How Firms Accumulate Inputs: Evidence from Import Switching*

Dan Lu†[1], Asier Mariscal[2], and Luis-Fernando Mejía[3]

[1]University of Rochester

[2]University of Alicante

[3]National Planning Department, Colombia

December 10, 2015

Abstract

We uncover new dynamic patterns related to importers age and the macroeconomic environment that static models cannot explain. Our patterns are related to import switching, i.e., the simultaneous adding and dropping of intermediates at the firm level. Three facts stand out. First, switching is pervasive as 65% of firms do it and, at the firm level, switching is not small at 35% of firms import value. Second, young firms switch higher shares of their imports. Third, when import prices are high, switching shares fall. Accordingly, in our model, firms dynamically search for suppliers and face an import choice with heterogeneously productive intermediates. When firms search, they find new suppliers and compare the newfound productivity draws to those by their current suppliers and keep the best productivity intermediates. Through this process, over time, firms improve their productivity, and grow. In the final section of the paper, we show that several key predictions of the model hold using within-firm variation regressions. First, least productive intermediates are more likely to be dropped. Second, over time firms increase the number of foreign intermediates they use and reduce their switching. Third, switching causes future sales growth and by a quantitatively large amount. We view our paper as complementary to those that emphasize capital accumulation and worker reallocation to be important for firm dynamics and aggregate productivity.

---

*This paper is a substantial revision of our paper "Import Switching and the Impact of a Large Devaluation". We would like to thank seminar and conference participants for comments on the early version at Universidad de Alicante, University of Rochester, Queen's University, Beijing University, Fedesarrollo, Philly-FED RMET, and SED. We also thank George Alessandria, Yan Bai, Mark Bils and Andreas Moxnes for comments on an early draft and Alejo Forero for his excellent research assistance. Financial support from the Ministerio de Ciencia e Innovación and FEDER funds under project SEJ-200762656 is gratefully acknowledged.

†Corresponding author: danlu@rochester.edu

1 Introduction

While foreign input sourcing is important for firm productivity[1], little work focuses on how firms' accumulate them. This paper documents the substantial simultaneous adding and dropping, also called switching, of imported input varieties by Colombian manufacturing firms. In this paper we show that imported input switching has patterns that depend on firms' lifecycle and are affected by the macroeconomic environment. This evidence on switching yields light on how firms accumulate and upgrade their foreign inputs, and cannot be explained by standard static models.

We start by describing three motivational facts. First, there is a large amount of switching of imported inputs by Colombian manufacturing firms. We find, on average, around 60% of firms and close to all firms in the 90-th percentile switch every year. Conditional on switching, and by a conservative measure[2], they add and drop more than 30% of their imported input value on average. On the aggregate, each one of these margins (add and drop) is also large, accounting for more than twice the total changes in import value in the sample[3]. Second, in the data, conditional on age, larger firms are more likely to switch. On the other hand, conditional on size, younger firms switch more. Third, we find that switching is procyclical. Specifically, there is more inaction during depreciation episodes: fewer firms switch, and firms that switch add and drop a lower share.

Switching involves adding and dropping imported input varieties defined at a highly disaggregated level. Accordingly, this can be seen as firms searching and substituting some inputs for others and some suppliers for others; Through this search process, firms will accumulate the number of imported varieties. From this perspective, the cross-section and time-series patterns of firm-level imported input switching suggests the existence of interesting dynamics on how firms accumulate foreign input varieties.

We propose a dynamic model of how firms accumulate foreign inputs through searching of new suppliers. The model extends the static model of endogenous choice of imported inputs in Halpern et al. (2011) and Gopinath and Neiman (2011) by introducing search and adjustment of imported inputs over time. Firms' production function fea-

[1] See Amiti and Konings (2007), Goldberg et al. (2010), Halpern et al. (2011), Gopinath and Neiman (2011), ect.

[2] Conservative measure defines dropped imported inputs are those never bought by the firm again, whereas added products as those that have never been bought by the firm before.

[3] When including temporary add and drop, each flow is about 8 times the value of import change.

tures a love-of-variety in intermediates, while imports incur a convex cost. We introduce heterogeneously productive inputs where firms choose to import an endogenous range of inputs depending on their productivity. Searching for new inputs is costly and modeled as a fixed cost and an adjustment cost: Together they allow for both intensive and extensive margins of search. As a consequence, only more productive firms do search and when they find new, more productive inputs, they substitute them for their old ones. In a nutshell, the switching of inputs can be seen as firms searching for new suppliers and reorganizing their production by changing imported inputs within narrowly defined categories.

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 and these firms have future sales growth. In the model, firms pay a search cost to be connected with new foreign input suppliers, and shift their use of imported inputs towards the more productive ones. Second, in the model, because the benefit from searching for new suppliers is larger for more productive firms, 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 model, there is indeed more inaction when the import price is high, simply because the gains from searching are lower. This mechanism also suggests that reducing import tariffs could lead to larger productivity gains and that devaluations lead to larger TFP declines, due to the dynamic allocation of inputs. Our empirical analysis shows that the productivity decline during devaluation times indeed relates to less gross switching of imported inputs.

The model's predictions are complemented with firm-level evidence consistent with our highlighted mechanisms. Three key results involve firm dynamics. First, the supplier search mechanism modulates firms TFP, not only through firms total number of varieties, but also through reallocation of inputs within firms. To be more precise, larger switching values are associated with larger future sales growth. Second, smaller value/share inputs are more likely to be dropped. Third, over time firms accumulate more inputs and suppliers but switch lower amounts/shares. The patterns we uncover suggest that firms substitute, accumulate and upgrade inputs in a dynamic process that improves firm productivity. Accordingly, these features have unique implications on firm and macro dynamics upon shocks, whether they are business cycles, trade policies, or exchange rate shocks.

Our paper is related to the recent work on the relationship between firm imports and productivity. Amiti and Konings (2007) and Goldberg et al. (2010) respectively show that reducing import tariffs leads to larger productivity gains and larger product scope for firms experiencing lower input tariffs. Halpern et al. (2011) estimate the effects of imported input use on total factor productivity for Hungarian firms and Gopinath and Neiman (2011) using a similar production function study the impact of the number of imported inputs on aggregate productivity. They focus on the Argentinian devaluation and show how price indices need to be adjusted to properly account for changes in the extensive margin of imports. While these papers focus on the net value of imports, we focus on the gross flows and the dynamic gains from imported inputs.

We also relate to Damijan et al. (2012) who show that import switching is relevant for firm TFP 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, and we show this process is dynamic in nature. Our results are robust to Bernard et al. (2014), who emphasize that the time of the year in which firms start trading influences growth estimates of new entrants.

In our paper, the relation between switching intensity and firm age suggests that firms slowly accumulate imported inputs and converge with import duration. This aspect is similar to the exporter dynamics emphasized by Eaton et al. (2014), Arkolakis et al. (2014), Fitzgerald et al. (2015), Ruhl and Willis (2014), and Alessandria et al. (2014). While these papers focus on learning about demand, accumulation of a customer stock and learning by exporting, we focus on how firms can improve productivity by accumulating suppliers and upgrading inputs. In this sense, our paper endogenizes the process of learning by doing in input use that Covert (2014) documents for young fracking companies[4]. Considering the accumulation of supplier contact is one type of organizational capital, we show that the capital adjustment cost affects the life-cycle dynamics of plants as in Hsieh and Klenow (2014)[5]. Furthermore, we shed light on

[4]The adoption of intermediates is also the topic of Carvalho and Voigtländer (2014), who study it in a network context, with the goal of understanding technology adoption in the product space.

