which case the firm would like to add it. For a large enough increase in the convex cost, firms will optimally drop some of the least productive inputs they previously imported. ■

We have determined that firms add and drop simultaneously conditional on choosing to readjust their production. What firms search and reorganize? Pending data evidence, the next two propositions provide a prediction on how the reorganization choices of a firm depend on age and productivity.

Proposition 3 *Older firms import more but there are decreasing returns to searching.*

[19] Note that although the cutoff increases, the productivity distribution of imported inputs also shifts to the right as firms connect to more suppliers.

Proof. See Theoretical Appendix. As firms search, they find better suppliers which allow them to increase the mass of imported inputs. However, the increase in profits from searching becomes smaller over time because it is harder and harder to find more productive suppliers for a given input over time. Hence, controlling for firm productivity, older firms import more varieties, but they add and drop less over time. ■

Proposition 4 *Searching new input suppliers increases profits and the profit increase is larger for more productive firms. The dynamic gains from searching are larger for more productive firms, hence, larger firms are more likely to do add and drop.*

Proof. See Theoretical Appendix in Section 6.1.5. $\frac{d\frac{d\pi}{da}}{dA} > 0$, the increase in current period profit is larger for more productive firms. We have shown that the profit gain from searching falls as time passes (Proposition 3), and the overall gain from searching can be thought of as a sum of change of profits flows. We can show that the overall gain from searching is also larger for more productive firms (See Theoretical Appendix). So controlling for age, more productive firms are more likely to pay the search cost. Intuitively, when firms want to find better imported inputs they pay a fixed cost to reorganize production and search. Once that fixed cost is paid, their variable cost is reduced and allows them to sell more. This larger sales benefits more productive firms more, so they are more likely to pay the search cost, and more likely to add and drop varieties. To put it differently, since firm productivity A is complementary to productivity gains coming from imported inputs, high A firms search and reorganize. ■

In the model, conditional on a given firm productivity, productive imported inputs are more likely to stay longer within a firm than the less productive ones. The next proposition deals with this intuition formally.

Proposition 5 *Conditional on importing, the higher an input's productivity, the lower the probability of it being dropped.*

Proof. See Theoretical Appendix. Intuitively, firms rank inputs by how productive they are. Since new draws are independent of the existing realization, the currently used inputs that are least productive are more likely to be dropped by the firm. ■

In Section 2 we use RER variation to document that adding and dropping is reduced during a devaluation in Colombia. In our model, both the number of varieties firms use and switching behavior are affected by devaluation.

Proposition 6 *In a devaluation firms use less imported inputs.*

Proof. See Theoretical Appendix in Section 6.1.8. $\frac{db^*}{d\varepsilon} < 0$, then when ε decreases, the productivity cutoff increases, firms use less imported inputs. In a nutshell, when imports become more expensive, firms import less. ∎

The following proposition shows that the number of firms that add and drop decreases with a devaluation, in other words, more firms become inactive.

Proposition 7 *In a devaluation less firms would like to pay the search costs to find new suppliers.*

Proof. See Theoretical Appendix in Section 6.1.9. Because $\frac{d\left(\frac{d\pi}{da}\right)}{d\varepsilon} > 0$, the profit increase due to searching is lower when the currency devaluates because imports have become more expensive. Accordingly, fewer firms would pay the search cost. Therefore, fewer firms would add and drop simultaneously. ∎

In general the relation between intensive margin of switching and RER depends on parameter values and distributional assumptions. For example, firms that still choose to search during a devaluation may drop more or less depending on the elasticity to the shock, i.e., depending on the parameters in the model. But more strict assumptions, like, for example, the search cost is per input instead of a fixed amount, would lead to less adding and dropping on the intensive margin during a devaluation.

4 Evidence On Firm Import Switching Behavior

4.1 Imported Input Switching

In this section, we use firm-level data to confirm the results presented in the introduction and provide further evidence on firms imported input switching behavior that is consistent with the model predictions. More precisely, we show 7 regressions, which are associated with the propositions in Section 3. We first show results on Proposition 1, which confirms the well-established fact that larger firms import more. Next, we present evidence on Propositions 4, 7, and 6, which are related to the impact of a devaluation. Finally, results on Proposition 5 and 3 further confirm that the mechanisms we highlight in the model are at work. Whenever possible, we measure the dependent variable both in terms of value and number. All of the results in this section are robust to an export switching dummy[20], exporter dummy and export value share in total sales.

In Proposition 1, we show that more productive firms use more imported inputs. Hence, we predict a positive relation between firms sales and import use. Accordingly, we use OLS and we run,

$$Imports_{it} = \alpha_t + \gamma_i + \beta Sales_{it-1} + \varepsilon_{it}$$

where $Imports_{it}$ is import value or number of different varieties for firm i in time t. α_t and γ_i are time and firm fixed-effects respectively. In this section all variables are defined in logs unless otherwise stated. In Table 1, we run import value or the number of different imported varieties on lagged firm size. We proxy firm size using sales, and do so throughout this section. Consistent with the model and the literature, we find that larger firms import more[21]. While this result shows that imported value is related to firm size, we want to emphasize that it is just a correlation reflecting the equilibrium relation between endogenous variables in the model. The regression coefficients capture both the decision to change import value and the impact of this decision on sales. This endogeneity issue holds in most of our results below except where we explicitly instrument the independent variable.

[20] If a firm does not export we set the export switching dummy equal to zero.

[21] See Table 11 for a result with age controls.

VARIABLES	(1) Import Value	(2) Import Number
Lagged Sales	0.580***	0.296***
	(33.74)	(31.41)
Constant	2.886***	-2.712***
	(10.54)	(-18.14)
Observations	45,431	45,431
R-squared	0.861	0.855
Firm FE	Yes	Yes
Time FE	Yes	Yes

Robust t-statistics in parentheses
*** p<0.01, ** p<0.05, * p<0.1

Table 1: Import Level And Productivity At the Firm Level.

We next turn to Proposition 4 which states that larger firms gain more from searching. In the model this occurs because of the complementarity between firm TFP and the gain in productivity from importing, which implies that larger firms are more likely to do switching. To test such prediction, we run a linear probability model, LPM, for adding and dropping simultaneously versus all other alternatives[22]. The equivalent intensive margin is that larger firms will do more intense switching so there will be more adding and dropping. We run,

$$\text{Extensive: } DummyAddAndDrop_{it} = \alpha_t + \gamma_i + \beta Sales_{it-1} + \varepsilon_{it}$$
$$\text{Intensive: } AddAndDrop_{it} = \alpha_t + \gamma_i + \beta Sales_{it-1} + \varepsilon_{it}$$

where $DummyAddAndDrop_{it}$ is a dummy with value one if firm i at time t adds and drops imported inputs at the same time, and $AddAndDrop_{it}$ is the gross change, i.e., value(number) of added plus dropped inputs.

[22] In unreported results, we use 4 definitions for the switching dummy: add versus do nothing, drop versus do nothing, either add or drop versus do nothing, and add and drop at the same time; we always obtain the same answer: larger firms switch more.

	(1)
VARIABLES	Add and Drop
Lagged Sales	0.0976***
	(21.21)
Constant	-0.895***
	(-12.11)
Observations	39,767
R-squared	0.483
Firm FE	Yes
Time FE	Yes

Robust t-statistics in parentheses
*** p<0.01, ** p<0.05, * p<0.1

Table 2: Probability of Adding And Dropping Imported Inputs And Firm Productivity.

	(1)	(2)	(3)	(4)	(5)	(6)
VARIABLES	Add	Drop	Add and Drop	Add	Drop	Add and Drop
	Value	Value	Value	Number	Number	Number
Lagged Sales	0.343***	0.500***	0.351***	0.201***	0.265***	0.205***
	(11.43)	(17.70)	(16.54)	(14.73)	(21.24)	(20.90)
Constant	5.845***	2.171***	6.257***	-1.096***	-2.764***	-0.915***
	(11.86)	(4.665)	(17.96)	(-4.883)	(-13.50)	(-5.675)
Observations	26,624	26,624	26,624	26,624	26,624	26,624
R-squared	0.534	0.559	0.680	0.644	0.684	0.769
Firm FE	Yes	Yes	Yes	Yes	Yes	Yes
Time FE	Yes	Yes	Yes	Yes	Yes	Yes

Robust t-statistics in parentheses
*** p<0.01, ** p<0.05, * p<0.1

Table 3: Adding And Dropping Imported Inputs And Firm Productivity.

