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Importers, Exporters, and Exchange Rate Disconnect†

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Large exporters are simultaneously large importers. We show that this pattern is key to understanding low aggregate exchange rate pass-through as well as the variation in pass-through across exporters. We develop a theoretical framework with variable markups and imported inputs, which predicts that firms with high import shares and high market shares have low exchange rate pass-through. We test and quantify the theoretical mechanism using Belgian firm-product-level data on imports and exports. Small nonimporting firms have nearly complete pass-through, while large import-intensive exporters have pass-through around 50 percent, with the marginal cost and markup channels contributing roughly equally. (*JEL* D24, F14, F31, L60)

One of the central puzzles in international macroeconomics is why large movements in exchange rates have small effects on the prices of internationally traded goods. This exchange rate disconnect has generated a vast literature, yet no empirical pass-through study has taken into account one of the most salient features of international trade, that is, that the largest exporters are simultaneously the largest importers. In this paper, we show that this pattern is key to understanding the low aggregate pass-through, as well as the variation in pass-through across firms.

Using detailed Belgian micro data, we find that more import-intensive exporters have significantly lower exchange rate pass-through into their export prices, as they face offsetting exchange rate effects on their marginal costs. These data reveal that the distribution of import intensity among exporters is highly skewed, with the import-intensive firms being among the largest exporters, accounting for a major share of international trade. Consequently, the import-intensive firms also have high export market shares and hence set high markups and actively move them in response to changes in marginal cost, providing a second channel that limits the

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effect of exchange rate shocks on export prices. These two mechanisms reinforce each other and act to introduce a buffer between local costs and international prices of the major exporters, thus playing a central role in limiting the transmission of exchange rate shocks across countries. The availability of firm-level data with imports by source country and exports by destination, combined with domestic cost data, enables us to estimate the magnitude of these two channels.

To guide our empirical strategy, we develop a theoretical framework to study the forces that jointly determine a firm's decisions to source its intermediate inputs internationally and to set markups in each of its export destinations. The two building blocks of our theoretical framework are an oligopolistic competition model of variable markups following Atkeson and Burstein (2008) and a model of the firm's choice to import intermediate inputs at a fixed cost following Halpern, Koren, and Szeidl (2011). These two ingredients allow us to capture the key patterns in the data that we focus on, and their interaction generates new insights on the determinants of exchange rate pass-through. In equilibrium, the more productive firms end up having greater market shares and choose to source a larger share of their inputs internationally, which in turn further amplifies the productivity advantage of these firms. The theory further predicts that a firm's import intensity and export market share form a sufficient statistic for its exchange rate pass-through within industry-destination, with import intensity proxying for marginal cost sensitivity to the exchange rate and market shares proxying for markup elasticity.[1]

We test the predictions of the theory with a rich dataset of Belgian exporters for the period 2000–2008. A distinctive feature of these data is that they comprise firm-level imports by source country and exports by destination at the CN 8-digit product codes (close to 10,000 distinct product codes), which we match with firm-level characteristics, such as wages and expenditure on inputs. This allows us to construct an import intensity measure for each firm as the share of imports in total variable costs and a measure of the firm's market share for each export destination, which are the two key firm characteristics in our analysis. Further, with the information on imports by source country, we can separate inputs from euro and non-euro countries, which is an important distinction since imported inputs from within the euro area are in the Belgian firms' currency.

We start our empirical analysis by documenting some new stylized facts related to the distribution of import intensity across firms, lending support to the assumptions and predictions of our theoretical framework. We show that in the already very select group of exporters relative to the overall population of manufacturing firms, there still exists a substantial heterogeneity in the share of imported inputs sourced internationally, in particular from the more distant source countries outside the euro

[1] Note that the relationship between import intensity and marginal cost is very general and does not rely on a particular structural model. In turn, the relationship between market share and markup is not universal, yet it emerges in a class of models commonly used in international macro (see Burstein and Gopinath 2013). The structural micro literature, however, adopts more sophisticated demand systems where markup variability depends not only on market share, but also on prices, product characteristics, and the distribution of consumer characteristics. Our approach provides a simple approximation of the markup, linking it exclusively to the market share of the firm, and while being less general at the level of individual industries, this approach allows us to proceed with estimation across broad sectors and multiple export markets. We find that the variation in the market share alone explains substantial variation in the markup variability across firms.

zone. The import intensity is strongly correlated with firm size and other firm characteristics and is heavily skewed toward the largest exporters.

Our main empirical specification, as suggested by the theory, relates exchange rate pass-through with the firm's import intensity capturing the marginal cost channel and the destination-specific market shares capturing the markup channel. We estimate the cross-sectional relationship between pass-through and its determinants within industries and destinations, holding constant the general equilibrium forces common to all firms.[2] Our methodological contribution is to show that such a relationship holds independently of the general equilibrium environment, thus we do not need to make specific assumptions about the sources of variation in the exchange rate. The exchange rate pass-through coefficients in this relationship can be directly estimated without imposing strong partial equilibrium or exogeneity assumptions. Theory further provides closed-form expressions for these coefficients, which allows us to directly test for the structural mechanism emphasized in the model.[3]

The results provide strong support for the theory. First, we show that import intensity is an important correlate of a firm's exchange rate pass-through, with each additional 10 percentage points of imports in total variable costs reducing pass-through by over 6 percentage points. Second, we show that this effect is due to both the marginal cost channel, which import intensity affects directly, and the markup channel through the selection effect. Finally, when we include market share, which proxies for the markup channel, together with import intensity, we find these two variables jointly to be robust predictors of exchange rate pass-through across different subsamples and specifications, even after controlling for other firm characteristics such as productivity and employment size.

Quantitatively, these results are large. A firm at the fifth percentile of both import intensity and market share (both approximately equal to zero) has a nearly complete pass-through (94 percent and statistically indistinguishable from 100 percent). In contrast, a firm at the ninety-fifth percentile of both import intensity and market share distributions has a pass-through slightly above 50 percent, with import intensity and market share contributing nearly equally to this variation across firms. In other words, while small exporters barely adjust their producer prices and fully pass on the exchange rate movements to foreign consumers, the largest exporters offset almost half of the exchange rate movement by adjusting their prices already at the factory gates. Active markup adjustment by the large firms explains this only in part, and an equally important role is played by the marginal cost channel by means of imported inputs. These results have important implications for aggregate pass-through since the low pass-through firms account for a disproportionately large share of exports.

Related Literature.—Our paper is related to three strands of literature. First, it relates to the recent and growing literature on the interaction of importing and exporting decisions of firms. Earlier work, for example, Bernard, Jensen, and Schott

[2] Such common forces include the correlations of sector-destination-specific price index, sector-specific productivity, and cost index with the exchange rate.

[3] In particular, we show in the data that import-intensive exporters have lower pass-through due to greater sensitivity of their marginal costs to exchange rates. Furthermore, the effect of import intensity on pass-through is larger when the import and export exchange rates are closely correlated and when the pass-through into the import prices is high, confirming the theoretical predictions.