[5]Foster et al. (2008) shows that, in the cross-section, new business are smaller and suggests it is due to a demand accumulation process. Other dynamic forces like capital adjustment cost could also produce similar qualitative pattern.

this accumulation process by showing how input switching relates to firm and input characteristics. In fact, the cross-section and over time patterns of switching of foreign inputs has similar features to the turnover of another crucial input of firms, namely workers, see Davis et al. (2012) and Shimer (2012). Analogously, we emphasize that imported input accumulation is a costly activity and takes time, and the efficient use of inputs involves reallocation, as in Pries and Rogerson (2005) occurs for workers.

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 Motivation

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[6]. Second, data from a manufacturing survey, conducted by the national statistical office, DANE. The survey, called EAM (Encuesta Anual Manufacturera), is a well-known panel for which we have data for the period 1994-2011. Using the common identifier, we merge both sources which results in an unbalanced panel for 1994-2011.

We focus on the flows of imported inputs, which basic accounting shows are given by $m_{it} = m_{it-1} + add_{it} - drop_{it}$. In particular, our paper is about the adding of new imported inputs and the dropping of old imported inputs, i.e. switching, which we define conservatively: Dropped imported inputs are those never bought by the firm again, whereas added products as those that have never been bought by the firm before[7]. While results are qualitatively the same with a less restrictive definition of add and drop, by being conservative we avoid an inventory explanation as in Alessandria et al.

[6] 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.

[7] In case of a 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.

(2010). Finally, we define products at the HS10 digit level, in order to capture large input substitutability that we believe is the essence of the search process we model.

Switching of imported inputs within firms is pervasive and not a small value within firms or on aggregate. Three figures help in providing context. First, Figure 1 shows that on average 62 percent of continuing importers add and drop imported input varieties simultaneously[8], a value that increases to 92% when weighted by import value. While we provide more detailed evidence on the relation between switching and size later on this Section, these numbers already show that switching is pervasive and suggest that large importers are doing it.

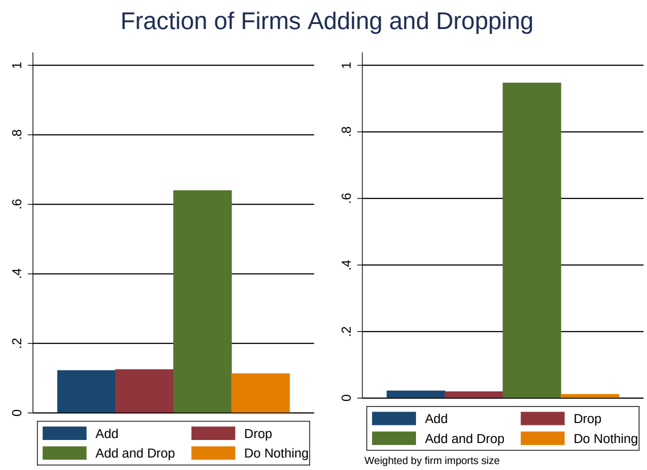

Figure 1: Fraction of Continuing Importers that Switch

On Figure 2 we present the average value that firms add(drop) as a fraction of their total imports. The share of add (drop) values over imports is substantial at around 30% to 40%[9], and 10% when weighted by import size, hinting that larger firms switch smaller shares. While these numbers become smaller when weighted by import size, the switching rate on the aggregate is not a small margin either.

[8] On average around 10 percent of importers exit.

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

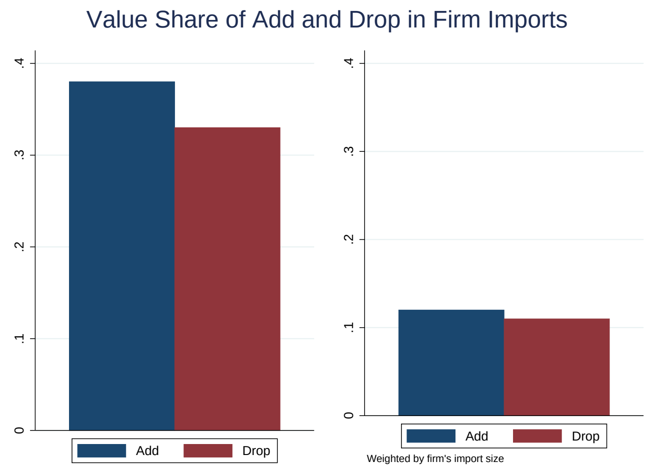

Figure 2: Firm Level Add And Drop Values As Fraction Of Total Import Value

So far, we have shown the extensive and intensive margins of switching to be large. Many stories could rationalize those facts. It is possible that they are due to a composition effect, where firms that expand (contract) mostly add (drop) imported inputs. Contrary to such scenario, what we find in Figure 3 is that, conditional on a firm switching, it's import value share of added and dropped imported products are positively correlated. The within firm correlation of the add share and drop share is 0.15, and 0.58 when weighted by firms import values. It shows that firms that add intensely, also drop intensely, which is consistent with firms substituting inputs and suppliers but not with the suggested composition effect.

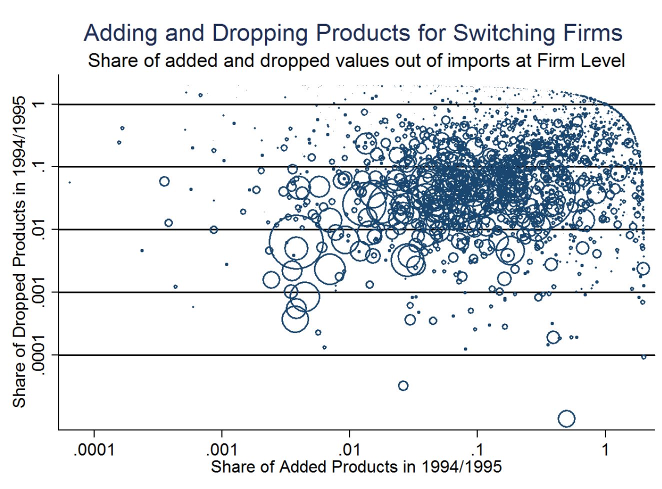

Figure 3: Share Of Imported Inputs Added And Dropped.

The static evidence so far shows substantial switching of imported inputs within firms. Why do importers switch imported inputs constantly? Are the imported inputs flows indicative of dynamics in which firms search and organize their inputs? We next provide evidence on the dynamic aspects of switching and show that imported input switching has features that are very similar to the turnover of another input of firms, namely workers.

Figure 4 displays the relation between import switching flows and firms' import growth. We define import growth rate as the difference between two consecutive quarters divided by the simple imports mean of both quarters[10]. Next, we assign firms to to 200 growth-rate bins, each with the same number of firms in them. Finally, we run regressions of firms' share of adding and dropping of imports on a vector of 200 dummies, one for each bin. In the figure, on the Y-axis we plot the estimated add share and drop share against the growth rate bin in the X-axis.

[10]This definition ensures that growth rates are bounded at [-2,2], with bounds being exit and entry respectively.

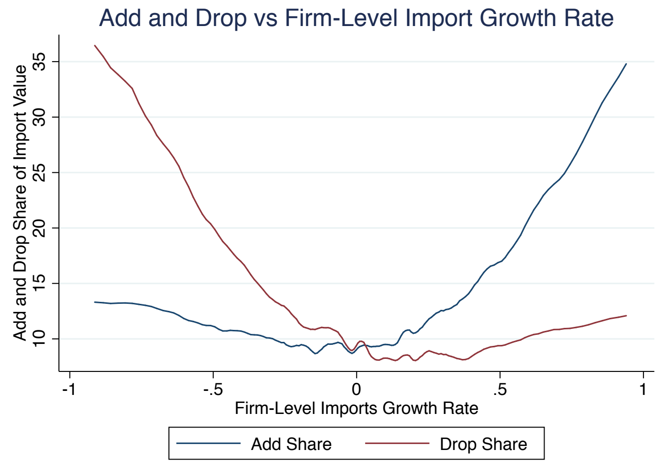

Figure 4: Firm Level Add And Drop Share vs Import Growth

Figure 4 shows that, as firms grow, the adding rate increases but drop is not negligible at around 12% on average[11]. This highlights the quantitative importance of simultaneous adding and dropping in growing firms. Note how the cross-sectional relations are very similar to Davis et al. (2012) for worker flows: growing importers are also dropping import varieties, while shrinking importers are also adding import varieties[12]. Note also that even the quantitative importance of drop value over imports is similar to the labor equivalent, since in Davis et al. (2012) both the share of quiting and laid-off workers over total employment is around 7% for growing firms.