Extensive and intensive results are reported in Table 2 and 3, respectively[23]. For the LPM, we find positive coefficients so larger firms are more likely to add and drop. On the intensive margin, i.e., conditional on adding and dropping products, we find larger firms switch more, both in terms of value and number of varieties[24].

Proposition 4 is key and states that the gross change of inputs matters for firms' profit growth. In particular, firms that pay the fixed cost of switching engage in adding and dropping which in turn improves their productivity and sales. Accordingly, we run,

$$ChangeSales_{it} = \alpha_t + \gamma_i + \beta_1 InputSwitch_{it} + \beta_2 Sales_{it-1} + \varepsilon_{it}$$

where $ChangeSales_{it}$ is the change in sales between t and $t+1$ for firm i, and $InputSwitch_{it}$ can be either the gross change in value or numbers, between t and $t+1$.

[23] See Table 12 for a result with age and further controls.

[24] In our model, larger firms are more likely to switch but whether they switch a larger value or not depends on parameter values. The regression suggests they also switch more on the intensive margin, which is consistent with our model for some parameter values.

VARIABLES	(1) Sales Change	(2) Sales Change	(3) Sales Change
Lagged Sales	-1.078***	-1.078***	-1.078***
	(-67.18)	(-67.18)	(-67.21)
Add and Drop Value	0.000751***		
	(3.529)		
Add and Drop Number		0.00110***	
		(3.816)	
Add and Drop			0.0273***
			(5.274)
Constant	-0.00581***	-0.00580***	-0.00565***
	(-2.688)	(-2.682)	(-2.617)
Observations	32,462	32,462	32,462
R-squared	0.509	0.510	0.510
Number of Firms	4,594	4,594	4,594
First Diff	Yes	Yes	Yes

Robust z-statistics in parentheses *** p<0.01, ** p<0.05, * p<0.1

Table 4: Productivity Growth And Gross Import Change.

In Table 4 we obtain results consistent with the prediction[25]. Notice how the switching dummy is associated with sales growth. Also, consistent with our model, the table shows that gross changes for both the value and number of varieties are positively associated with changes in sales. However, these results could be due to reverse causality. For example, firms that grow more could be also reorganizing their production. More generally, it could be the result of a spurious correlation between growth and switching. In order to deal with these issues, we instrument gross switching with the RER, which as predicted by the theory are positively related. When the RER is high there is more switching because the net gain from searching is larger. More precisely,

[25] In this section, whenever we run a dynamic panel data regression or include the RER as explanatory variable, the results are obtained in First Differences.

$$1^{st}Stage\colon\ InputSwitch_{it} = \alpha_1 + \gamma_i + \delta_1 RER_t + \delta_2 Sales_{it-1} + \omega_{it}$$
$$2^{nd}Stage\colon\ ChangeProductivity_{it} = \alpha_2 + \gamma_i + \beta_1 InputSwitch_{it} + \beta_2 Sales_{it-1} + \varepsilon_{it} \tag{6}$$

where the variable definitions are consistent with the previous regressions. The IV results are reported in Table 5. On the first stage, we confirm that both the import switching dummy and gross import changes comove positively with the RER, so our instrument is valid. On the second stage, we obtain that both the switching dummy and the gross switching measures are positively associated with changes in sales.

	(1)	(2)	(3)	(4)	(5)	(6)
	1st stage	2nd stage	1st stage	2nd stage	1st stage	2nd stage
VARIABLES	Add and Drop Value	Sales Change	Add and Drop Number	Sales Change	Add and Drop Dummy	Sales Change
RER	3.263***		2.029***		0.137***	
	(5.12)		(4.40)		(4.90)	
Add and Drop Value		0.0601***				
		(4.400)				
Add and Drop Number				0.0966***		
				(3.927)		
Add and Drop Dummy						1.428***
						(4.283)
Lagged Sales	0.783***	-1.124***	0.527***	-1.128***	0.0542***	-1.155***
	(4.80)	(-51.55)	(4.53)	(-47.69)	(6.66)	(-42.29)
Constant	-0.111*	-0.00217	-0.0849**	-0.000609	-0.00946***	0.00470
	(-1.89)	(-0.530)	(-2.01)	(-0.130)	(-3.63)	(0.976)
Observations	32445	32,445	32445	32,445	32445	32,445
R-squared	0.002	-0.798	0.001	-1.258	0.003	-0.934
Number of Firms	4,585	4,585	4,585	4,585	4,585	4,585
First Differences	Yes	Yes	Yes	Yes	Yes	Yes

Robust z-statistics in parentheses
*** p<0.01, ** p<0.05, * p<0.1

Table 5: Productivity Growth, Gross Import Change and RER.

There are two main concerns that we address next. First, import switching may be related to export product churning or to being an exporter more generally. A devaluation not only makes imports more expensive and import switching less profitable but also makes exports cheaper. Incumbent exporters could find profitable to change the export product mix because of the reasons in Bernard et al. (2010). Moreover, exports being cheaper could induce entry into the export market which may require some adjustment of imported inputs. In both cases, export churning could alter import demand without input search generating productivity gains. However our results do not change when we control for a time-varying exporter dummy, an export over sales control, and an export product churning dummy.

Another set of criticisms regarding Table 5 has to do with two other channels, demand and competition. Regarding the demand channel, a devaluation could affect industries demand differently. Note that, while our firm fixed-effects capture the permanent level of firms demand, it is still possible that changes over time in demand across industries could be biasing our results. Regarding competition, the Colombian devaluation makes exports from the rest of the world more difficult, which affects competition in Colombia. For example, the reduction in competition in some industries due to the devaluation could be associated with larger sales growth for domestic firms and a simultaneous switch towards less quality imports. To control for the effects of demand and competition[26], in regression 6 we further include an industry absorption measure[27] and the number of importing firms in each industry[28]. Results are reported in Table 6 and are in line with our baseline regression[29]. Finally, in unreported results, when we further control for the 1999 crisis by adding a dummy for those observations results do not change.

[26] Nevertheless, note that it is hard to see how these two alternative channels by themselves could generate less switching and hence be reconciled with the set of facts we report.

[27] Industry absorption is a measure of domestic consumption and we obtain it as industry production minus exports plus imports.

[28] For these variables, we define industry at the 2 digit level, which implies there is a total of 10.

[29] Some may think switching is simply due to idiosyncratic shocks, but our results are hard to reconcile with a model where imported inputs face iid productivity shocks. In that model, on average we should not observe productivity gains associated with switching. For larger firms, shocks should wash out within a period. For smaller firms they should wash out across periods. However, we find that larger firms switch more and have larger productivity gains.

VARIABLES	(1) 1st stage Add and Drop Value	(2) 2nd stage Sales Change	(3) 1st stage Add and Drop Number	(4) 2nd stage Sales Change	(5) 1st stage Add and Drop Dummy	(6) 2nd stage Sales Change
RER	3.237***		2.042***		0.137***	
	(4.71)		(4.11)		(4.50)	
Add and Drop Value		0.0354***				
		(3.056)				
Add and Drop Number				0.0561***		
				(2.877)		
Add and Drop Dummy						0.836***
						(3.000)
Lagged Sales	0.844***	-1.101***	0.570***	-1.103***	0.0553***	-1.118***
	(5.06)	(-54.49)	(4.80)	(-52.23)	(6.70)	(-46.42)
Industry Importers	-0.182	-0.0904***	-0.0863	-0.0920***	-0.0210	-0.0793***
	(-0.34)	(-3.361)	(-0.22)	(-3.193)	(-1.04)	(-2.862)
Industry Absorption	0.192	0.107***	0.0976	0.108***	0.0145	0.102***
	(0.65)	(5.128)	(0.46)	(5.042)	(1.08)	(4.715)
Observations	31,860	31,860	31,860	31,860	31,860	31,860
R-squared	0.002	0.057	0.001	-0.084	0.003	0.016
Number of Firms	4,540	4,540	4,540	4,540	4,540	4,540
First Differences	Yes	Yes	Yes	Yes	Yes	Yes

Robust z-statistics in parentheses
*** p<0.01, ** p<0.05, * p<0.1

Table 6: Productivity Growth, Gross Import Change and RER. Extra Controls.