(2009), has documented a large overlap in the import and export activity of firms.[4] Indeed, major exporters are almost always major importers, and this is also true in our dataset. We focus exclusively on the already select group of exporters, most of whom are also importers from multiple source countries. We emphasize the strong selection that still operates within the group of exporters, in particular the heterogeneity in the intensity with which firms import their intermediate inputs and its consequences for export price pass-through.

Second, our paper is related to the recent empirical and structural work on the relationship between firm import intensity and firm productivity. Although we base our model on Halpern, Koren, and Szeidl (2011), who estimate the effects of imports on total factor productivity for Hungarian firms, similar models were developed in Amiti and Davis (2012) to study the effects of import tariffs on firm wages and in Gopinath and Neiman (2014) to study the effects of the Argentine trade collapse following the currency devaluation of 2001 on the economy-wide productivity.[5] In our study, we focus instead on how the interplay between import intensity and markup variability contributes to incomplete exchange rate pass-through.

Third, our paper contributes to the vast literature on the exchange rate disconnect (see Obstfeld and Rogoff 2001; Engel 2001) and in particular on the incomplete pass-through of exchange rate shocks into international prices. In the past decade, substantial progress has been made in the study of this phenomenon, both theoretically and empirically.[6] This literature has explored three channels leading to incomplete pass-through. The first channel, as surveyed in Engel (2003), is short-run nominal rigidities with prices sticky in the local currency of the destination market, labeled in the literature as *local currency pricing* (LCP). Under LCP, the firms that do not adjust prices have zero short-run pass-through. Gopinath and Rigobon (2008) provide direct evidence on the extent of LCP in US import and export prices. The second channel—*pricing-to-market* (PTM)—arises in models of variable markups in which firms optimally choose different prices for different destinations depending on local market conditions. Atkeson and Burstein (2008) provide an example of a recent quantitative investigation of the PTM channel and its implication for international aggregate prices.[7] Finally, the third channel of incomplete pass-through into consumer prices often considered in the literature is local distribution costs, as for example in Burstein, Neves, and Rebelo (2003) and Goldberg and Campa (2010). Our imported inputs channel is similar in spirit to the local distribution costs in that they make the costs of the firm more stable in the local currency of

[4] Other related papers include Kugler and Verhoogen (2009); Manova and Zhang (2009); Feng, Li, and Swenson (2012); and Damijan, Konings, and Polanec (2012).

[5] Blaum, Lelarge, and Peters (2013) document stylized facts about import behavior of French firms and provide another related model. Amiti and Konings (2007) provide an empirical analysis of the micro-level effects of imports on firm productivity.

[6] For a survey of earlier work, see Goldberg and Knetter (1997), who in particular emphasize that "[l]ess is known about the relationship between costs and exchange rates" (see p. 1244). The handbook chapter by Burstein and Gopinath (2013) provides a summary of recent developments in this area.

[7] Gopinath and Itskhoki (2011) show the importance of PTM in matching patterns in the international aggregate and micro price data. Fitzgerald and Haller (2014) provide the most direct evidence on PTM by comparing the exchange rate response of prices of the same item sold to both the domestic and the international market. Gopinath, Itskhoki, and Rigobon (2010) and Gopinath and Itskhoki (2010) show that the PTM and LCP channels of incomplete pass-through interact and reinforce each other, with highly variable-markup firms endogenously choosing to price in local currency as well as adopting longer price durations.

export destination. The difference with the distribution cost channel is that the use of imported inputs results in incomplete pass-through not only into consumer prices, but also into producer factory gate prices.

A related line of literature, surveyed in Goldberg and Hellerstein (2008), has identified the PTM channel by structurally estimating industry demand to back out model-implied markups of the firms. Goldberg and Verboven (2001) apply this methodology in the context of the European car market, while Nakamura and Zerom (2010) and Goldberg and Hellerstein (2013) study the coffee and the beer markets, respectively, incorporating sticky prices into the analysis. Based on the finding that markups do not vary enough to capture the variation in exporter prices arising from exchange rate volatility, these studies conclude there must be a residual role for the marginal cost channel, due to either the local distribution margin or imported inputs. Our paper is the first to directly estimate the importance of the marginal cost channel for incomplete pass-through into exporter prices arising from the use of imported intermediate inputs.

Our work is closely related to Berman, Martin, and Mayer (2012) in that we also study the variation in pass-through across heterogeneous firms. While they focus on the role of firm productivity and size, we emphasize the role of imported inputs and destination-specific market shares.[8] Our approach also enables us to provide a quantitative decomposition of the contribution of the marginal cost and variable markup channels to incomplete exchange rate pass-through.

The rest of the paper is structured as follows. Section I lays out the theoretical framework and provides the theoretical results that motivate the empirical analysis that follows. Section II introduces the dataset and describes the stylized patterns of cross-sectional variation in the data. Section III describes our main empirical findings. Section IV concludes. The technical derivations and additional results are provided in the online Appendix.

I. Theoretical Framework

In this section, we develop a theoretical framework linking a firm's exchange rate pass-through to its import intensity and export market shares, all of which are endogenously determined. We use this framework to formulate testable implications and to derive an equilibrium relationship, which we later estimate in the data. We start by laying out the two main ingredients of our framework—the Atkeson and Burstein (2008) model of strategic complementarities and variable markups and the Halpern, Koren, and Szeidl (2011) model of the firm's choice to import intermediate inputs. We then show how the interaction of these two mechanisms generates new theoretical insights on the determinants of exchange rate pass-through. The key predictions of this theory are that a firm's import intensity and market shares are positively correlated in the cross section and together constitute a sufficient statistic for the exchange rate pass-through of the firm within sector-export market, with import intensity capturing the marginal cost sensitivity to the exchange rate and market share capturing the markup elasticity.

[8] A number of earlier papers have linked pass-through with the market share of exporters (see Feenstra, Gagnon, and Knetter 1996; Alessandria 2004; Garetto 2012; Auer and Schoenle 2013).

We characterize the equilibrium relationship among market share, import intensity, and pass-through, which holds parametrically independently of the particular general equilibrium environment. The parameter values in this relationship depend on the specifics of the general equilibrium, in particular the equilibrium comovement between aggregate variables such as exchange rates, price levels, and cost indexes. Nonetheless, we need *not* take a stand on the specific general equilibrium assumptions as we directly estimate these parameters using cross-sectional variation between firms within industries and export destinations, without relying on strong partial equilibrium or exchange rate exogeneity assumptions.

To focus our analysis on the relationship between import intensity and pass-through, we make a number of simplifying assumptions. First, we condition our analysis on the subset of exporting firms, and hence we do not model entry, exit, or selection into exporting (as, for example, in Melitz 2003), but rather focus on the import decisions of the firms. Similarly, we do not model the decision to export to multiple destinations, but simply take this information as exogenously given. Furthermore, we assume all firms are single-product. In the empirical section we discuss the implications of relaxing these assumptions.