Since imported input flows are related to firms' import growth, it is natural to think these flows are indicative of the dynamic adjustment of firms' imports and so we further look into these aspects. In particular, we dig into two dimensions: how do the adding and dropping shares of imported inputs change with firms' duration in the import market, and with the price of imports.

First, we group firms according to their age in the import market. Figure 5 plots the average add and drop shares against their growth bins for two importer age groups[13]: younger than 3 year importers, and those older than 10[14]. Conditional on a growth

[11] As the Y-axis ranges from 0 to 200, the figure is zoomed in to help the visibility while still capturing 80% of firms. Figures using yearly switching looks similar, with higher values for add and drop shares.

[12] Our model will focus on the positive growth side of the figure, though a simply extension including productivity shocks would generate the negative section of the figure.

[13] We define age as the number of years in the import market. We eliminate firms in the first year of the sample in order to limit measurement noise.

[14] Similar results are obtained with different age groups.

level, older firms add and drop less: both add and drop shares shift downward for older firms. This figure provides a clean comparison of switching across ages, since even if young firms grow more than older ones, at any growth level switching is larger for younger importers. Note that a static model would be silent about these features of the data. On the other hand, our dynamic model will feature simultaneous adding and dropping as firms search imported input suppliers and reorganize their input usage. Over time, firms will find more difficult to find better suppliers for their inputs and will search less intensively and switch less.

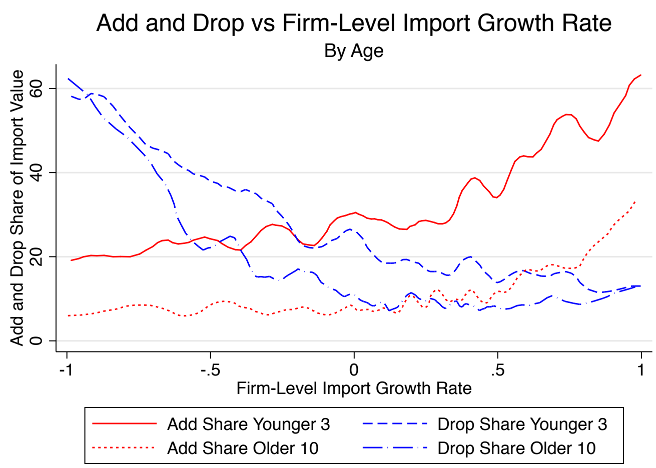

Figure 5: Firm Level Add And Drop Share vs Import Growth by Age Groups

Second, we examine how the switching behavior changes with the price of imported inputs. We compare periods of high and low exchange rates[15] since as long as there is at least some pass-through, those periods provide variation in imported input prices. Figure 6 and Figure 7 display extensive and intensive switching margins in those periods.

In figure 6, we plot the fraction of firms switching against their size quantile based on imports, for the aforementioned 2 period types: high and low RER. Low RER periods are depreciations and imply relatively high import prices. The figure shows that higher import prices induce more inaction, i.e., less switching and that, larger firms are more likely to switch; in fact, on the largest quantiles most do. If the observed switching was purely due to random idiosyncratic shocks to firms' inputs, we should

[15] RER_t is the US-Colombia rate, with base year 1992, i.e., the nominal rate used is dollars per peso. We choose this metric because almost all Colombian imports are dollar denominated.

not observe a decreased fraction of switchers during devaluations, but, on the other hand, this evidence is consistent with a decreased gain from searching for inputs during devaluation and hence less switching.

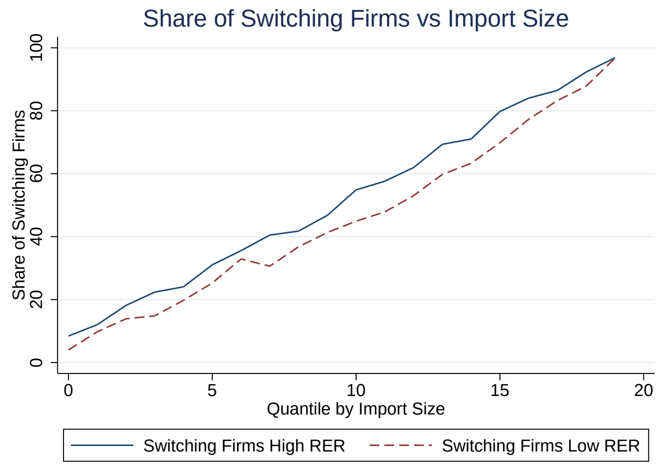

Figure 6: Fraction of Importers that Switch by Time Periods

On Figure 7 instead, we show that periods of expensive inputs (low RER) induce lower adding and dropping; more precisely, conditional on import growth, periods of expensive imports are associated with low switching. It is well documented that the net amount of imports falls in devaluations and here we show that also switching falls, which is a feature not easily reconciled with a standard static model. On the other hand, in our dynamic model the benefit from searching for imported inputs will fall as prices increase, which will reduce the search intensity[16].

[16]In Table 9 in the Empirical Appendix, we show this fact as number of imported inputs with a similar view. It further shows how adding and dropping activities are related to firm size. Larger firms are more likely to switch, if switch they do more adding and dropping, but a smaller ratio. See Section 4 for a regression version of this results.

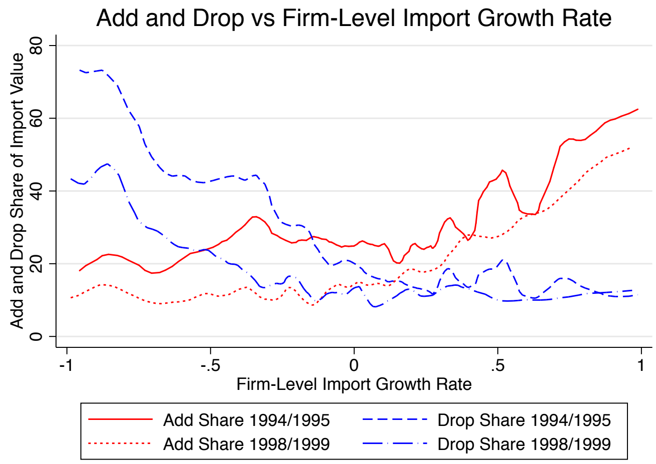

Figure 7: Firm Level Add And Drop Share vs Import Growth by Different Time Periods

Overall, we have shown that there is substantial simultaneous adding and dropping of imported inputs by Colombian manufacturing firms. We provide evidence that switching of imported inputs depends on an importer's size, age and is affected by the price of imports. 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.

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 Halpern et al. (2011) and Gopinath and Neiman (2011), to introduce over time search and adjustment of imported inputs. We show that imported input switching behavior depends on firms' productivity, age and the price of imports, and that imported inputs switching relates to dynamic productivity gains of firms.

3.1 Production and Imported Inputs

The demand quantity, q, firm can sell is inversely related to the price it sets, p [17]:

$$q = Dp^{-\rho}.$$

where ρ is the elasticity of demand and D is a demand shifter.