Next, we test Proposition 7, which states that, during a devaluation, fewer firms do import switching during a devaluation. We run a linear probability model,

$$\text{Extensive: } DummyAddandDrop_{it} = \gamma_i + \beta_1 Sales_{it-1} + \beta_2 RER_t + \varepsilon_{it}$$
$$\text{Intensive: } AddAndDrop_{it} = \alpha_t + \gamma_i + \beta_1 Sales_{it-1} + \beta_2 RER_t + \varepsilon_{it}$$

where $DummyAddandDrop_{it}$ is a dummy that takes a value of one if firm i at time t adds and drops imports simultaneously and zero otherwise. Results in Table 7 show that fewer firms do simultaneous adding and dropping when the RER goes down, i.e., during the devaluation. In light of our model, we interpret this as firms reducing their reorganizing activities as a consequence of import prices going up.

VARIABLES	(1) Add and Drop Dummy
Lagged Sales	0.0564***
	(7.091)
RER	0.138***
	(4.939)
Constant	-0.0115***
	(-4.424)
Observations	32,796
R-squared	0.003
Number of Firms	4,651
First Differences	Yes

Robust z-statistics in parentheses
*** p<0.01, ** p<0.05, * p<0.1

Table 7: Import Switching LPM and RER.

Table 8 is the intensive equivalent.

VARIABLES	(1) Add Value	(2) Drop Value	(3) Add and Drop Value	(4) Add Number	(5) Drop Number	(6) Add and Drop Number
Lagged Sales	0.123**	0.440***	0.240***	0.0582***	0.185***	0.0976***
	(2.424)	(9.115)	(8.093)	(3.059)	(9.791)	(8.207)
RER	1.916***	0.848***	1.207***	0.785***	0.259***	0.509***
	(10.76)	(4.787)	(10.68)	(10.77)	(3.695)	(12.14)
Constant	-0.194***	0.0981***	-0.0298***	-0.128***	0.0748***	-0.0212***
	(-11.96)	(6.122)	(-2.912)	(-19.14)	(11.69)	(-5.507)
Observations	19,003	19,003	19,003	19,003	19,003	19,003
R-squared	0.007	0.007	0.010	0.007	0.006	0.013
Number of Firms	3,282	3,282	3,282	3,282	3,282	3,282
First Differences	Yes	Yes	Yes	Yes	Yes	Yes

Robust z-statistics in parentheses
*** p<0.01, ** p<0.05, * p<0.1

Table 8: Import Switching Intensity and RER.

To be sure, not only there is less adding and dropping during a devaluation but also, in line with a simple price impact on quantity, the net also falls. In other words, Proposition 6 holds in the data. This is shown in Table 9 which is obtained from running,

$$NetImports_{it} = \alpha_1 + \gamma_i + \beta_1 RER_t + \omega_{it}$$

where $NetImports_{it}$ can be either import value or number of different imported inputs by firm i at time t. Notice that both import value and the number of varieties imported fall when the RER goes down.

VARIABLES	(1) Import Value	(2) Import Value	(3) Import Number	(4) Import Number
RER	1.285***	1.253***	0.456***	0.436***
	(19.81)	(19.34)	(11.63)	(11.10)
Lagged Sales		0.154***		0.0992***
		(7.208)		(8.633)
Constant	-0.00676	-0.00896	-0.0138***	-0.0152***
	(-1.102)	(-1.457)	(-3.777)	(-4.161)
Observations	35,254	35,254	35,254	35,254
R-squared	0.011	0.013	0.004	0.007
Number of Firms	5,243	5,243	5,243	5,243
First Differences	Yes	Yes	Yes	Yes

Robust z-statistics in parentheses

*** p<0.01, ** p<0.05, * p<0.1

Table 9: Value and number of imported inputs and RER.

Finally, we turn to the model predictions at the input-firm-level. We use within-firm variation to show that the likelihood of dropping an input is related to it's productivity. This is shown in proposition 5. In our model, searching allows productivity of inputs to improve over time. If the productivity draw of a purchased input is large, the firm will use relatively more of it, and it will be more difficult that a better draw is obtained; hence, that imported input will be less likely to be dropped. To test this hypothesis, we run,

$$DummyInputDrop_{i,j,t} = \alpha_t + \gamma_i + \beta_1 ImportedInputSize_{i,j,t-1} + \varepsilon_{i,j,t}$$

where $DummyInputDrop_{ijt}$ is a dummy for whether input j was dropped or not, 1 and 0 respectively. $ImportedInputSize_{ijt}$ can be either the imported value of input j by firm i or the share of the input in total sales. Some specifications have a further control for firm sales of firm i at time t. Table 10 shows the results, which are in accordance with the theory: a larger import value for an intermediate is associated with a lower dropping likelihood[30].

VARIABLES	(1) Input Drop Dummy	(2) Input Drop Dummy	(3) Input Drop Dummy	(4) Input Drop Dummy	(5) Input Drop Dummy
Input share	-0.0625***			-0.0628***	
	(-362.7)			(-364.5)	
Input size		-0.0640***			-0.0640***
		(-369.3)			(-369.1)
Lagged Sales			-0.00968***	-0.0361***	-0.00320***
			(-7.685)	(-30.70)	(-2.745)
Constant	-0.0824***	0.860***	0.494***	0.554***	0.917***
	(-34.50)	(323.7)	(22.07)	(26.52)	(44.16)
Observations	802,704	802,704	802,704	802,704	802,704
R-squared	0.237	0.240	0.119	0.238	0.240
Firm FE	Yes	Yes	Yes	Yes	Yes
Time FE	Yes	Yes	Yes	Yes	Yes
Product FE	No	No	No	No	No

Robust t-statistics in parentheses

*** p<0.01, ** p<0.05, * p<0.1

Table 10: Imported Input Dropping Relation to it's Productivity.

4.2 Implications of Firms' Age

In this section we present evidence related to how two margins, input and supplier searching, are related to firms' age. We define age as the number of years in the import market. Since we cannot observe the first year in the import market, we drop all firms present in 1994, our first year[31].

[30] Note, that our result that larger firms are more likely to drop an input, see columns 3-5, on Table 10, cannot be explained by a model with idiosyncratic shocks to inputs.

[31] Some firms may import before 1994, temporarily stop importing in 1994, and import again in later years. For those firms, their import age will contain measurement error. But from other years, we know temporary exit is a very small fraction.

4.2.1 Imported Input Switching

The next two tables deal with Proposition 3, which are about the dynamic implications of the model. We have highlighted that if firms choose to search for suppliers, over time they will increase the number of imported inputs and suppliers. This implies that older firms use more imported inputs. Table 11 is obtained by running

$$NumberImportedInputs_{it} = \alpha_t + \gamma_i + \beta_1 Age_{it} + \beta_2 Age_{it}^2 + \beta_3 Sales_{it} + \varepsilon_{it}$$

where $NumberImportedInputs_{it}$ is the number of products imported by firm i at time t and age_{it} is the number of years firm i has imported inputs. The results are in line with the prediction of the model and show that the coefficient on age is positive. Further, consistent with our model, older firms add imported inputs at a decreasing rate.

VARIABLES	(1) Import Number	(2) Import Number
Age	0.0656***	0.0488***
	(8.662)	(6.458)
Age^2	-0.00130**	-0.000615
	(-2.558)	(-1.232)
Lagged Sales		0.214***
		(12.26)
Constant	0.952***	-2.246***
	(21.23)	(-8.511)
Observations	15,153	15,153
R-squared	0.794	0.799
Firm FE	Yes	Yes
Time FE	Yes	Yes

Robust t-statistics in parentheses
*** p<0.01, ** p<0.05, * p<0.1

Table 11: Number of products and age.