Second, we assume flexible price setting as in Atkeson and Burstein (2008) and hence do not need to characterize the currency choice (i.e., local versus producer currency pricing). This modeling choice is motivated by the nature of our dataset in which we use unit values as proxies for prices. Empirically, incomplete pass-through is at least in part due to price stickiness in local currency, and in light of this we provide a careful interpretation of our results in Section IIIE.[9]

Last, while the marginal cost channel emphasized in the paper is inherently a mechanism of *real hedging*, in modeling firms' import decisions we abstract from choosing or switching import source countries to better hedge their export exchange rate risk. Empirically, we find that the positive correlation between a firm's destination-specific exchange rate and its import-weighted exchange rate does not vary with the main firm variables that are the focus of our analysis (see Section IIID).[10]

A. *Demand and Markups*

Consider a firm producing a differentiated good i in sector s and supplying it to destination market k in period t. Consumers in each market have a nested CES demand over the varieties of goods, as in Atkeson and Burstein (2008). The elasticity

[9] It is useful to keep in mind that, as shown in Gopinath, Itskhoki, and Rigobon (2010), the flexible-price pass-through forces shape the currency choice of the firms, i.e., firms with a low pass-through conditional on a price change choose to price in local currency, which further reduces the short-run pass-through of these firms. In this paper, we focus on the endogenous determinants of flexible-price (or long-run) pass-through in the cross section of firms, which in the sticky price environment would also contribute to the prevalence of local currency pricing, with the two forces working in the same direction.

[10] Note that, under the assumption of risk neutrality of the firm and in the absence of liquidity constraints (for example, of the type modeled in Froot, Scharfstein, and Stein 1993), financial hedging constitutes only a side bet to the firm and does not affect its import and pricing decisions. Fauceglia, Shingal, and Wermelinger (2012) provide evidence on the role of imported inputs in "natural" hedging of export exchange rate risk by Swiss firms and Martin and Méjean (2012) provide survey evidence on the role of currency hedging in international transactions of firms in the euro zone.

of substitution across the varieties within sectors is ρ, while the elasticity of substitution across sectoral aggregates is η, and we assume $\rho > \eta \geq 1$.

Under these circumstances, a firm i faces the following demand for its product:

$$Q_{k,i} = \xi_{k,i} P_{k,i}^{-\rho} P_k^{\rho-\eta} D_k, \tag{1}$$

where $Q_{k,i}$ is quantity demanded, $\xi_{k,i}$ is a relative preference (quality) parameter of the firm, $P_{k,i}$ is the firm's price, P_k is the sectoral price index, and D_k is the sectoral demand shifter, which the firm takes as given. Index k emphasizes that all these variables are destination specific. For brevity, we drop the additional subscripts s and t for sector and time, since all of our analysis focuses on variation within a given sector.

The sectoral price index is given by $P_k \equiv \left[\sum_i \xi_{k,i} P_{k,i}^{1-\rho}\right]^{1/(1-\rho)}$, where the summation is across all firms in sector s serving market k in time period t, and we normalize $\sum_i \xi_{k,i} = 1$. As a convention, we quote all prices in the local currency of the destination market.

An important characteristic of the firm's competitive position in a market is its market share given by

$$S_{k,i} \equiv \frac{P_{k,i} Q_{k,i}}{\sum_{i'} P_{k,i'} Q_{k,i'}} = \xi_{k,i} \left(\frac{P_{k,i}}{P_k} \right)^{1-\rho} \in [0, 1], \tag{2}$$

where market share is sector-destination-year specific. The effective demand elasticity for the firm is then

$$\sigma_{k,i} \equiv -\frac{d \log Q_{k,i}}{d \log P_{k,i}} = \rho(1 - S_{k,i}) + \eta S_{k,i}, \tag{3}$$

since $\partial \log P_k / \partial \log P_{k,i} = S_{k,i}$. In words, the firm faces a demand elasticity that is a weighted average of the within-sector and the across-sector elasticities of substitution with the weight on the latter equal to the market share of the firm. High-market-share firms exert a stronger impact on the sectoral price index, making their demand less sensitive to their own price.

When firms compete in prices, they set a multiplicative markup $\mathcal{M}_{k,i} \equiv \sigma_{k,i}/(\sigma_{k,i} - 1)$ over their costs. Firms face a demand with elasticity decreasing in the market share, and hence high-market-share firms charge high markups. We now define a measure of the markup elasticity with respect to the price of the firm, *holding constant the sector price index*:[11]

$$\Gamma_{k,i} \equiv -\frac{\partial \log \mathcal{M}_{k,i}}{\partial \log P_{k,i}} = \frac{S_{k,i}}{\left(\frac{\rho}{\rho - \eta} - S_{k,i}\right)\left(1 - \frac{\rho - \eta}{\rho - 1} S_{k,i}\right)} > 0. \tag{4}$$

[11] We focus on this partial measure of markup elasticity because this is the relevant measure in our empirical analysis, where the identification strategy exploits variation within industries across firms that all face the same price index. It should be noted that an alternative measure of markup elasticity, which does not hold the sector price index fixed, in general results in a U-shaped relationship between pass-through and market share (as, for example, in Garetto 2012 and Auer and Schoenle 2013).

A lower price set by the firm leads to an increase in the firm's market share, making optimal a larger markup. Furthermore, the markup elasticity is also increasing in the market share of the firm: firms with larger markups choose to adjust them by more in response to shocks and to keep their prices and quantities more stable. We summarize this discussion in Proposition 1.

PROPOSITION 1: *The market share of a firm, $S_{k,i}$, is a sufficient statistic for its markup; both markup $\mathcal{M}_{k,i}$ and markup elasticity $\Gamma_{k,i}$ are increasing in the market share of the firm.*

This theoretical framework has two sharp predictions about the markup. First, the variation in the market share fully characterizes the variation in the markup elasticity across firms. As we discuss in the introduction, this is less than general, and alternative demand structures emphasize other determinants of markup variability. Nonetheless, our empirical analysis shows that this prediction provides a useful approximation across broad sectors and multiple export destinations. Second, markup variability is monotonically increasing in the market share. Although this prediction is also model specific, our empirical analysis provides support for this monotonic relationship (see Section IIIC).

B. *Production and Imported Inputs*

We build on Halpern, Koren, and Szeidl (2011) to model the cost structure of the firm and its choice to import intermediate inputs. Consider a firm i, which uses labor L_i and intermediate inputs X_i to produce its output Y_i according to the production function:

$$Y_i = \Omega_i X_i^{\phi} L_i^{1-\phi}, \tag{5}$$

where Ω_i is firm productivity. Parameter $\phi \in [0, 1]$ measures the share of intermediate inputs in firm expenditure and is sector specific but common to all firms in the sector.