Each firm has a TFP given by A and produces a single good using labor, L, and intermediate inputs, X,

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

The intermediate inputs used by the firm consists of a bundle of intermediate goods indexed by $j \in [0, 1]$ and aggregated according to a Cobb-Douglas technology:

$$X = \exp \int_0^1 \ln X_j dj.$$

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

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

where σ is the elasticity of substitution between the home and foreign varieties in the production function, and $b_j > 1$ measures the productivity advantage of foreign variety j.

Firms' productivity A does not change over time. Furthermore, to import m varieties, firms need to pay a convex cost of $m^{\eta}F$ in wage units. We assume $\eta > 1$ so the cost function is convex on the number of varieties as in standard static models. We assume each input productivity has a distribution $F(b)$, with support over $(1, \infty)$, and firms decide their input quantity choices knowing the productivity of each input. Given this setup, all firms use all the home inputs, and potentially also foreign inputs depending on the trade-off between the productivity gains induced by foreign inputs and the convex cost of importing. We will refer to p_H and p_F as the home and foreign variety prices.

Before describing in more detail the static part of our model, let us briefly introduce

[17] 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.

the dynamic aspects. Every period an importer decides whether to pay an input search fixed cost, which in turn allows him to choose his search intensity for the measure one of foreign inputs. Having met a stock n of suppliers, the firm compares their draws for each input and chooses from which supplier to source if at all. Finally, the firm chooses the range of imported inputs given the convex cost of importing. We solve the model backwards: first, obtain the optimal imported input productivity cutoff; second, the search intensity conditional on searching; finally, the search versus not search decision. We fully introduce the dynamic aspects in section 3.3, but note that we focus on the imported input decision and ignore firms entry and exit[18].

3.2 Firms' Static Problem

A firm with productivity A, after the imported input productivities are realized, decides which foreign inputs to use by maximizing profits. It is intuitive to guess that the solution involves firms using 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 used by the firm is $m(b^*) = \int_{b^*}^{\infty} f(b)\, db$.

The firm maximizes profits:

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

where

$$\lambda(A, b^*) = \min_{L,\{H_j,M_j\}} \left\{ wL + \int_0^1 p_H H_j dj + \int_{b^*} p_F M_b dF(b) \right\}$$

subject to:

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

$$X = \exp \int_0^1 \ln X_j dj$$

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

To summarize, firms' unit cost is composed of compensation to workers and spending on domestic and foreign intermediate inputs, demand is CES and there is love-of-variety in inputs.

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

Given b^*, the price index for intermediate inputs, P, is

$$
\begin{aligned}
P &= \exp \int_0^1 \ln \left[p_H^{1-\sigma} + I\left(im\right)\left(\frac{p_F}{b_j}\right)^{1-\sigma}\right]^{\frac{1}{1-\sigma}} dj \\
&= p_H \exp \int_{b^*}^{\infty} \ln \left[1 + \left(\frac{b p_H}{p_F}\right)^{\sigma-1}\right]^{\frac{1}{1-\sigma}} dF\left(b\right).
\end{aligned}
$$

where $I\left(im\right)$ is an indicator function that takes value 1 if input j is imported and zero otherwise. Solving the firm problem[19], we can express the unit cost, λ, as

$$
\begin{aligned}
\lambda\left(A, b^*\right) &= \frac{1}{A}\left(\frac{w}{1-\alpha}\right)^{1-\alpha}\left(\frac{P}{\alpha}\right)^{\alpha} \\
&= \frac{1}{A} C G(b^*)^{-\alpha}.
\end{aligned} \tag{1}
$$

where $C = \left(\frac{w}{1-\alpha}\right)^{1-\alpha}\left(\frac{p_H}{\alpha}\right)^{\alpha}$, $G(b^*) = \exp \int_{b^*} \left(\ln B\right) dF\left(b\right)$ and $B = \left[1 + \left(\frac{b p_H}{p_F}\right)^{\sigma-1}\right]^{\frac{1}{\sigma-1}}$.

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.

Combining the two first order conditions for Y and b^*, we have that the marginal input[20] b^* satisfies[21],

$$
C_1 A^{\rho-1} G(b^*)^{\alpha(\rho-1)} \ln B^* = \eta m(b^*)^{\eta-1} F. \tag{2}
$$

Equation 2 shows that, at the optimum, the marginal benefit of an extra imported input equals the marginal cost of importing it. Adding more imports, i.e., a smaller b^*, increases the benefit from using more productive foreign inputs, $G(b^*) = \exp \int_{b^*}^{\infty} \left(\ln B\right) dF\left(b\right)$, hence the unit cost is lower and the firm faces higher demand. On the other hand, using more imports implies an increasing importing cost.

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

[20] There is a unique b^* if the second order condition is negative. See the Theoretical Appendix for the parameter restriction required.

[21]$C_1 = \alpha D \left(\frac{\rho-1}{\rho}\right)^{\rho} C^{1-\rho}$.

3.3 Imported Input Switching

Firms are born in period 1. At period 2, an importer decide if they want to pay a searching cost F_s to search for new foreign input suppliers If he does, he also decides the search intensity $n' - n$, subject to the convex cost

$$\Phi\left(n, n'\right) = \frac{\phi}{\gamma}\left(n' - n\right)^{\gamma}, \tag{3}$$

and gets new draws for each imported input from the $n' - n$ measure of new suppliers. Then the firm chooses from whom to source each input: either continue with their current supplier or switch to a more productive supplier. In this process, some inputs will be added: those that had low productivity before the search but now have high-enough productivity. Other things equal, this will increase the mass if imported inputs, which increases the cost of importing them. As a consequence some inputs will be dropped: those that the firm was using but now fall below the productivity cut-off.

In general, with a measure n of suppliers the productivity CDF for a given imported input is,

$$F_n\left(b\right) = Prob[\max_n \tilde{b} < b]. \tag{4}$$

We assume $F\left(b\right)$, the suppliers' productivity distribution for each input is a Frechet distribution, $F\left(b\right) = \exp\left(-T\left(b-1\right)^{-\theta}\right)$, which gives us closed-form solutions[22] for F_n. The maximum productivity of two draws for an input has a Frechet distribution with parameter $2T$. Letting n denote the measure of suppliers a firm has met, the distribution of the productivity of inputs is $F_n\left(b\right)$ with parameter nT.

Having spelled out the environment, we now turn to firms' dynamic decisions. They have two options: either paying the fixed cost of searching for new suppliers, F_s or not searching. The Bellman equation of a firm with productivity A is,

$$V\left(n, A\right) = \max\left\{V^s\left(n, A\right), V^d\left(n, A\right)\right\}.$$

If the firm searches, it also chooses an optimal search intensity $n' - n$, and the value function for searching, V^s, is

[22] The model can be simulated for more general distributional assumptions.

$$V^s(n,A) = \max_{n'} \{\pi(n',A) - F_s - \Phi(n,n') + \beta V(n',A)\}.$$

If the firm doesn't search, the value function is

$$V^d(n,A) = \pi(n,A) + \beta V(n,A).$$

The firm pays to search for new draws when $V^s(n,A) > V^d(n,A)$ occurs, which rearranging in terms of gains from switching versus the cost of switching becomes

$$\pi(n',A) - \pi(n,A) + \beta V(n',A) - \beta V(n,A) > F_s + \Phi(n,n').$$

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

The optimal decision rules for the firm's problem are: The firm's binary decision of searching or not; the optimal searching intensity conditional on searching; the imported input usage conditional on the firm's measure of suppliers. Summarizing, a firm with productivity A and supplier measure n, uses inputs that have productivity larger than a cutoff b_n^* that satisfies,

$$C_1 A^{\rho-1} G(b_n^*)^{\alpha(\rho-1)} \ln B_n^* = \eta m(b_n^*)^{\eta-1} F, \tag{5}$$

Conditional on searching, the search intensity satisfies:

$$\frac{d\pi(n',A)}{dn'} = \phi(n'-n)^{\gamma-1} - \beta\phi(n''-n')^{\gamma-1} \tag{6}$$

Searching for new draws occurs if $A > \bar{A}(n)$, where $\bar{A}(n)$ satisfies:

$$V^s\left(n,\bar{A}(n)\right) = V^d\left(n,\bar{A}(n)\right). \tag{7}$$

Note that given parameters $\left(\alpha, C, \rho, \sigma, \eta, \gamma, F, F_s, \frac{p_H}{p_F}, T, \theta\right)$, for each firm A, we can solve the optimal imports cutoff b_n^*, and the decision rule for the firm to search or not, and if it does search, the search intensity at every t.