Another dynamic feature shown in Proposition 3 is that, over time, it is increasingly difficult to find better foreign suppliers for inputs. This implies that, as firms have spent more time searching, the switching value should be smaller. This is confirmed in Table 12 where age has a negative sign[32]. Further, since older firms are larger, this also emphasizes that our results are not driven by firms with more inputs adding and dropping more[33].

	(1)	(2)	(3)	(4)
VARIABLES	Add and Drop Value	Add and Drop Value Share	Add and Drop Number	Add and Drop Number Share
RER	1.375***	1.050***	0.227***	0.355***
	(7.799)	(5.159)	(2.655)	(4.335)
Age	-0.0783***	-0.178***	-0.0126	-0.0774***
	(-3.168)	(-6.200)	(-1.070)	(-6.896)
Age^2	0.00561***	0.00580***	0.00241***	0.00286***
	(3.494)	(3.197)	(2.622)	(4.028)
Lagged Sales	0.298***	-0.266***	0.137***	-0.0695***
	(5.946)	(-4.987)	(6.248)	(-3.557)
Constant	6.462***	4.018***	-0.155	1.440***
	(8.397)	(4.868)	(-0.458)	(4.776)
Observations	6,411	6,411	6,411	6,411
R-squared	0.691	0.679	0.777	0.613
Firm FE	Yes	Yes	Yes	Yes

Robust t-statistics in parentheses

*** p<0.01, ** p<0.05, * p<0.1

Table 12: Switching over time.

[32] While we do not report the extensive margin, results are consistent with the reported intensive margin.

[33] There are two pieces of evidence that suggest switching is not simply due to idiosyncratic input shocks. First, that firms over time use more inputs. Second, that the share of switching in total imports decreases over the search period length.

4.2.2 Import Supplier Switching

A unique feature of the Colombian import transaction data is that there is information on the supplier of the importer[34]. We use the supplier switching information to run equivalent regressions to those reported in Section 4 and obtain the same predictions in terms of sign and significance.

According to our theory, larger firms have more suppliers and buy from smaller suppliers on average[35], because they have a lower cutoff. Firms increase the number of suppliers over time, so older firms have more of them. Accordingly, the mass of better than current suppliers is reduced over time, and it is harder to find more productive suppliers. This means older firms are less likely to search and hence do less switching. To obtain evidence on the relation of the number of suppliers and age, we run

$$NumberSuppliers_{it} = \alpha_t + \gamma_i + \beta_1 Age_{it} + \beta_2 Age_{it}^2 + \beta_3 Sales_{it} + \varepsilon_{it}$$

where $NumberSuppliers_{it}$ is the number of suppliers that firm i at time t sources from. Table 13 confirms that the number of suppliers increases with age at a decreasing rate.

[34] For more details on the data construction please see the Appendix in Section 6.2.2.

[35] In Figure 6 in the Empirical Appendix, Section 6.2, we provide evidence of how firms and suppliers are matched. The figure reports the average size of suppliers for importers with a given number of suppliers, by measuring supplier size with the number of Colombian importers it sells to. It shows that firms that have more suppliers buy from smaller ones on average. Using importer-exporter two-sided matched customs transactions between Chile and Argentina, Chile and Colombia, respectively, Blum et al. (2010) and Blum et al. (2008) show the same sorting pattern.

VARIABLES	(1) Supplier Number	(2) Supplier Number	(3) Supplier Number
Age	0.0565***	0.048***	0.113***
	(9.703)	(8.303)	(11.05)
Age^2			-0.0034***
			(-7.35)
Lagged Sales		0.198***	0.186***
		(13.71)	(13.03)
Constant	0.659***	-2.282***	-2.137***
	(14.23)	(-10.43)	(-9.869)
Observations	14,836	14,836	14,836
R-squared	0.822	0.815	0.829
Firm FE	Yes	Yes	Yes
Time FE	Yes	Yes	Yes

Robust t-statistics in parentheses
*** p<0.01, ** p<0.05, * p<0.1

Table 13: Number of suppliers and age.

5 Conclusion

While reallocation of resources across firms has received great attention in economics, less emphasis has been given to within firm reallocation. In this paper we focus on the changes in the imported input composition of Colombian firms as a source of firm productivity growth. Potentially, this can be a relevant source of aggregate productivity growth because, on average, around 30% of firms' imported value is due to newly added (dropped) products. Moreover, most firms add and drop imported inputs at the same time.

To understand the mechanisms behind this input reorganization, we introduce dynamics through a natural extension of existing models of input choice by allowing for searching for the most productive inputs. The model rationalizes our newly uncovered facts related to the input switching in a large devaluation and normal times. In particular, we find that, during a devaluation, firms drop fewer but add even fewer imported varieties. Focusing only on changes in net imports neglects an important dynamic adjustment. Our framework can also account for the evidence in Amiti and Konings (2007) among others, namely, that input tariff reductions are important for productivity growth. Furthermore, we show evidence that supports the dynamic nature of the process we highlight, instead of alternative and simpler models. For example, three facts show that switching is not simply due to random independent shocks to imported inputs. First, firms' switching behavior depends on their size and age. Over time firms use more inputs and older firms switch less. Second, more productive inputs are less likely to be dropped. Larger firms are more likely to drop a particular input. Third, imported input reorganization generates sales growth.

Our simple model focuses on explaining why firms constantly switch imported inputs, and how it is affected by imports price. Extending the model to allow firms to choose the intensity of supplier searching, or allowing suppliers to produce multiple inputs are also interesting, and such modifications would rely on further research on the dynamic relations of importers and suppliers.

6 Online Appendix

6.1 Theoretical appendix

6.1.1 Firms' Problem

The Lagrangian for the firm problem in the main text is:

$$\begin{aligned} L &= wL + \int_0^1 p_H H_j dj + \int_\Omega \frac{p_F}{\varepsilon} M_j dj + |\Omega|^\eta wF + \lambda\left(Y - AL^{1-\alpha}X^\alpha\right) \\ &\quad + \psi\left[X - \exp\left[\int_0^1 \ln X_j dj\right]\right] + \int_\Omega \chi_j \left[X_j - \left[H_j^{\frac{\sigma-1}{\sigma}} + (b_j M_j)^{\frac{\sigma-1}{\sigma}}\right]^{\frac{\sigma}{\sigma-1}}\right] dj \end{aligned}$$

Guess that the solution is firms use imported inputs that have productivity larger than b^*. By the law of large numbers, because there are $f(b)$ fraction of inputs draw productivity equal b, the price index for intermediate inputs is

$$p_H \int_0^1 \left(\ln\left[1 + I(im)\left(b_j \frac{\varepsilon p_H}{p_F}\right)^{\sigma-1}\right]^{\frac{1}{1-\sigma}}\right) dj = p_H \int_{b^*}^\infty \ln\left[1 + \left(b\frac{\varepsilon p_H}{p_F}\right)^{\sigma-1}\right]^{\frac{1}{1-\sigma}} f(b)\, db.$$

And the measure of inputs the firm would use is $\int_{b^*}^\infty f(b)\, db$.

Solving this problem, we get for intermediate good j:

$$X_j = \frac{\lambda\alpha Y}{p_H\left[1 + \left(b_j \frac{\varepsilon p_H}{p_F}\right)^{\sigma-1}\right]^{\frac{1}{1-\sigma}}} \text{ if } M_j > 0,$$

and firm's unit cost is

$$\lambda = \frac{1}{A}\left(\frac{w}{1-\alpha}\right)^{1-\alpha}\left(\frac{\exp\left[\int_0^1 \ln p_H dj\right]}{\alpha\exp\left[\int_{b^*}^\infty \ln\left[1+\left(b\frac{\varepsilon p_H}{p_F}\right)^{\sigma-1}\right]^{\frac{1}{\sigma-1}} f(b)\, db\right]}\right)^\alpha.$$

Define $C = \left(\frac{w}{1-\alpha}\right)^{1-\alpha}\left(\frac{p_H}{\alpha}\right)^\alpha$, $G(b^*) = \exp\left[\int_{b^*}^\infty (\ln B) f(b)\, db\right]$, and $B = \left[1 + \left(b\frac{\varepsilon p_H}{p_F}\right)^{\sigma-1}\right]^{\frac{1}{\sigma-1}}$

to obtain unit cost as

$$\lambda = \frac{1}{A} C G(b^*)^{-\alpha}.$$

Firm's total cost is then:

$$\lambda Y + |\Omega|^\eta \, wF,$$

and firm maximizes net profits:

$$\begin{aligned} & \max_{Y,b} \left(\frac{Y}{D}\right)^{-\frac{1}{\rho}} Y - \lambda Y - |\Omega|^\eta \, wF \\ = \; & \max_{Y,b} \left(\frac{Y}{D}\right)^{-\frac{1}{\rho}} Y - \lambda Y - m(b^*)^\eta wF, \end{aligned}$$

where $m(b^*) = \int_{b^*}^{\infty} f(b)\, db$.