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

$$X_i = \exp\left\{\int_0^1 \gamma_j \log X_{i,j}\, dj\right\}. \tag{6}$$

The types of intermediate inputs vary in their importance in the production process as measured by γ_j, which satisfy $\int_0^1 \gamma_j\, dj = 1$. Each type j of intermediate good comes in two varieties—domestic and foreign—which are imperfect substitutes:

$$X_{i,j} = \left[Z_{i,j}^{\frac{\zeta}{1+\zeta}} + a_j^{\frac{1}{1+\zeta}} M_{i,j}^{\frac{\zeta}{1+\zeta}}\right]^{\frac{1+\zeta}{\zeta}}, \tag{7}$$

where $Z_{i,j}$ and $M_{i,j}$ are, respectively, the quantities of domestic and imported varieties of the intermediate good j used in production. The elasticity of substitution between the domestic and the foreign varieties is $(1+\zeta)>1$, and a_j measures the productivity advantage (when $a_j>1$, and disadvantage otherwise) of the foreign variety. Note that since home and foreign varieties are imperfect substitutes, production is possible without the use of imported inputs. At the same time, imported inputs are useful due both to their potential productivity advantage a_j and to the love-of-variety feature of the production technology (7).

A firm needs to pay a firm-specific sunk cost f_i in terms of labor in order to import each type of the intermediate good. The cost of labor is given by the wage rate W^*, and the prices of domestic intermediates are $\{V_j^*\}$, both denominated in units of producer currency (hence starred). The prices of foreign intermediates are $\{\mathcal{E}_m U_j\}$, where U_j is the price in foreign currency and $\mathcal{E}_m$ is the nominal exchange rate measured as a unit of producer currency for one unit of foreign currency.[12] The total cost is therefore given by $W^*L_i + \int_0^1 V_j^* Z_{i,j}\,dj + \int_{J_{0,i}}(\mathcal{E}_m U_j M_{i,j} + W^* f_i)\,dj$, where $J_{0,i}$ denotes the set of intermediates imported by the firm.

With this production structure, we can derive the cost function. In particular, given output Y_i and the set of imported intermediates $J_{0,i}$, the firm chooses inputs to minimize its total costs subject to the production technology in equations (5)–(7). This results in the following total variable cost function net of the fixed costs of importing:

$$TVC_i^*(Y_i\,|\,J_{0,i}) = \frac{C^*}{B_i^{\phi}\Omega_i}\,Y_i, \tag{8}$$

where C^* is the cost index for a nonimporting firm.[13] The use of imported inputs leads to a cost-reduction factor $B_i \equiv B(J_{0,i}) = \exp\left\{\int_{J_{0,i}} \gamma_j \log b_j\,dj\right\}$, where $b_j \equiv \left[1 + a_j(\mathcal{E}_m U_j/V_j^*)^{-\zeta}\right]^{1/\zeta}$ is the productivity-enhancing effect from importing type-j intermediate good, adjusted for the relative cost of the import variety.

We now describe the optimal choice of the set of imported intermediate goods, $J_{0,i}$. For simplicity, we discuss here the case without uncertainty, and the online Appendix generalizes the results. First, we sort all intermediate goods j by $\gamma_j \log b_j$, from highest to lowest. Then, the optimal set of imported intermediate inputs is an interval $J_{0,i} = [0, j_{0,i}]$, with $j_{0,i} \in [0,1]$ denoting the cutoff intermediate good. The optimal choice of $j_{0,i}$ trades off the fixed cost of importing $W^* f_i$ for the reduction in total variable costs from the access to an additional imported input, which is proportional to the total material cost of the firm.[14] This reflects the standard trade-off that the fixed cost activity is undertaken provided that the scale of operation (here total spending on intermediate inputs) is sufficiently large.

[12] We denote by m a generic source of imported intermediates, and hence $\mathcal{E}_m$ can be thought of as an import-weighted exchange rate faced by the firms. The generalization of the model to multiple import source countries is straightforward; in the data, we measure $\mathcal{E}_m$ as an import-weighted exchange rate at the firm level, as well as split imports by source country (see Section IIID).

[13] This cost index is given by $C^* = (V^*/\phi)^{\phi}(W^*/(1-\phi))^{1-\phi}$ with $V^* = \exp\left\{\int_0^1 \gamma_j \log(V_j^*/\gamma_j)\,dj\right\}$.

[14] The marginal imported input satisfies $\gamma_{j0,i} \log b_{j0,i} \cdot TMC_i = W^* f_i$, where the left-hand side is the incremental benefit proportional to the total material cost of the firm $TMC_i \equiv \phi C^* Y_i / \left[B_i^{\phi}\Omega_i\right]$ and the cost-saving impact of additional imports $\gamma_{j0,i} \log b_{j0,i}$.

With this cost structure, the fraction of total variable cost spent on imported intermediate inputs equals

$$\varphi_i = \phi \int_0^{j0,i} \gamma_j \left(1 - b_j^{-\zeta}\right) dj, \tag{9}$$

where ϕ is the share of material cost in total variable cost and $\gamma_j\left(1 - b_j^{-\zeta}\right)$ is the share of material cost spent on imports of type-j intermediate good for $j \in J_{0,i}$. We refer to φ_i as the *import intensity* of the firm, and it is one of the characteristics of the firm we measure directly in the data.

Finally, holding the set of imported varieties $J_{0,i}$ constant, this cost structure results in the following marginal cost:

$$MC_i^* = C^*/[B_i^{\phi}\Omega_i]. \tag{10}$$

The *partial* elasticity of this marginal cost with respect to the exchange rate $\mathcal{E}_m$ equals the expenditure share of the firm on imported intermediate inputs, $\varphi_i = \partial \log MC_i^*/\partial \log \mathcal{E}_m$, which emphasizes the role of import intensity in the analysis that follows.

We summarize these results in Proposition 2.

PROPOSITION 2: (*i*) *Within sectors, firms with larger total material cost or smaller fixed cost of importing have a larger import intensity*, φ_i. (*ii*) *The partial elasticity of the marginal cost of the firm with respect to the* (*import-weighted*) *exchange rate equals* φ_i.