In our model, there are increasing costs to searching for marginal suppliers, which generates a slow accumulation of suppliers. Meanwhile, the benefit from searching becomes smaller over time because it is harder and harder to find more productive suppliers for a given input. As a result, older firm search less intensively. We formally show these results in the next section.

3.4 Propositions

In this section we state the main propositions derived 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 *More productive firms use more imported inputs, conditional on age.*

Proof. See Theoretical Appendix in Section 6.1.2.

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

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 optimality 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. We only need to prove that, when increasing their measure of suppliers, firms will add and drop varieties simultaneously. $\frac{db^*}{dn} > 0$, i.e., searching new suppliers increases the measure of known suppliers, and raises the cutoff, hence some original inputs should be dropped. However, the measure of imported inputs increases, as $\frac{dm(b^*)}{dn} > 0$ [23]. So if firms pay the search cost, they add and drop imported inputs simultaneously. Searching allows the firm to access a better input distribution. For some previously not imported inputs, a more productive new

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

supplier will be found, and the firm will add them. For a large enough increase in the convex cost, firms will optimally drop some of the least productive inputs they were previously importing. ■

We have determined that firms add and drop inputs simultaneously, conditional on choosing to readjust their production. Which 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.*

Proof. See Theoretical Appendix in Section 6.1.4. 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. The decreasing return to scale of searching and the convex searching cost makes older firms search less intensively, hence they add and drop a smaller fraction of their imported inputs. 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. $\frac{d\frac{d\pi}{dn}}{dA} > 0$, 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. In the Appendix, we show that the overall gain from searching is also larger for more productive firms. 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. Put it differently, since firm productivity A is complementary to productivity gains coming from imported inputs, high A firms search and reorganize (for a longer time). ■

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 imported inputs firms use and switching behavior are affected by devaluations. We first show that, in our model, it is still true that net imports falls in devaluations.

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

Proof. See Theoretical Appendix in Section 6.1.8. $\frac{db^*}{dp_F} > 0$, then when foreign inputs price increases, the productivity cutoff increases, firms use less imported inputs. In a nutshell, when imports become more expensive, firms import less. ■

Finally, on the next two propositions, we show that the number of firms that add and drop decreases in devaluations and that, for those firms that switch, they do it less intensely and it is a smaller share of their inputs.

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 $\frac{d\left(\frac{d\pi}{dn}\right)}{dp_F} < 0$, 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. ■

Proposition 8 *In a devaluation firms that switch would add and drop a smaller share of their imported inputs.*

Proof. See Theoretical Appendix in Section 6.1.9. Firms reduce the search intensity because the benefit from searching decreases when the currency devaluates. ■

4 Evidence On Firm Import Switching Behavior

4.1 Imported Input Switching

In this section, we use firm-level data to provide further evidence on firms' imported input switching behavior that is consistent with the model predictions. More precisely, we show regressions that are associated with the propositions in Section 3. All of the results in this section are robust to an export switching dummy[24], exporter dummy and export value share in total sales; And also to partial year effects as in Bernard et al. (2014), who emphasize that the time of the year in which firms start trading influences growth estimates of new entrants. 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[25].

We start our empirical analysis section focusing on results that relate firms' import behavior to their sales, a proxy for productivity, and the RER. Results shown in Table 1 are obtained from running,

$$Imports_{it} = \alpha + \gamma_i + \beta_1 RER_t + \beta_2 Sales_{it-1} + \omega_{it}$$

where $Imports_{it}$ can be either import value or number of different imported inputs by firm i at time t. Unless otherwise specified all variables are in logs in this section. Two results are worth highlighting in this table. First, that as a firm becomes larger, it imports more (Proposition 1). Second, that both import value and the number of varieties imported fall when the RER goes down, Proposition 6. Both results essentially confirm abundant previous work of other authors.

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

[25] This makes age, the proxy for the known supplier mass, drop in some specifications.

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 1: Value and number of imported inputs and RER.

We now turn to predictions related to the most specific mechanisms in our model. In the next two tables we start with the dynamic implications of the model which deal with Proposition 3. In our model, 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. Both tables share the structure of the independent variables and are obtained by running

$$Imports_{it} = \alpha_t + \gamma_i + \beta_1 Age_{it} + \beta_2 Age_{it}^2 + \beta_3 Sales_{it-1} + \varepsilon_{it}$$

where $Imports_{it}$ is, depending on the table, either imported inputs or switching intensity by firm i at time t and age_{it} is the number of years firm i has been importing inputs. Table 2 has as dependent variable the number of imported inputs, and shows that results are in line with the prediction of the model: the coefficient on age is positive and older firms increase their 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 2: Number of products and age.

On the next table we show another dynamic feature shown in Proposition 3: over time, it is increasingly difficult to find better foreign suppliers for inputs. As firms have spent more time searching, the switching value becomes smaller. This is confirmed in Table 3 where age has a negative effect on switching measures. Further, since older firms are larger, this also emphasizes that our results are not driven by firms with more inputs adding and dropping more[26].

[26] At this point it is worth highlighting that at least three pieces of evidence in our empirical results 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. Third, input drop probability is negatively related to firm size.

VARIABLES	(1) Add and Drop Value	(2) Add and Drop Value Share	(3) Add and Drop Number	(4) 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 3: Switching over time.

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,

$$DummyAddandDrop_{it} = \gamma_i + \beta_1 Sales_{it-1} + \beta_2 RER_t + \varepsilon_{it}$$

where $DummyAddandDrop_{it}$ is a dummy that takes a value of one if firm i adds and drops imports simultaneously between $t-1$ and t, and zero otherwise. Results in Table 4 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 it as firms reducing their reorganizing activities as a consequence of import prices going up.

	(1)
VARIABLES	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 4: Import Switching LPM and RER.

The model also has predictions at the input-firm level, see Proposition 5. 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,

$$DummyInputDrop_{i,j,t} = \alpha_t + \gamma_i + \beta_1 ImportedInputSize_{i,j,t-1} + \beta_2 Sales_{i,t-1} + \varepsilon_{i,j,t}$$

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. We show the robustness of this result by running several specifications. Table 5 shows the results, which are in accordance with the theory: a larger import value for an intermediate is associated with a lower dropping likelihood[27].

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 5: Imported Input Dropping Relation to it's Productivity.