The two first order conditions are

$$Y = \left(\frac{\rho - 1}{\rho}\right)^\rho D \lambda^{-\rho}$$

and

$$-\frac{d\lambda}{db} Y - \eta m^{\eta-1} m' wF = 0$$

This last condition can be written as

$$-\frac{d\lambda}{db} Y - \eta m^{\eta-1} f(b^*) wF = -Y \frac{C}{A} (-\alpha) G(b^*)^{-\alpha-1} G'(b^*) + \eta m^{\eta-1} f(b^*) wF$$

$$\alpha Y \frac{C}{A} G(b^*)^{-\alpha-1} \left(G(b^*)(-1) \ln \left[1 + \left(b^* \frac{\varepsilon p_H}{p_F} \right)^{\sigma-1} \right]^{\frac{1}{\sigma-1}} f(b^*) \right) + \eta m^{\eta-1} f(b^*) wF = 0,$$

Using a more compact form, the marginal input satisfies:

$$\alpha Y \frac{C}{A} G(b^*)^{-\alpha} \ln B^* = \eta m(b^*)^{\eta-1} wF,$$

and using the FOC for Y becomes 3 in the main text:

$$\alpha D \left(\frac{\rho-1}{\rho}\right)^\rho \left(\frac{C}{A}\right)^{1-\rho} G(b^*)^{\alpha(\rho-1)} \ln B^* = \eta m(b^*)^{\eta-1} wF. \tag{7}$$

By rewriting the FOC for b^*, we obtain the next function which will be the basis of our proofs:

$$\alpha D\left(\frac{\rho-1}{\rho}\right)^{\rho}\left(\frac{C}{A}\right)^{1-\rho}G(b^*)^{\alpha(\rho-1)}\ln B^* - \eta m(b^*)^{\eta-1}wF \tag{8}$$

To check the property of the optimal b^* we differentiate 8. Also note that the second order condition is -$\frac{d(8)f(b^*)}{db}$, which is negative as long as

$$\alpha D\left(\frac{\rho-1}{\rho}\right)^{\rho}\left(\frac{C}{A}\right)^{1-\rho}G(b^*)^{\alpha(\rho-1)}f(b^*)\left(\alpha\left(\rho-1\right)\left(\ln B^*\right)^2 f\left(b^*\right) - \frac{\left(\frac{\varepsilon p_H}{p_F}\right)^{\sigma-1}b^{*\sigma-2}}{\left[1+\left(b^*\frac{\varepsilon p_H}{p_F}\right)^{\sigma-1}\right]}\right)$$

$$-\eta(\eta-1)m^{\eta-2}(f(b^*))^2 wF < 0$$

which occurs if η is large enough. In that case the optimal b^* is unique.

The profit is

$$\pi = \frac{1}{\rho-1}\lambda Y - m(b^*)^{\eta}wF,$$

and $Y = \left(\frac{\rho-1}{\rho}\right)^{\rho} DP^{\rho-1}\lambda^{-\rho}$, so

$$\pi = \frac{1}{\rho-1}D\left(\frac{\rho-1}{\rho}\right)^{\rho}\left(\frac{C}{A}\right)^{1-\rho}G(b^*)^{\alpha(\rho-1)} - m(b^*)^{\eta}wF,$$

which using 7 can be written as

$$\pi = \frac{1}{\rho-1}\frac{\eta m(b^*)^{\eta-1}wF}{\alpha\ln B^*} - m(b^*)^{\eta}wF = m(b^*)^{\eta-1}wF\left(\frac{1}{\rho-1}\frac{\eta}{\alpha\ln B^*} - m(b^*)\right). \tag{9}$$

Next is another key equation in our proofs. The total profit change if they search for new suppliers is $\frac{dV(a;A)}{da}$, and the firm will pay to search for new draws if it is larger than wF_s, i.e.,

$$\pi\left(a+1,A\right) - \pi\left(a,A\right) + \beta\left(V\left(a+1,A\right) - V\left(a,A\right)\right) > wF_s \tag{10}$$

6.1.2 Proof of Proposition 1

Proof. From equation 8, $\frac{d(8)}{db^*} > 0$ and $\frac{d(8)}{dA} > 0$. So $\frac{db^*}{dA} = -\frac{\frac{d(8)}{dA}}{\frac{d(8)}{db^*}} < 0$.

$$\frac{db_a^*}{dA} < 0,$$

so when firm productivity increases, the input cutoff decreases and the firm uses more inputs. ■

6.1.3 Proof of Proposition 2

1. If firms pay the search costs, they will drop some varieties.

   Proof. From equation 8, $\frac{d(8)}{db^*} > 0$, because $SOC = -\frac{d(8)f(b)}{db} = -\frac{d(8)}{db}f(b) < 0$. And

$$\begin{aligned} \frac{d(8)}{da} = \alpha D \left(\frac{\rho-1}{\rho}\right)^{\rho} \left(\frac{C}{A}\right)^{1-\rho} \ln B^* \alpha(\rho-1) G(b^*)^{\alpha(\rho-1)-1} \frac{dG(b^*)}{da} - \\ \cdots \eta(\eta-1) m(b^*)^{\eta-2} wF \frac{dm(b^*)}{da} = \\ \alpha D \left(\frac{\rho-1}{\rho}\right)^{\rho} \left(\frac{C}{A}\right)^{1-\rho} \ln B^* \alpha(\rho-1) G(b^*)^{\alpha(\rho-1)} \alpha \int_{b^*} \ln B \frac{df(b)}{da} db - \\ \cdots \eta(\eta-1) m(b^*)^{\eta-2} wF \int_{b^*} \frac{df(b)}{da} db \end{aligned} \tag{11}$$

   Looking at the second term we notice that using more inputs, improves productivity but increases marginal costs as well. $\frac{d(8)}{da}$ can be positive or negative. If η big enough, it is negative. Since $\frac{db^*}{da} = -\frac{\frac{d(8)}{da}}{\frac{d(8)}{db^*}} > 0$, searching new suppliers increases cutoff. Some original inputs should be dropped.