C. *Equilibrium Relationships*

We now combine the ingredients introduced above to derive the optimal price setting of the firm, as well as the equilibrium determinants of the market share and import intensity of the firm. Consider firm i supplying an exogenously given set K_i of destination markets k. The firm sets destination-specific prices by solving

$$\max_{Y_i,\{P_{k,i},Q_{k,i}\}_k} \left\{ \sum_{k \in K_i} \mathcal{E}_k P_{k,i} Q_{k,i} - \frac{C^*}{B_i^{\phi}\Omega_i} Y_i \right\},$$

subject to $Y_i = \sum_{k \in K_i} Q_{k,i}$ and demand equation (1) in each destination k. We quote the destination-k price $P_{k,i}$ in the units of destination-k local currency and use the bilateral nominal exchange rate $\mathcal{E}_k$ to convert the price to the producer currency, denoting with $P_{k,i}^* \equiv \mathcal{E}_k P_{k,i}$ the producer-currency price of the firm for destination k. An increase in $\mathcal{E}_k$ corresponds to the depreciation of the producer currency. The total cost is quoted in units of producer currency.[15] Note that we treat the choice of the set of imported goods $J_{0,i}$ and the associated fixed costs as sunk by the price setting stage when the uncertainty about exchange rates is realized. The problem

[15] We do not explicitly model variable trade costs, but if they take an iceberg form, they are without loss of generality absorbed into the $\xi_{k,i} D_k$ term in the firm-i demand (1) in destination k.

of choosing $J_{0,i}$ under this circumstance is defined and characterized in the online Appendix and Section IIB provides empirical evidence supporting this assumption.

The firm optimally sets prices in each of its destination markets according to

$$(11) \qquad P^*_{k,i} = \frac{\sigma_{k,i}}{\sigma_{k,i} - 1} MC^*_i, \quad k \in K_i,$$

where MC^*_i is the marginal cost as defined in (10) and $\mathcal{M}_{k,i} \equiv \sigma_{k,i}/(\sigma_{k,i} - 1)$ is the multiplicative markup with the effective demand elasticity $\sigma_{k,i}$ defined in (3). This set of optimality conditions together with the constraints fully characterizes the allocation of the firm, given industry-level variables. In the online Appendix, we exploit these equilibrium conditions to derive how relative market shares and import intensities are determined in equilibrium across firms, and since these results are very intuitive, here we provide only a brief summary.

We show that other things equal and under mild regularity conditions, a firm with higher productivity Ω_i, higher quality/demand $\xi_{k,i}$, lower fixed cost of importing f_i, and serving a larger set of destinations K_i has a larger market share $S_{k,i}$ and a higher import intensity φ_i. Intuitively, a more productive or high-demand firm has a larger market share and hence operates on a larger scale, which justifies paying the fixed cost for a larger set of imported intermediate inputs, $J_{0,i}$. This makes the firm more import intensive, enhancing its productivity advantage through the cost-reduction effect of imports (larger B_i in (8)). This implies that, independently of the specifics of the general equilibrium environment, we should expect market shares and import intensities to be positively correlated in the cross section of firms, a pattern that we document in the data in Section II.

D. *Imported Inputs, Market Share, and Pass-Through*

We are now in a position to relate the firm's exchange rate pass-through into its export prices with its market share and import intensity. The starting point for this analysis is the optimal price setting equation (11), which we rewrite as a full log differential:

$$(12) \qquad d\log P^*_{k,i} = d\log \mathcal{M}_{k,i} + d\log MC^*_i.$$

Consider first the markup term. Using (2)–(4), we have

$$(13) \qquad d\log \mathcal{M}_{k,i} = -\Gamma_{k,i}(d\log P_{k,i} - d\log P_{s,k}) + \frac{\Gamma_{k,i}}{\rho - 1} d\log \xi_{k,i},$$

where converting the export price to local currency yields $d\log P_{k,i} = d\log P^*_{k,i} - d\log \mathcal{E}_k$, and we now make explicit the subscript s to indicate that $P_{s,k}$ is the industry-destination-specific price index. The markup declines in the relative price of the firm and increases in the firm's demand shock. From Proposition 1, $\Gamma_{k,i}$ is increasing in the firm's market share, and hence price increases for larger market-share firms are associated with larger declines in the markup.

Next, the change in the marginal cost in equation (10) can be decomposed as follows:

$$d\log MC_i^* \;=\; \varphi_i d\log\frac{\mathcal{E}_m \overline{U}_s}{\overline{V}_s^*} \;+\; d\log\frac{\overline{C}_s^*}{\overline{\Omega}_s} \;+\; \epsilon_i^{MC}. \tag{14}$$

This expression generalizes the result of Proposition 2 on the role of import intensity φ_i by providing the full decomposition of the change in the log marginal cost. Here $\overline{U}_s$ and $\overline{V}_s^*$ are the price indexes for the imported intermediates (in foreign currency) and domestic intermediates (in producer currency), respectively. The subscript *s* emphasizes that these indexes can be specific to sector *s* in which firm *i* operates. Finally, $d\log\overline{C}_s^*/\overline{\Omega}_s$ is the log change in the industry-average marginal cost for a firm that does not import any intermediates, and ϵ_i^{MC} is a firm-idiosyncratic residual term defined explicitly in the online Appendix and assumed orthogonal to the exchange rate.[16]

Combining and manipulating equations (12)–(14), we prove our key theoretical result:

PROPOSITION 3: *In any general equilibrium, the first-order approximation to the exchange rate pass-through elasticity into producer-currency export prices of the firm is given by*

$$\Psi_{k,i}^* \;\equiv\; E\left\{\frac{d\log P_{k,i}^*}{d\log\mathcal{E}_k}\right\} \;=\; \alpha_{s,k} \;+\; \beta_{s,k}\varphi_i \;+\; \gamma_{s,k}S_{k,i}, \tag{15}$$

where $(\alpha_{s,k},\,\beta_{s,k},\,\gamma_{s,k})$ *are sector-destination specific and depend only on average moments of equilibrium comovement between aggregate variables common to all firms.*

The pass-through elasticity $\Psi_{k,i}^*$ measures the equilibrium log change of the destination-*k* producer-currency price of firm *i* relative to the log change in the bilateral exchange rate, averaged across all possible states of the world and shocks that hit the economy.[17] Under this definition, the pass-through elasticity is a measure of equilibrium comovement between the price of the firm and the exchange rate, and not a partial equilibrium response to an exogenous movement in the exchange rate. Thus, we do *not* need to assume that movements in exchange rates are exogenous, nor do we rely on any source of exogenous variation in our estimation. In fact,

[16] This orthogonality assumption is necessary for Proposition 3, and it holds provided that firm idiosyncratic shocks are not systematically correlated with exchange rate movements. More precisely, we allow firm demand, productivity, and import prices to move with exchange rates in arbitrary ways, but we require that the relative demand, productivity, and import prices of any two firms within sector-destination do not systematically change with exchange rate movements.

[17] Formally, the expectation in (15) is over all possible exogenous shocks that affect the exchange rate in general equilibrium, as well as over all state variables (e.g., the distribution of firm productivities). Further, the expectation in (15) is conditional on the persistent characteristics of a given firm $(\Omega_i,\,\xi_{k,i},\,f_i)$, which, as Proposition 3 emphasizes, affect the firm's pass-through only through the sufficient statistic $(\varphi_i,\,S_{k,i})$.

we allow for arbitrary equilibrium comovement between exchange rates and other aggregate variables, including price and cost indexes.