We now turn to the final set of results, those in Proposition 4. It is one of the most unique predictions of our model 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. To motivate the regressions we run, take the expression for sales from our model, as a function of the marginal cost, $Sales_t = k\left(\lambda(b_t)\right)^{1-\rho}$ where k is an uninteresting constant. Taking the log of the ratio of sales between two consecutive periods, we obtain

$$Log(Sales_t) - Log(Sales_{t-1}) = (1-\rho)Log\left(\frac{\lambda(b_t)}{\lambda(b_{t-1})}\right) \tag{8}$$

Equation 8 shows that the change in log sales is related to the change in the marginal

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

cost of the firm which is a function of the optimal switching activity of firms. In particular, the optimal policy of a firm depends on it's state variables A and n, which we proxy by lagged sales, and age in the import market, and on the aggregate state, say the RER. Accordingly, we start by running sales changes on switching using OLS but afterwards use these arguments to motivate an instrument. We run,

$$Sales_{it} - Sales_{it-1} = \alpha_t + \gamma_i + \beta_1 InputSwitch_{it-1} + \beta_2 Sales_{it-1} + \beta_3 Age_{it-1} + \varepsilon_{it}$$

where $InputSwitch_{it}$ can be either the gross change in value(numbers) or a switching dummy, between $t-1$ and t.

VARIABLES	(1) Sales Change	(2) Sales Change	(3) Sales Change
Lagged Sales	-1.071***	-1.078***	-1.078***
	(-67.18)	(-67.18)	(-67.21)
Add and Drop Value	0.00581***		
	(3.529)		
Add and Drop Number		0.0353***	
		(3.816)	
Add and Drop			0.0278***
			(5.274)
Constant	-0.00581***	-0.00580***	-0.00565***
	(-2.688)	(-2.682)	(-2.617)
Observations	27,778	27,778	32,490
R-squared	0.509	0.510	0.505
Number of Firms	4,208	4,208	4,594
First Diff	Yes	Yes	Yes

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

Table 6: Productivity Growth And Gross Import Change.

In Table 6 we obtain results consistent with the prediction. 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 and hence switching more. More generally, it could be the result of a spurious correlation between growth and switching, so in order to deal with reverse causality, 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, we run

$$\begin{aligned} &1^{st}Stage\text{: } InputSwitch_{it} = \alpha_1 + \gamma_i + \delta_1 RER_t + \delta_2 Sales_{it-1} + \delta_3 Age_{it-1} + \omega_{it} \\ &2^{nd}Stage\text{: } Sales_{it} - Sales_{it-1} = \alpha_2 + \gamma_i + \beta_1 InputSwitch_{it-1} + \beta_2 Sales_{it-1} + \beta_3 Age_{it-1} + \varepsilon_{it} \end{aligned} \tag{9}$$

The IV results are reported in Table 7. On the first stage, we confirm that both the import switching dummy and gross switching comove positively with the RER, so our instrument is valid[28]. On the second stage, both the switching dummy and the gross switching measures are positively associated with changes in sales.

[28] Since we run dynamic panel regressions using First Differences, Age is dropped.

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	1.234***		0.483***		0.137***	
	(5.12)		(4.40)		(4.90)	
Add and Drop Value		0.156***				
		(4.400)				
Add and Drop Number				0.399***		
				(3.927)		
Add and Drop Dummy						1.403***
						(4.283)
Lagged Sales	0.279***	-1.124***	0.157***	-1.128***	0.0542***	-1.155***
	(4.80)	(-51.55)	(4.53)	(-47.69)	(6.66)	(-42.29)
Constant	-0.0111*	-0.00217	-0.0849**	-0.000609	-0.00946***	0.00470
	(-1.89)	(-0.530)	(-2.01)	(-0.130)	(-3.63)	(0.976)
Observations	27,778	27,778	27,778	27,778	32,490	32,490
Number of Firms	4,208	4,208	4,208	4,208	4,600	4,600
First Differences	Yes	Yes	Yes	Yes	Yes	Yes

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

Table 7: Productivity Growth, Gross Import Change and RER.

Finally, we address the two main concerns raised by our IV results. 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) and Timoshenko (2015). 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 7 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, a devaluation of the Peso 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[29], in regression 9 we further include an industry absorption measure[30] and the number of importing firms in each industry[31]. Results are reported in Table 8 and are in line with our baseline regression[32]. Finally, in unreported results, when we further control for the 1999 crisis by adding a dummy for those observations results do not change.

[29] 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.

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

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

[32] 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	1.135***		0.467***		0.137***	
	(4.71)		(4.11)		(4.50)	
Add and Drop Value		0.102***				
		(3.056)				
Add and Drop Number				0.248***		
				(2.877)		
Add and Drop Dummy						0.836***
						(3.000)
Lagged Sales	0.282***	-1.094***	0.158***	-1.103***	0.0553***	-1.118***
	(5.06)	(-54.49)	(4.80)	(-52.23)	(6.70)	(-46.42)
Industry Importers	-0.182	-0.0904***	-0.0163	-0.0720***	-0.0210	-0.0628***
	(-0.34)	(-3.361)	(-0.22)	(-3.193)	(-1.04)	(-2.862)
Industry Absorption	0.108	0.091***	0.0254	0.0961***	0.0145	0.0915***
	(0.65)	(5.128)	(0.46)	(5.042)	(1.08)	(4.715)
Observations	27,447	27,447	27,447	27,447	32,071	32,071
Number of Firms	4,173	4,173	4,173	4,173	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 8: Productivity Growth, Gross Import Change and RER. Extra Controls.

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. We view our paper as complementary to those that emphasize capital accumulation and worker reallocation to be important for firm dynamics and aggregate productivity. Considering the accumulation of supplier contact is one type of organizational capital, we show that the capital adjustment cost affects the life-cycle dynamics of plants as in Hsieh and Klenow (2014). Furthermore, we shed light on this accumulation process by showing how input switching relates to firm and input characteristics. In fact, the cross-section and over time patterns of switching of foreign inputs has similar features to the turnover of another crucial input of firms, namely workers, see Davis et al. (2012) and Shimer (2012). Analogously, we emphasize that imported input accumulation is a costly activity and takes time, and the efficient use of inputs involves reallocation, as in Pries and Rogerson (2005) occurs for workers. Our proposed mechanism has the potential to be a relevant determinant of aggregate productivity growth because aggregate reallocation value as share of imports is similar to the worker reallocation employment shares.

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. Our framework not only explains firm dynamics but 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 model focuses on explaining why firms constantly switch imported inputs, and how it is related to firm age profile and the imports price. Extending the model to allow for differential searching intensity across countries would reveal further interesting dynamic relations of importers and their suppliers. We focus on importers because of the detailed data it allows us to use but, having domestic buyer-supplier linked data, it would be particularly relevant to allow for firms to simultaneously search in domestic and foreign markets.

6 Online Appendix

6.1 Theoretical appendix

6.1.1 Firms' Problem

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

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

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

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

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:

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

and firm's unit cost is

$$\lambda = \frac{1}{A} \left(\frac{w}{1-\alpha} \right)^{1-\alpha} \left(\frac{p_H \exp \int_{b^*}^{\infty} \ln \left[1 + \left(\frac{b p_H}{p_F} \right)^{\sigma-1} \right]^{\frac{1}{1-\sigma}} dF(b)}{\alpha} \right)^{\alpha}$$

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

to obtain unit cost as

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

Firm's total cost is then:

$$\lambda Y + m^\eta F,$$

and firm maximizes net profits:

$$\max_{Y,b^*} \left(\frac{Y}{D}\right)^{-\frac{1}{\rho}} Y - \lambda\left(b^*\right) Y - m(b^*)^\eta F, \tag{10}$$

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

The two first order conditions are

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

and

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

This last condition can be written as

$$-\frac{d\lambda}{db} Y - \eta m^{\eta-1} f(b^*) F = -Y \frac{C}{A}(-\alpha) G(b^*)^{-\alpha-1} G'(b^*) + \eta m^{\eta-1} f(b^*) F = 0$$

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

Using a more compact form, the marginal input satisfies:

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

and using the FOC for Y becomes (2) in the main text:

$$\alpha D \left(\frac{\rho - 1}{\rho}\right)^{\rho} \left(\frac{C}{A}\right)^{1-\rho} G(b^*)^{\alpha(\rho-1)} \ln B^* = \eta m(b^*)^{\eta-1} F. \tag{11}$$

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

$$\alpha D\left(\frac{\rho-1}{\rho}\right)^{\rho}\left(\frac{C}{A}\right)^{1-\rho}G(b^{*})^{\alpha(\rho-1)}\ln B^{*}-\eta m(b^{*})^{\eta-1}F \tag{12}$$

To check the property of the optimal b^* we differentiate (12). Also note that the second order condition is -$\frac{d(12)f(b^*)}{db}$, which is negative as long as

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

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

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

The profit is

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

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

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

which using (11) can be written as

$$\pi=\frac{1}{\rho-1}\frac{\eta m(b^{*})^{\eta-1}F}{\alpha\ln B^{*}}-m(b^{*})^{\eta}F=m(b^{*})^{\eta-1}F\left(\frac{1}{\rho-1}\frac{\eta}{\alpha\ln B^{*}}-m(b^{*})\right). \tag{13}$$

This is another key equation in our proofs. The effects of A, n, and p_F on profits are through the optimal choice of imported inputs.