2. If firms search new inputs, they will add some varieties.

$$\frac{dm(b^*)}{da} = -f(b^*)\frac{db^*}{da} + \int_{b^*}^{\infty} \frac{df(b)}{da}db = -f(b^*)\left[-\frac{\frac{d8}{da}}{\frac{d8}{db^*}}\right] + \int_{b^*}^{\infty} \frac{df(b)}{da}db =$$

$$f(b^*)\frac{\alpha D\left(\frac{\rho-1}{\rho}\right)^{\rho}\left(\frac{C}{A}\right)^{1-\rho}\ln(B^*)\alpha(\rho-1)G^{\alpha(\rho-1)}\int_{b^*}^{\infty}\ln(B)\frac{df(b)}{da}db - \eta(\eta-1)m^{\eta-2}wF\int_{b^*}^{\infty}\frac{df(b)}{da}db}{-\alpha D\left(\frac{\rho-1}{\rho}\right)^{\rho}\left(\frac{C}{A}\right)^{1-\rho}G^{\alpha(\rho-1)}\left[\alpha(\rho-1)(\ln(B^*))^2 f(b) - \frac{Eb^{\sigma-2}}{1+Eb^{\sigma-1}}\right] + \eta(\eta-1)m^{\eta-2}wFf(b^*)}\cdots$$

$$+\int_{b^*}^{\infty}\frac{df(b)}{da}db =$$

$$\frac{f(b^*)\alpha D\left(\frac{\rho-1}{\rho}\right)^{\rho}\left(\frac{C}{A}\right)^{1-\rho}\ln(B^*)\alpha(\rho-1)G^{\alpha(\rho-1)}\int_{b^*}^{\infty}\ln(B)\frac{df(b)}{da}db - \eta(\eta-1)m^{\eta-2}wF\int_{b^*}^{\infty}\frac{df(b)}{da}db}{\alpha D\left(\frac{\rho-1}{\rho}\right)^{\rho}\left(\frac{C}{A}\right)^{1-\rho}G^{\alpha(\rho-1)}\left[\frac{Eb^{\sigma-2}}{1+Eb^{\sigma-1}} - \alpha(\rho-1)(\ln(B^*))^2 f(b)\right] + \eta(\eta-1)m^{\eta-2}wFf(b^*)} =$$

$$\frac{f(b^*)\ln(B^*)\left[\alpha(\rho-1)\int_{b^*}^{\infty}(\ln(B)-\ln(B^*))\frac{df(b)}{da}db + \frac{Eb^{\sigma-2}}{1+Eb^{\sigma-1}}\int_{b^*}^{\infty}\frac{df(b)}{da}db\right]}{\left[\frac{Eb^{\sigma-2}}{1+Eb^{\sigma-1}} - \alpha(\rho-1)(\ln(B^*))^2 f(b)\right]} > 0$$

Some original inputs should be dropped, but the measure of imported inputs increases. So if firm paid the search cost, they add and drop imported inputs simultaneously. ■

6.1.4 Proof of Proposition 3

Decreasing returns to searching.

Proof. From Section 6.1.3, we know the mass of imports increases over time. Here we prove the decreasing returns to scale on age property of our search process. First note that from Section 6.1.5 we have,

$$\frac{d\pi}{da} = \eta m(b^*)^{\eta-1}wF\int_{b^*}\left(\frac{\ln B}{\ln B^*} - 1\right)\frac{df\ (b)}{da}db > 0$$

Also note that since

$$
\begin{aligned}
&\frac{d^2\pi}{da^2} = \frac{\partial\left(\frac{d\pi}{da}\right)}{\partial b^*}\frac{db^*}{da} + \frac{\partial\left(\frac{d\pi}{da}\right)}{\partial a} = \\
&= \frac{db^*}{da}\left[\eta(\eta-1)m(b^*)^{\eta-2}m'(b^*)wF\int_{b^*}\left(\frac{\ln B}{\ln B^*}-1\right)\frac{df\,(b)}{da}db\cdots\right. \\
&+\eta m(b^*)^{\eta-1}wF(-1)\int_{b^*}\left(\frac{\ln B^*}{\ln B^*}-1\right)\frac{df\,(b)}{da}db\cdots \\
&\left.+\,\eta m(b^*)^{\eta-1}wF\int_{b^*}\left((-1)\frac{\ln B\frac{1}{B^*}}{(\ln B^*)^2}-1\right)\frac{df\,(b)}{da}db\right]\cdots \\
&+\eta m(b^*)^{\eta-1}wF\int_{b^*}\left(\frac{\ln B}{\ln B^*}-1\right)\frac{d^2f\,(b)}{da^2}db
\end{aligned}
$$

Since $f(b) = \theta aT(b-1)^{-\theta-1}\exp\left(-aT(b-1)^{-\theta}\right)$, then

$$
\frac{df\,(b)}{da} = \theta T(b-1)^{-\theta-1}\exp\left(-aT(b-1)^{-\theta}\left(1-aT(b-1)^{-\theta}\right)\right)
$$

which is positive for large b and so

$$
\frac{d^2f\,(b)}{da^2} = 2\theta T(b-1)^{-\theta-1}\exp\left(-aT(b-1)^{-\theta}\left(1-aT(b-1)^{-\theta}\right)\right)\left(-T(b-1)^{-\theta}\right) < 0
$$

Using these last two results, equation 6.1.4 has the first term negative, since $m'(b) < 0$, the second is zero, and the third is negative, while the fourth is negative. The total effect is that profit increases at a decreasing rate with searching age. ■

6.1.5 Proof of Proposition 4

1. Searching new input suppliers increases profits.

Proof.

$$\frac{d\pi}{da} = \frac{\partial \pi}{\partial b^*}\frac{\partial b^*}{\partial a} + \frac{\partial \pi}{\partial a} = \left.\frac{\partial \pi}{\partial a}\right|_{b_a^*} =$$

$$\alpha D\left(\frac{\rho-1}{\rho}\right)^{\rho}\left(\frac{C}{A}\right)^{1-\rho} G(b^*)^{\alpha(\rho-1)-1}\frac{dG(b^*)}{da} - \eta m(b^*)^{\eta-1} wF\frac{dm(b^*)}{da} =$$

$$\alpha D\left(\frac{\rho-1}{\rho}\right)^{\rho}\left(\frac{C}{A}\right)^{1-\rho} G(b^*)^{\alpha(\rho-1)}\int_{b^*}\ln B\frac{df\,(b)}{da}db - \eta m(b^*)^{\eta-1} wF\int_{b^*}\frac{df\,(b)}{da}db =$$

$$\frac{\eta m(b^*)^{\eta-1} wF}{\ln B^*}\int_{b^*}\ln B\frac{df\,(b)}{da}db - \eta m(b^*)^{\eta-1} wF\int_{b^*}\frac{df\,(b)}{da}db =$$

$$\eta m(b^*)^{\eta-1} wF\int_{b^*}\left(\frac{\ln B}{\ln B^*}-1\right)\frac{df\,(b)}{da}db > 0$$

where the 3rd equality uses equation 9, and the 5th equation 7.

2. The increased profit from searching new suppliers is larger for more productive firms. For this part of the proof start using the intermediate step derived above,

$$\frac{d\pi}{da} = \alpha D\left(\frac{\rho-1}{\rho}\right)^{\rho}\left(\frac{C}{A}\right)^{1-\rho} G(b^*)^{\alpha(\rho-1)}\int_{b^*}\ln B\frac{df\,(b)}{da}db - \eta m(b^*)^{\eta-1} wF\int_{b^*}\frac{df\,(b)}{da}db$$

Now, take derivatives wrt A,

$$\frac{d\frac{d\pi}{da}}{dA} = \alpha D\left(\frac{\rho-1}{\rho}\right)^{\rho}(\rho-1)A^{\rho-2}C^{1-\rho}G(b^*)^{\alpha(\rho-1)}\int_{b^*}\ln B\frac{df\,(b)}{da}db +$$
$$\frac{db^*}{dA}\Bigg(- \eta(\eta-1)m^{\eta-2}f(b_a^*)wF\cdots$$
$$- \eta m^{\eta-1}wF\left(\int_{b_a^*}\ln B\frac{df_a\,(b)}{da}db\right)\frac{\left(\frac{\varepsilon p_H}{p_F}\right)^{\sigma-1} b_a^{*\sigma-2}}{(\ln B_a^*)^2\left[1+\left(b_a^*\frac{\varepsilon p_H}{p_F}\right)^{\sigma-1}\right]}\Bigg) > 0$$

because the first term is positive and $\frac{db^*}{dA} < 0$ ∎

6.1.6 Intertemporal problem

Here we show that, not only the current period profit gain is larger for more productive firms, but also the dynamic gains are larger for more productive firms. Firms have two alternatives: either they pay the fixed searching cost and connect to a new bunch of suppliers, or don't search.

$$V(a, A) = \max_{\{\text{search,not search}\}} \left\{\pi(a+1, A) - wF_s + \beta V(a+1, A), \pi(a, A) + \beta V(a, A)\right\},$$

the firm would pay to search for new draws if

$$\pi(a+1, A) - \pi(a, A) + \beta(V(a+1, A) - V(a, A)) > wF_s \tag{12}$$

which is when the value of searching is larger than the cost of switching.