Proposition 3 shows that we can relate firm-level pass-through to market share and import intensity of the firm, which form a *sufficient statistic* for cross-sectional variation in pass-through within sector-destination, independently of the specifics of the general equilibrium environment and, in particular, independently of what shocks hit the economy and shape the dynamics of the exchange rate. This relationship is the focus of our empirical investigation in the next section. The values of the coefficients in this relationship $(\alpha_{s,k}, \beta_{s,k}, \gamma_{s,k})$ are sector-destination specific, and, although they depend on the general equilibrium environment in which firms operate, we show in Section IIIA that we can directly estimate them in the data without imposing any general equilibrium assumptions.[18]

Furthermore, the theory provides closed form expressions for the coefficients in (15). The coefficients $\alpha_{s,k}$ and $\gamma_{s,k}$ depend on the unconditional moments of equilibrium comovement between the exchange rate and aggregate variables such as the price index in the destination market and the domestic cost index (see the online Appendix). For example, pass-through into *destination prices* is lower (i.e., $\alpha_{s,k}$ is higher) in an equilibrium environment where the domestic cost index offsets some of the effects of the exchange rate on marginal costs. And pass-through is relatively lower (i.e., $\gamma_{s,k}$ is higher) for large market-share firms when the destination price index responds weakly to the exchange rate, because of the stronger strategic complementarities in their price setting.

The closed form expression for $\beta_{s,k}$ highlights the structural determinants of the relationship between pass-through and import intensity:

$$\beta_{s,k} = \frac{1}{1 + \overline{\Gamma}_{s,k}} E\left\{\frac{d \log \mathcal{E}_m}{d \log \mathcal{E}_k} \cdot \frac{d \log (\mathcal{E}_m \overline{U}_s / \overline{V}_s^*)}{d \log \mathcal{E}_m}\right\}, \tag{16}$$

where $\overline{\Gamma}_{s,k}$ is the markup elasticity evaluated at some average measure of market share $\overline{S}_{s,k}$. Intuitively, $\beta_{s,k}$ depends on the comovement between export and import exchange rates and the pass-through of import exchange rate into the relative price of imported intermediates, as reflected by the two terms inside the expectation in (16). Indeed, import intensity proxies for the marginal cost correlation with the export exchange rate only to the extent that import and export exchange rates are correlated and movements in the import exchange rate are associated with the changes in the import prices of the intermediate inputs. Importantly, we do not restrict the exchange rate pass-through into import prices to be complete. In our empirical work, we directly examine our theoretical mechanism by using the variation in exchange rate correlation and import price pass-through across import source countries.

Proposition 3 predicts that pass-through into *destination-currency* prices, equal to $(1 - \Psi^*_{k,i})$, is lower for more import-intensive firms and for firms with higher

[18] We estimate the coefficients by exploiting the cross-sectional variation in the panel data within industries and destinations in the responses to shocks across firms. These estimates, however, are not suitable for undertaking counterfactuals across general equilibrium environments, as when the source of variation in exchange rate changes, so do the coefficients. Such counterfactuals need to be carried out in the context of a specific calibrated general equilibrium model.

destination market share, provided $\beta_{s,k}$ and $\gamma_{s,k}$ are positive.[19] Although theoretically these coefficients can have either sign (or equal to zero), we expect them to be positive, and this is what we find in the data. Intuitively, a more import-intensive firm is effectively hedged from a domestic currency appreciation via decreasing import prices and hence keeps its destination-currency price more stable. Further, a high-market-share firm has a lower pass-through as it chooses to accommodate the marginal cost shocks with a larger markup adjustment as opposed to a larger movement in its destination-currency price.

II. Data and Stylized Facts

In this section we describe the dataset that we use for our empirical analysis and the basic stylized facts on exporters and importers.

A. *Data Description and Construction of Variables*

Our main data source is the National Bank of Belgium, which provided a comprehensive panel of Belgian trade flows by firm, product (CN 8-digit level), exports by destination, and imports by source country. We merge these data, using a unique firm identifier, with firm-level characteristics from the Belgian Business Registry, comprising information on firms' inputs, which we use to construct total variable cost measures and total factor productivity estimates. Our sample includes annual data for the period 2000 to 2008, beginning the year after the euro was introduced. We focus on manufacturing exports to the OECD countries outside the euro zone: Australia, Canada, Iceland, Israel, Japan, the Republic of Korea, New Zealand, Norway, Sweden, Switzerland, the United Kingdom, and the United States, accounting for 58 percent of total non-euro exports.[20] We also include a robustness test with the full set of non-euro destinations. We provide a detailed description of all the data sources in the online data Appendix.

The dependent variable in our analysis is the log change in a firm f's export price of good i to destination country k at time t, proxied by the change in a firm's export unit value, defined as the ratio of export values to export quantities:

$$\Delta p^*_{f,i,k,t} \equiv \Delta \log\left(\frac{Export\ value_{f,i,k,t}}{Export\ quantity_{f,i,k,t}}\right), \tag{17}$$

where quantities are measured as weights or units. We use the change in the ratio of value to weights, where available, and the change in the ratio of value to units otherwise. We note that unit values are an imprecise proxy for prices because there may

[19] Note that Proposition 3 provides a linear approximation (15) to the generally nonlinear equilibrium relationship. In the data, we test directly for the nonlinearity in this relationship and find no statistically significant evidence. Our interpretation is that this is not because nonlinearities are unimportant in general, but because these finer features of the equilibrium relationship are less robust across broad industries that we consider in our analysis. This is why we choose to focus on the first-order qualitative prediction of the theory captured by the approximation in (15).

[20] The euro zone was formed on January 1, 1999, in Austria, Belgium, Finland, France, Germany, Ireland, Italy, Luxembourg, the Netherlands, Portugal, and Spain. Greece joined on January 1, 2001, Slovenia joined in 2007, Cyprus and Malta joined in 2008. We also exclude Denmark from the set of export destinations because its exchange rate hardly moves relative to the euro.

be more than one distinct product within a CN 8-digit code despite the high degree of disaggregation constituting close to 10,000 distinct manufacturing product categories over the sample period. Some price changes may be due to compositional changes within a product code or due to errors in measuring quantities.[21] To try to minimize this problem, we drop all year-to-year unit value changes of plus 200 percent or minus 67 percent (around 7 percent of the observations).

A distinctive feature of these data that is critical for our analysis is that they also contain firm-level import values and quantities for each CN 8-digit product code by source country. We include all 234 source countries and all 13,000 product codes in the sample. Studies that draw on price data have not been able to match import and export prices at the firm level. In general, many firms engaged in exporting also import their intermediate inputs. In Belgium, around 80 percent of manufacturing exporters import some of their inputs. We use these data to construct three key variables—the import intensity from outside the euro zone $\varphi_{f,t}$, the log change in the marginal cost $\Delta mc^*_{f,t}$, and the firm's market share $S_{f,s,k,t}$. Specifically,

$$\varphi_{f,t} \equiv \frac{\textit{Total non-euro import value}_{f,t}}{\textit{Total variable costs}_{f,t}}, \tag{18}$$

where total variable costs comprise a firm's total wage bill and total material cost. We often average this measure over time to obtain a firm-level average import intensity denoted by φ_f.