6.1.2 Proof of Proposition 1

Proof. From equation (12), $\frac{d(12)}{db^*}>0$ and $\frac{d(12)}{dA}>0$. So $\frac{db^*}{dA}=-\frac{\frac{d(12)}{dA}}{\frac{d(12)}{db^*}}<0$.

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

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 and increase their suppliers, they will drop some varieties.

   Proof. From equation (12), $\frac{d(12)}{db^*} > 0$, because $SOC = -\frac{d(12)f(b)}{db} = -\frac{d(12)}{db}f(b) < 0$. And

$$\begin{aligned}\frac{d(12)}{dn} = \alpha D\left(\frac{\rho-1}{\rho}\right)^{\rho}\left(\frac{C}{A}\right)^{1-\rho}\ln B^*\alpha(\rho-1)G(b^*)^{\alpha(\rho-1)-1}\frac{dG(b^*)}{dn}-\\ \cdots\eta(\eta-1)m(b^*)^{\eta-2}F\frac{dm(b^*)}{dn} =\\ \alpha D\left(\frac{\rho-1}{\rho}\right)^{\rho}\left(\frac{C}{A}\right)^{1-\rho}\ln B^*\alpha(\rho-1)G(b^*)^{\alpha(\rho-1)}\alpha\int_{b^*}\ln B\frac{df\,(b)}{dn}db-\\ \cdots\eta(\eta-1)m(b^*)^{\eta-2}F\int_{b^*}\frac{df\,(b)}{dn}db\end{aligned} \tag{14}$$

   Looking at the second term we notice that using more inputs, improves productivity but increases marginal costs as well. $\frac{d(12)}{dn}$ can be positive or negative. If η big enough, it is negative. Since $\frac{db^*}{dn} = -\frac{\frac{d(12)}{dn}}{\frac{d(12)}{db^*}} > 0$, searching new suppliers increases cutoff. Some original inputs should be dropped.

2. If firms search new inputs and increase their suppliers, they will add some vari-

eties.

$$\frac{dm(b^*)}{dn} = -f(b^*)\frac{db^*}{dn} + \int_{b^*}^{\infty} \frac{df(b)}{dn} db = -f(b^*)\left[-\frac{\frac{d(12)}{dn}}{\frac{d(12)}{db^*}}\right] + \int_{b^*}^{\infty} \frac{df(b)}{dn} db =$$

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

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

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

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

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

6.1.4 Proof of Proposition 3

1. 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 of our search process. First note that from Section 6.1.5 we have,

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

Also note that since

$$\begin{aligned}\frac{d^2\pi}{dn^2} &= \frac{\partial\left(\frac{d\pi}{dn}\right)}{\partial b^*}\frac{db^*}{dn} + \frac{\partial\left(\frac{d\pi}{dn}\right)}{\partial n} = \\ &= \frac{db^*}{dn}\left[\eta(\eta-1)m(b^*)^{\eta-2}m'(b^*)F\int_{b^*}\left(\frac{\ln B}{\ln B^*}-1\right)\frac{df\left(b\right)}{dn}db\cdots\right. \\ &+ \eta m(b^*)^{\eta-1}F(-1)\int_{b^*}\left(\frac{\ln B^*}{\ln B^*}-1\right)\frac{df\left(b\right)}{dn}db\cdots \\ &\left.+\ \eta m(b^*)^{\eta-1}F\int_{b^*}\left((-1)\frac{\ln B\frac{1}{B^*}}{(\ln B^*)^2}-1\right)\frac{df\left(b\right)}{dn}db\right]\cdots \\ &+ \eta m(b^*)^{\eta-1}F\int_{b^*}\left(\frac{\ln B}{\ln B^*}-1\right)\frac{d^2f\left(b\right)}{dn^2}db\end{aligned} \tag{15}$$

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

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

which is positive for large b and so

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

Using these last two results, equation (15) 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 number of suppliers.

2. Older firms that have more suppliers have a lower search intensity.

When a firm search, the search intensity satisfies:

$$\frac{d\pi\left(n', A\right)}{dn'} = \phi\left(n'-n\right)^{\gamma-1} - \beta\phi\left(n''-n'\right)^{\gamma-1} \tag{16}$$

We have proved that the left hand side is decreasing with n'. The right hand side increases with n', hence the equation pins down the optimal searching intensity. Older firms have a larger n as they accumulate suppliers over time, which shift the RHS down, and older firms have a lower search intensity $n' - n$.

The decreasing return to scale of searching and the convex searching cost make older firms search less intensively, hence they add and drop a smaller fraction of their imported inputs. ■

6.1.5 Proof of Proposition 4

1. A larger measure of input suppliers increases profits.

   Proof.

$$\frac{d\pi}{dn} = \frac{\partial\pi}{\partial b^*}\frac{\partial b^*}{\partial n} + \frac{\partial\pi}{\partial n} = \left.\frac{\partial\pi}{\partial n}\right|_{b_n^*} =$$
$$\alpha D\left(\frac{\rho-1}{\rho}\right)^{\rho}\left(\frac{C}{A}\right)^{1-\rho} G(b^*)^{\alpha(\rho-1)-1}\frac{dG(b^*)}{dn} - \eta m(b^*)^{\eta-1}F\frac{dm(b^*)}{dn} =$$
$$\alpha D\left(\frac{\rho-1}{\rho}\right)^{\rho}\left(\frac{C}{A}\right)^{1-\rho} G(b^*)^{\alpha(\rho-1)}\int_{b^*}\ln B\frac{df\left(b\right)}{dn}db - \eta m(b^*)^{\eta-1}F\int_{b^*}\frac{df\left(b\right)}{dn}db =$$
$$\frac{\eta m(b^*)^{\eta-1}F}{\ln B^*}\int_{b^*}\ln B\frac{df\left(b\right)}{dn}db - \eta m(b^*)^{\eta-1}F\int_{b^*}\frac{df\left(b\right)}{dn}db =$$
$$\eta m(b^*)^{\eta-1}F\int_{b^*}\left(\frac{\ln B}{\ln B^*}-1\right)\frac{df\left(b\right)}{dn}db > 0$$

   where the 3rd equality uses Equation (13), and the 5th uses Equation (11).