In Section 3, we show that the profit gain from searching falls as time passes. This implies that there exists an age $\bar{a}(A)$ when a firm with productivity A optimally stops searching. So the value function is

$$V(a, A) = \begin{cases} \pi(a+1, A) - wF_s + \beta V(a+1, A), & \text{if } a < \bar{a}. \\ \frac{\pi(\bar{a}, A)}{1-\beta}, & \text{if } a > \bar{a}. \end{cases} \tag{13}$$

or

$$V(a, A) = \begin{cases} \sum_{i=1}^{\bar{a}-a-1} \left(\beta^i \pi(a+i, A) - wF_s\right) + \beta^{\bar{a}-a} \frac{\pi(\bar{a}, A)}{1-\beta}, & \text{if } a < \bar{a}. \\ \frac{\pi(\bar{a}, A)}{1-\beta}, & \text{if } a \geq \bar{a}. \end{cases} \tag{14}$$

From this result then, if $\pi(a, A)$ increases with A then $V(a, A)$ also increases with A. Because a firm have two alternatives the values of which we discuss next.

If the firm does not search at $a+1$, the LHS of 12 is

$$\begin{aligned} & \pi(a+1, A) - \pi(a, A) + \beta(V(a+1, A) - V(a, A)) \\ = \; & \pi(a+1, A) - \pi(a, A) + \beta \frac{\pi(a+1, A) - \pi(a, A)}{1-\beta} \\ = \; & \frac{\pi(a+1, A) - \pi(a, A)}{1-\beta} \end{aligned}$$

If the firm searches at $a+1$, the LHS is

$$\begin{aligned} & \pi(a+1,A)-\pi(a,A)+\beta(V(a+1,A)-V(a,A)) \\ = \; & \pi(a+1,A)-\pi(a,A)+\beta(\pi(a+2,A)-\pi(a+1,A)+\beta w F_s) \end{aligned}$$

Hence, if $\pi(a+1,A)-\pi(a,A)$ increases with A, the LHS increases with A and the gain from searching is larger for more productive firms. In fact, in proposition 4, we show that searching has such property. Therefore, for every a, there is a productivity cutoff, and firms with productivity above the threshold search. Also, for all cohorts, we can determine what firms will search at all and if so until what age.

6.1.7 Proof of Proposition 5

Proof. Because draws are independent, the probability of dropping a product with productivity b is $1-F(b)$. ■

6.1.8 Proof of Proposition 6

Proof. From equation 8, $\frac{d(8)}{db^*}>0$,. We also have

$$\frac{d(8)}{\varepsilon}=\alpha D\left(\frac{\rho-1}{\rho}\right)^{\rho}\left(\frac{C}{A}\right)^{1-\rho}G(b^*)^{\alpha(\rho-1)}\cdots$$
$$\left(\frac{\left(b^*\frac{p_H}{p_F}\right)^{\sigma-1}\varepsilon^{\sigma-2}}{1+\left(b^*\frac{\varepsilon p_H}{p_F}\right)^{\sigma-1}}+\ln B_a^*\alpha(\rho-1)\int_{b^*}\frac{\left(b^*\frac{p_H}{p_F}\right)^{\sigma-1}\varepsilon^{\sigma-2}}{1+\left(b^*\frac{\varepsilon p_H}{p_F}\right)^{\sigma-1}}f(b)\,db\right)>0$$

Since $\frac{db^*}{d\varepsilon}=-\frac{\frac{d(8)}{d\varepsilon}}{\frac{d(8)}{db^*}}<0$, then when ε decreases, the productivity cutoff increases, firms use less imported inputs: $m(b^*)$ falls. ■

6.1.9 Proof of Proposition 7

Proof. Equation 10 states the condition under which firms search for new draws. Taking a as continuous,

$$\frac{d\left(\frac{d\pi}{da}\right)}{d\varepsilon} = \frac{d\left(\eta m(b^*)^{\eta-1} wF \int_{b^*}\left(\frac{\ln B}{\ln B^*}-1\right)\frac{df(b)}{da}db\right)}{d\varepsilon} =$$

$$\frac{d\eta m(b^*)^{\eta-1} wF \int_{b^*}\left(\frac{\ln B}{\ln B^*}-1\right)\frac{df(b)}{da}db}{db^*}\frac{db^*}{d\varepsilon} =$$

$$\left(\eta(\eta-1)m^{\eta-2}f(b_a^*)wF - m^{\eta-1}wF\left(\int_{b_a^*}\ln B\frac{df_a(b)}{da}db\right)\frac{\left(\frac{\varepsilon p_H}{p_F}\right)^{\sigma-1} b_a^{*\sigma-2}}{(\ln B_a^*)^2\left[1+\left(b_a^*\frac{\varepsilon p_H}{p_F}\right)^{\sigma-1}\right]}\right)\frac{db_a^*}{d\varepsilon} =$$

$$\left(-\eta(\eta-1)m^{\eta-2}f(b_a^*)wF - \eta m^{\eta-1}wF\left(\int_{b_a^*}\ln B\frac{df_a(b)}{da}db\right)\frac{\left(\frac{\varepsilon p_H}{p_F}\right)^{\sigma-1} b_a^{*\sigma-2}}{(\ln B_a^*)^2\left[1+\left(b_a^*\frac{\varepsilon p_H}{p_F}\right)^{\sigma-1}\right]}\right)\frac{db_a^*}{d\varepsilon} > 0 \tag{15}$$

because $\frac{db_a^*}{d\varepsilon} < 0$. The change of profit from searching is lower when the currency devaluates as imports have become more expensive. Accordingly, fewer firms would pay the searching cost. ■

6.2 Empirical Appendix

6.2.1 Harmonized System Code

There are changes of product classification over time by the Harmonized Commodity Description and Coding system, which would create variety adding and dropping by firms. We create a correspondence using the document that specify during 1993-2012, the date when a Decree was approved, the code that it affected and how it affected it, and the date when the change was applied.

We look at the most conservative case by defining dropped products as products that are never bought by the firm again, whereas added products as those that have never been bought by the firm before. Our algorithm uses the concordance and compares the varieties in the current quarter with all the previous quarters to find added varieties, and with all the following quarters to find dropped varieties within each firm.

6.2.2 Data Construction

We use two sources of data the Annual Manufacturing Survey, AMS, and the DIAN, import and export transaction data. The AMS is a panel of industrial plants from 1994-2012. Firms enter in the sample if they produce at least 137 million pesos in 2011 or 71.000 US dollars or have at least ten employees. Once a firm is included in the sample it is followed overtime until it goes out of business, regardless whether the inclusion criteria is satisfied each year. It is collected by the National Statistics Department DANE. The customs data are administrative records of imports and exports collected by the customs national authority DIAN. Information includes importing or exporting, HS code of traded product at ten digits (NANDINA), FOB value. Nandina codes use standard HS at 6 digits and complements with 4 digits customized for the Andean Community of Nations.

Next we report all data steps, from cleaning to merging to variable creation.

1. Data Cleaning:

    - Data Source 1: AMS:

        - Subcontracted products are excluded from the sales value of the firm. These are products that are not sold by the firm but rather the firm is hired to produce them using inputs of the contractor.

    - Products with value of 0, 1, 2 or 3 are excluded from the sample.
    - The original data is at the plant level. We use information collapsed to the firm-level.
  - Data Source 2: Customs:
    - Tax identifiers in the customs database are not completely clean as they may include a verification code in some cases, or letters in others. Both are truncated to make them match the AMS data format.
    - Exclusions are applied, mainly of temporary imports/exports or for purposes of repair or commercial samples. Our trade aggregate data virtually equals to the aggregates reported by DANE at their website.

2. Merging: AMS and trade data are matched using the unique tax identifier (NIT) present in both databases.

3. Variable creation:

   - Sales: Firm sales are defined as the sum of sales of all products by a firm in a given year. Value is deflated using the CPI.
   - Import value: is the CIF dollar value of imports declared in administrative records. No deflator is used.
   - Export value: is the FOB dollar value of imports declared in administrative records. No deflator is used.
   - Exporter: indicator variable taking the value 1 if firm has positive export value, and 0 otherwise.
   - Exports share: exports as fraction of total sales.
   - Imports/exports number: is the number of different NANDINA codes for a given firm. See next for an explanation of NANDINA codes.
   - Absorption: is the current value of production plus imports minus exports for an industry at CIIUv2 two digits. Only manufacturing industries are included.
   - Number of importer firms by industry: This is the number of firms in the trade data for a given industry.