The change in marginal cost is defined as the log change in unit values of firm imports from all source countries weighted by respective expenditure shares:

$$\Delta mc^*_{f,t} \equiv \sum_{j \in J_{f,t}} \sum_{m \in M_{f,t}} \omega_{f,j,m,t} \Delta \log U^*_{f,j,m,t}, \tag{19}$$

where $U^*_{f,j,m,t}$ is the euro price (unit value) of firm f's imports of intermediate good j from country m at time t, the weights $\omega_{f,j,m,t}$ are the average of period t and $t-1$ shares of respective import values in the firm's total variable costs, and $J_{f,t}$ and $M_{f,t}$ denote the set of all imported goods and import source countries (including inside the euro zone) for the firm at a given time. Note that this measure of the marginal cost is still a proxy since it does not reflect the costs of domestic inputs and firm productivity. We control separately for estimated firm productivity and average firm wage rate, however, detailed data on the prices and values of domestic inputs are not available. Nonetheless, controlling for our measure of the firm-level marginal cost is a substantial improvement over previous pass-through studies that typically control only for the aggregate manufacturing wage rate or producer price level.

[21] This is the typical drawback of customs data (as, for example, is also the case with the French dataset used in Berman, Martin, and Mayer 2012), where despite the richness of firm-level variables, we do not observe trade prices of individual items. As a result, there are two potential concerns: one, aggregation across heterogeneous goods even at the very fine level of disaggregation (firm-destination CN 8-digit product code level); and, two, aggregation over time of sticky prices. This means we cannot condition our analysis on a price change of a good, as was done in Gopinath, Itskhoki, and Rigobon (2010) using BLS IPP item-level data. The BLS data, however, is limited in the available firm characteristics and hence is not suitable for our analysis. We address these two caveats by conducting a number of robustness tests and providing a cautious interpretation of our findings in Section IIIE.

Furthermore, our measure of marginal cost arguably captures the component of the marginal cost most sensitive to exchange rate movements.

Ideally, we would like to construct $\varphi_{f,t}$ and $\Delta\, mc^*_{f,t}$ for each of the products i a firm produces; however, this measure is available only at the firm-f level, which may not be the same for all of the products produced by multiproduct firms. To address this multiproduct issue, we keep only the firm's main export products, which we identify using Belgium's input-output table for the year 2005, comprising 56 IO manufacturing codes. For each firm, we identify an IO code that accounts for its largest export value over the whole sample period and keep only the CN 8-digit products within this major-IO code. The objective is to keep only the set of products for each firm that have similar production technologies. This leaves us with 60 percent of the observations but 90 percent of the value of exports. We also present results with the full set of export products and experiment with defining the major product using more disaggregated product lines, such as HS 4-digit.[22] Further, it is possible that some of the firm's imports might be final goods rather than intermediate inputs. We attempt to identify imported intermediate inputs using a number of different approaches. First, we omit any import from the construction of $\varphi_{f,t}$ that is defined as a final product using Broad Economic Codes (BEC). Second, we construct φ_f using only the intermediate inputs for a given industry according to the IO tables.

The last key variable in our analysis is a firm's market share, which we construct as follows:

$$S_{f,s,k,t} \equiv \frac{Export\ value_{f,s,k,t}}{\sum_{f' \in F_{s,k,t}} Export\ value_{f',s,k,t}}, \tag{20}$$

where s is the sector in which firm f sells product i and $F_{s,k,t}$ is the set of Belgian firms that export to destination k, in sector s at time t. Therefore, $S_{f,s,k,t}$ measures a Belgium firm's market share in sector s, export destination k at time t relative to all other Belgium exporters. Note that, following the theory, this measure is destination specific. The theory also suggests that the relevant measure is the firm's market share relative to all firms supplying the destination market in a given sector, including exporters from other countries as well as domestic competitors in market k. But, since our analysis is across Belgian exporters within sector-destinations, the competitive stance in a particular sector-destination is common for all Belgian exporters, and hence our measure of $S_{f,s,k,t}$ captures all relevant variation for our analysis (see Section IIIA).[23] We define sectors at the HS 4-digit level, at which we

[22] By only keeping the firm's major products, we also deal with the potential problem of including products that firms export but do not produce—a phenomenon referred to as *carry-along trade* (Bernard et al. 2012). As a further robustness check, in Section IIIE we use IO tables to isolate the inputs that are used in the production of firms' major products, and only use these inputs to construct the firm's import intensity variable. See De Loecker et al. (2012) for an alternative structural treatment of multiproduct firms.

[23] In an extension of the theory, a multiproduct firm facing a nested-CES demand (1) sets the same markup for all its varieties within a sector, as in (11), where its markup depends on the cumulative market share of all these varieties. Therefore, $S_{f,s,k,t}$ is indeed the appropriate measure of market power for all varieties i exported by firm f to destination k in sector s at time t. See Chatterjee, Dix-Carneiro, and Vichyanond (2013) for a study of pass-through of multiproduct firms under an alternative demand structure.

Table 1—Exporter and Importer Incidence (*percent*)

	Exporters and/or importers	All exporters
Fraction of all firms	32.6	23.7
Among them		
exporters and importers	57.0	78.4
only exporters	15.8	21.6
only importers	27.2	—

Notes: The data include all manufacturing firms. The frequencies are averaged over the years 2000–2008.

both obtain a nontrivial distribution of market shares and avoid having too many sector-destinations served by a single firm.[24]

B. *Stylized Facts About Exporters and Importers*

A salient pattern in our dataset is that most exporters are also importers, a pattern also present in many earlier studies cited in the introduction. As reported in Table 1, in the full sample of Belgian manufacturing firms, the fraction of firms that are either exporters or importers is 33 percent. Out of these firms, 57 percent both import and export, 27 percent only import, and 16 percent only export. That is, 24 percent of manufacturing firms in Belgium export and 78 percent of exporters also import.[25] This high correlation between exporting and importing suggests that the selection into both activities is driven by the same firm characteristics, such as productivity, which determines the scale of operations. We show how this overlap in importing and exporting activities turns out to be important for understanding the incomplete exchange rate pass-through.

Interestingly, the data reveal a lot of heterogeneity within exporting firms, which are an already very select subsample of firms. The large differences between exporters and nonexporters are already well-known and are also prevalent in our data. The new stylized facts we highlight here are the large differences within exporters between high- and low-import-intensity exporting firms. We show in Table 2 that these two groups of exporting firms differ in fundamental ways. We report various firm-level characteristics for high- and low-import-intensity exporters, splitting exporters into two groups based on the median import intensity outside the euro zone (φ_f) equal to 4.2 percent.[26] For comparison, we also report the available analogous statistics for nonexporting firms with at least five employees.