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

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

   Now, take derivatives wrt A,

$$\frac{d\frac{d\pi}{dn}}{dA} = \alpha D\left(\frac{\rho-1}{\rho}\right)^{\rho}(\rho-1)A^{\rho-2}C^{1-\rho}G(b^*)^{\alpha(\rho-1)}\int_{b^*}\ln B\frac{df\left(b\right)}{dn}db +$$
$$\frac{db^*}{dA}\Bigg(-\eta(\eta-1)m^{\eta-2}f(b_n^*)F\cdots$$
$$-\eta m^{\eta-1}F\left(\int_{b_n^*}\ln B\frac{df_n\left(b\right)}{dn}db\right)\frac{\left(\frac{p_H}{p_F}\right)^{\sigma-1}b_n^{*\sigma-2}}{(\ln B_n^*)^2\left[1+\left(b_n^*\frac{p_H}{p_F}\right)^{\sigma-1}\right]}\Bigg) > 0$$

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 options: either paying the fixed searching cost to search for new bunch of suppliers, or not searching. The Bellman equation of a firm with productivity A and measure of suppliers n is the maximum between the value of searching and not searching,

$$V(n, A) = \max \left\{ V^s(n, A), V^d(n, A) \right\}.$$

Conditional on searching, a firm can choose an optimal search intensity $n' - n$, and the value function is

$$V^s(n, A) = \max_{n'} \left\{ \pi(n', A) - F_s - \Phi(n, n') + \beta V(n', A) \right\}.$$

Instead, if the firm doesn't search,

$$V^d(n, A) = \pi(n, A) + \beta V(n, A).$$

The firm would pay to search for new draws if

$$\pi(n', A) - \pi(n, A) + \beta V(n', A) - \beta V(n, A) > F_s + \Phi(n, n'). \tag{17}$$

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 $\bar{n}(A)$ when a firm with productivity A optimally stops searching. So the value function is

$$V(n, A) = \begin{cases} \pi(n', A) - F_s - \Phi(n, n') + \beta V(n', A), & \text{if } n < \bar{n}. \\ \frac{\pi(\bar{n}, A)}{1-\beta}, & \text{if } n > \bar{n}. \end{cases} \tag{18}$$

From this result then, if $\pi(n, A)$ increases with A then $V(n, A)$ also increases with A.

The overall gain from searching can be thought of as a sum of change of profits flows. Hence, if $\pi(n', A) - \pi(n, A)$ increases with A, the overall gain from searching is larger for more productive firms. In fact, in proposition 4, we show that searching has such property. Therefore, for every n, 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 12, $\frac{d(12)}{db^*} > 0$,. We also have

$$\frac{d(12)}{dp_F} = \alpha D \left(\frac{\rho-1}{\rho}\right)^{\rho} \left(\frac{C}{A}\right)^{1-\rho} G(b^*)^{\alpha(\rho-1)} \cdots$$
$$\left(-\frac{(b^* p_H)^{\sigma-1} p_F^{-\sigma}}{1+\left(b^* \frac{p_H}{p_F}\right)^{\sigma-1}} - \ln B^* \alpha(\rho-1) \int_{b^*} \frac{(b^* p_H)^{\sigma-1} p_F^{-\sigma}}{1+\left(b^* \frac{p_H}{p_F}\right)^{\sigma-1}} f(b)\, db \right) < 0$$

Since $\frac{db^*}{dp_F} = -\frac{\frac{d(12)}{dp_F}}{\frac{d(12)}{db^*}} > 0$, then when p_F increases, the productivity cutoff increases, firms use less imported inputs: $m(b^*)$ falls. ■

6.1.9 Proof of Proposition 7 and Proposition 8

Proof. Equation (17) states the condition under which firms search for new draws. First we show the marginal profit of a larger measure of suppliers is smaller during devaluation.

$$\frac{d\left(\frac{d\pi}{dn}\right)}{dp_F} = \frac{d\left(\eta m(b^*)^{\eta-1} F \int_{b^*} \left(\frac{\ln B}{\ln B^*} - 1\right) \frac{df(b)}{dn} db\right)}{dp_F} =$$
$$\frac{d\eta m(b^*)^{\eta-1} F \int_{b^*} \left(\frac{\ln B}{\ln B^*} - 1\right) \frac{df(b)}{dn} db}{db^*} \frac{db^*}{dp_F} =$$
$$\left(-\eta(\eta-1) m^{\eta-2} f(b^*) F - \eta m^{\eta-1} F \left(\int_{b^*} \ln B \frac{df(b)}{dn} db \right) \frac{\left(\frac{p_H}{p_F}\right)^{\sigma-1} b^{*\sigma-2}}{(\ln B^*)^2 \left[1+\left(b^* \frac{p_H}{p_F}\right)^{\sigma-1}\right]} \right) \frac{db^*}{dp_F} < 0,$$

because $\frac{db_n^*}{dp_F} > 0$. The marginal profit from more suppliers is lower when the currency devaluates as imports have become more expensive. From Equation (6), firms' search intensity decreases. Combining the two forces, the overall gains from searching decreases. Accordingly, fewer firms would pay the searching cost, and for firms that do pay the searching cost, they search less intensively. ■

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

References

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

G. Alessandria, H. Choi, and K. J. Ruhl. Trade adjustment dynamics and the welfare gains from trade. 2014. 4

M. Amiti and J. Konings. Trade liberalization, intermediate inputs, and productivity: Evidence from indonesia. *American Economic Review*, 97(5):1611–1638, 2007. 2, 4, 32

C. Arkolakis, T. Papageorgiou, and O. Timoshenko. Firm learning and growth. 2014. 4

A. B. Bernard, S. Redding, and P. K. Schott. Multiple-product firms and product switching. *American Economic Review*, 100(1):70–97, 2010. 4, 29

A. B. Bernard, R. Massari, J.-D. Reyes, and D. Taglioni. Exporter dynamics, firm size and growth, and partial year effects. Working Paper 19865, National Bureau of Economic Research, January 2014. URL http://www.nber.org/papers/w19865. 4, 21

V. M. Carvalho and N. Voigtländer. Input diffusion and the evolution of production networks. Working Paper 20025, National Bureau of Economic Research, 2014. URL http://www.nber.org/papers/w20025. 4

T. Covert. Experiential and Social Learning in Firms: The Case of Hydraulic Fracturing in the Bakken Shale. *Harvard Thesis*, May 2014. 4

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

S. J. Davis, R. J. Faberman, and J. Haltiwanger. Labor market flows in the cross section and over time. *Journal of Monetary Economics*, 2012. 5, 9, 32

J. Eaton, M. Eslava, D. Jinkins, C. Krizan, and J. Tybout. A search and learning model of export dynamics. 2014. 4

D. Fitzgerald, S. Haller, and Y. Yedid-Levi. How exporters grow. 2015. 4

L. Foster, J. Haltiwanger, and C. Syverson. Reallocation, Firm Turnover, and Efficiency: Selection on Productivity or Profitability? *American Economic Review*, 98(1):394–425, Feb. 2008. 4

P. K. Goldberg, A. K. Khandelwal, N. Pavcnik, and P. Topalova. Imported intermediate inputs and domestic product growth: Evidence from india. *The Quarterly Journal of Economics*, 2010. 2, 4

G. Gopinath and B. Neiman. Trade adjustment and productivity in large crises. *American Economic Review, R&R*, 2011. 2, 4, 12

L. Halpern, M. Koren, and A. Szeidl. Imported inputs and productivity. *American Economic Review, R&R*, 2011. 2, 4, 12

C.-T. Hsieh and P. J. Klenow. The Life Cycle of Plants in India and Mexico. *The Quarterly Journal of Economics*, 129(3):1035–1084, May 2014. 4, 32

M. Pries and R. Rogerson. Hiring policies, labor market instituitions, and labor market flows. *Journal of Political Economy*, 2005. 5, 32

K. J. Ruhl and J. L. Willis. New exporter dynamics. 2014. 4

R. Shimer. Reassessing the ins and outs of unemployment. *Review of Economic Dynamics*, 15(2):127–148, 2012. 5, 32

Timoshenko. Product switching in a model of learning. *Journal of International Economics*, 95:233–249, 2015. 29