- Creation status for products: The status of a firm/product is determined using data from imports only. There's a quarterly and a yearly version. The yearly one is the one used in the regressions. There are five possible statuses for a firm in a given year:
  - Enter: the firm has never imported in the data sample and it's the first year it imports.
  - Enter old: the firm didn't import the previous year but imported in any other year before the previous one.
  - Stay: The firm imports in the previous period and the current one as well.
  - Exit: The firm imported in the previous period, but does not import in the current year nor it imports in the rest of the future years.
  - Exit temp: The firm imported in the previous period, didn't import in the current one, but will import again in a later year of the sample.
- Given the firm status we subdivide the products for continuing firms in several groups:
  - Add: the product is new and has never been imported by the firm
  - Add old: the product was not imported in the previous year, but has been imported in some other years before.
  - Keep up: The product was imported in the previous period, is also imported in the current one, and the total import value of it is greater or equal than in the previous period.
  - Keep down: The product was imported in the previous period, is also used in the current one, and the total used/produced value of it is less than in the previous period
  - Drop: The product was imported in the previous period, but not in the current one, nor in the future ones.
  - Drop temp: The product was imported in the previous period, but not in the current one, but is imported again in the sample.

  To classify products by their status, several steps are needed, which we describe here. Imported and exported products are codified using a NANDINA code. NANDINA codes are standard Harmonized System at 6 digits, complemented with additional 4 digits used in the Andean Community of Nations and in Colombia. This code system is not constant across years. Some changes are made both at the international HS6 level and at the more detailed NANDINA level. This changes include reclassifications, opening of new categories, and closing of old categories. We want to deal with these changes so we obtain a clean measure of product adding and dropping. Changes do not distribute evenly across years, but occur particularly in 1996, 2001 and 2007 where modifications were made to the international Harmonized System.

In sum, the process to determine the status of products involves three steps. First, using a correspondence of all the products (re)codifications. This correspondence is available at DANE webpage. Second, creating a file that determines all past and future codes for a product. In this file each column has a different combination of past and future codes of a product. Third, isolating products whose codifications have not changed. For those whose code that change at any point in time we do the following. For each product of each firm in a given year, we compare it to the observations in all past years using the correlative, to decide if a product is indeed newly added or just the same product with a change in the codification. Similarly, we compare each product of each firm in a given year, to all products in all future years, to decide if a product is no longer imported in the future, or is imported by the firm but with a different code.

- Supplier id's: data on the supplier of importer lacks a unique numeric identifier. Accordingly, we use three variables to identify suppliers: country of origin of the supplier, city of the supplier, and the name of the supplier. Because different importers may write the name of the supplier in a different way, we clean the names and use a metric to compare them. We use the Levenshtein Distance, which measures the difference in spelling of two strings. The most common algorithm is to match them whenever two strings have a distance that is less than a parameter epsilon(10% for example). Because of the large number of names and spelling possibilities of several countries is very high we created a different two-step, iterative process.

  The first step is to create a new group with the first observation; this first observation can be thought of as the head of a group. The second step is to compare the second observation with the head of all the previously existing groups. If the distance between the two strings is less than a parameter epsilon, then the new observation is matched to the group with the least distance calculated. If on the other case all the distances calculated with all the heads of existing groups are greater than a parameter epsilon, then a new group is created with this new observation as the head of the new group. The process is iterated until all the observations are assigned to previous groups or in their own new group. This simple algorithm gave us much better results than the more popular method described above.

6.2.3 Extra Figures and tables

Sales Quartile	Total	Add	Drop	Net	Add Share	Drop Share	Surviving Importers
				1994/1995			
1	6.02	4.30	3.38	0.85	0.69	0.58	397
2	7.00	4.64	4.17	0.61	0.67	0.56	543
3	14.20	8.44	6.20	2.68	0.60	0.46	694
4	56.05	27.71	15.92	11.55	0.56	0.36	766
Total	24.57	13.84	8.92	4.95	0.61	0.46	2,400
				1998/1999			
1	6.29	3.46	4.23	-1.16	0.55	0.53	388
2	7.40	4.20	3.99	-0.05	0.52	0.49	511
3	12.44	5.18	5.79	-0.73	0.45	0.43	646
4	52.37	15.52	15.24	0.22	0.37	0.33	723
Total	22.98	8.82	8.73	-0.32	0.44	0.42	2,268

Table 14: Number Of Different Imported Inputs By Quartile broken down by normal period and devaluation.

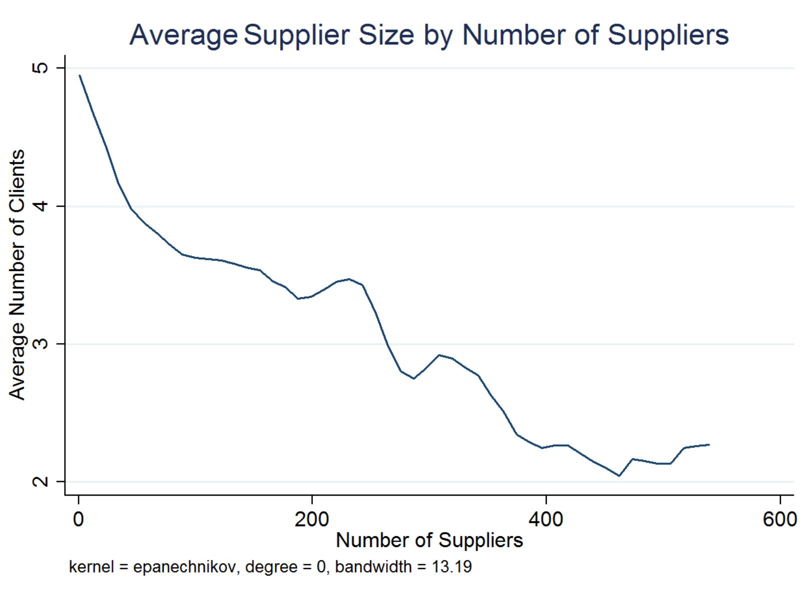

Figure 6: Size of suppliers and size of importer. Polynomial plot.

References

G. Alessandria, J. P. Kaboski, and V. Midrigan. Inventories, lumpy trade, and large devaluations. *American Economic Review*, 2010. 5

M. Amiti and J. Konings. Trade liberalization, intermediate inputs, and productivity: Evidence from indonesia. *American Economic Review*, 97(5):1611–1638, 2007. 3, 35

A. B. Bernard, S. Redding, and P. K. Schott. Multiple-product firms and product switching. *American Economic Review*, 100(1):70–97, 2010. 4, 25

B. S. Blum, S. Claro, and I. Horstmann. Intermediation and the nature of trade costs: Theory and evidence. *U. Toronto Mimeo*, 2008. 33

B. S. Blum, S. Claro, and I. Horstmann. Facts and figures on intermediated trade. *American Economic Review, P&P*, 100(2):419–23, 2010. 33

J. P. Damijan, J. Konings, and S. Polanec. Import churning and export performance of multi-product firms. *Mimeo University of Ljubljana*, 2012. 4

P. K. Goldberg, A. K. Khandelwal, N. Pavcnik, and P. Topalov. Imported intermediate inputs and domestic product growth: Evidence from india. *The Quarterly Journal of Economics*, 2010. 3

G. Gopinath and B. Neiman. Trade adjustment and productivity in large crises. *American Economic Review, R&R*, 2011. 3, 5, 11, 12

L. Halpern, M. Koren, and A. Szeidl. Imported inputs and productivity. *American Economic Review, R&R*, 2011. 3, 11

R. Shimer. Reassessing the ins and outs of unemployment. *Review of Economic Dynamics*, 15(2):127–148, 2012. 2