[24] The median of $S_{f,s,k,t}$ is 7.8 percent, yet the seventy-fifth percentile is over 40 percent and the export-value-weighted median is 55 percent. Twenty-four percent of $S_{f,s,k,t}$ observations are less than 1 percent, yet these observations account for only 1.4 percent of export sales. Three percent of $S_{f,s,k,t}$ observations are unity, yet they account for less than 2.5 percent. Our results are robust (and, in fact, become marginally stronger) to the exclusion of observations with very small and very large market shares. We depict the cumulative distribution function of $S_{f,s,k,t}$ in Figure A1 in the online Appendix.

[25] These statistics are averaged over the sample length, but they are very stable year-to-year. In the subsample of exporters we use for our regression analysis in Section IIIB, the fraction of importing firms is somewhat higher at 85.5 percent, reflecting the fact that data availability is slightly biased toward larger firms.

[26] The unit of observation here is a firm-year. If we split our sample based on firm-product-destination-year (which is the unit of observation in our regression analysis), the median import intensity is higher at 8.2 percent, however, this has no material consequences for the patterns we document in Table 2.

TABLE 2—IMPORT-INTENSIVE EXPORTERS

	Exporters		
	Import intensive	Not import intensive	Non-exporters
Share of imports in total cost			
All imports	0.37	0.17	0.02
Non-euro imports (φ_f)	0.17	0.01	0.00
Employment (number of workers)	270.6	112.2	20.7
Average wage rate	48.8	42.3	34.9
Material cost	103.3	28.2	3.0
Total factor productivity (log)	0.33	0.07	—
Total exports (manufacturing)	66.5	14.1	
to non-euro OECD	14.4	2.4	
Total imports (all products)	49.3	6.8	
outside euro zone	20.8	0.5	
Number of import source countries	14.4	6.6	
Number of HS-8 products imported	79.3	38.2	

Notes: The exporter subsample is split at the median of non-euro import intensity (share of non-euro imports in total costs) equal to 4.2 percent. The nonexporter subsample is all nonexporting manufacturing firms with five or more employees. Material cost, import, and export values are in millions of euros, and average wage rate is in thousands of euros. Twenty-eight percent of low import intensity firms do not import at all, and 33 percent of them do not import from outside the euro zone. The construction of the measured TFP is described in the online data Appendix.

From Table 2, we see that import-intensive exporters operate on a larger scale and are more productive. The share of imported inputs in total variable costs for import-intensive exporters is 37 percent compared to 17 percent for nonimport-intensive exporters, and similarly for imports sourced outside the euro zone it is 17 percent compared to 1.2 percent. And of course, these numbers are much lower for nonexporters at 1.6 percent for imports outside Belgium and 0.3 percent for imports outside the euro zone. Import-intensive exporters are 2.5 times larger in employment than nonimport-intensive exporters and 13 times larger than nonexporters; they pay a 15 percent wage premium relative to nonimport-intensive firms and a 40 percent wage premium relative to nonexporters. Similarly, import-intensive exporters have much larger total material costs, total factor productivity, and market share. These firms also export and import on a much larger scale, and are more likely to trade with more distant countries outside the euro zone. These firms import more in terms of total value, number of imported goods, and from a larger set of import source countries. These results highlight that both types of exporting firms are active in importing from a range of countries both within and outside the euro zone but that the two types of firms differ substantially in import intensity, consistent with the predictions of our theoretical framework.

We now provide more details on the distribution of import intensity outside the euro zone (φ_f). We see that the distribution of import intensity among exporters in Table 3, although somewhat skewed toward zero, has a wide support and substantial variation, which we exploit in our regression analysis in Section III. Over 24 percent of exporters do not import from outside the euro zone, yet they account for only 1 percent of Belgian manufacturing exports. For the majority of firms, the

Table 3—Distribution of Import Intensity among Exporters

	Number of firms	Fraction of firms (percent)	Fraction of export value (percent)
$\varphi_f = 0$	717	24.9	1.4
$0 < \varphi_f \leq 0.1$	1,478	51.3	38.2
$0.1 < \varphi_f \leq 0.2$	348	12.1	23.8
$0.2 < \varphi_f \leq 0.3$	155	5.4	8.8
$0.3 < \varphi_f \leq 0.4$	94	3.3	23.0
$\varphi_f > 0.4$	89	3.1	4.9

Note: Import intensity, φ_f, is the share of imported intermediate inputs from outside the euro zone in the total variable cost of the firm, averaged over the sample period.

Table 4—Correlation Structure of Import Intensity

	Import intensity	TFP	Revenues	Employment	Material cost
Market share	0.16	0.20	0.28	0.25	0.27
Material cost	0.23	0.70	0.99	0.83	
Employment	0.10	0.60	0.86		
Revenues	0.21	0.72			
TFP	0.15				

Notes: Cross-sectional correlations of firm-level variables averaged over time. Material costs, employment, revenues, and TFP are in logs. Import intensity is the share of imported intermediate inputs from outside the euro zone in the total cost of the firm. Market share corresponds to our measure $S_{f,s,k,t}$, defined in (20), aggregated to the firm-level by averaging across sector-destination-years.

share of imported inputs in total costs ranges between 0 and 10 percent, while the export-value-weighted median of import intensity is 13 percent. At the same time, nearly 28 percent of export sales are generated by the firms with import intensity in excess of 30 percent.[27] We further depict the cumulative distribution function of import intensity φ_f in Figure A1 in the online Appendix, which also provides a cumulative distribution function for our market share variable $S_{f,s,k,t}$.

Table 4 displays the correlations of import intensity with other firm-level variables in the cross section of firms. Confirming the predictions of Section IC, import intensity is positively correlated with market share, as well as with firm TFP, employment, and revenues. The strongest correlate of import intensity is the total material cost of the firm, consistent with the predictions of Proposition 2. Overall, the correlations in Table 4 broadly support the various predictions of our theoretical framework. At the same time, although import intensity and market share are positively correlated with productivity and other firm performance measures, there is sufficient independent variation to enable us to distinguish between the determinants of incomplete pass-through in the following subsections.

[27] While the unweighted distribution (firm count) has a single peak, the export-value-weighted distribution has two peaks. This is due to the fact that one exporter with $\varphi_f = 0.33$ accounts for almost 14 percent of export sales. Our results are not sensitive to the exclusion of this largest exporter, which accounts for only 134 observations out of a total of over 90,000 firm-destination-product-year observations in our sample.

We close this section with a brief discussion of the patterns of time-series variation in import intensity for a given firm. Import intensity appears to be a relatively stable characteristic of the firm, moving little over time and in response to exchange rate fluctuations. Specifically, the simple regression of $\varphi_{f,t}$ on firm fixed effects has an R^2 of over 85 percent, implying that the cross-sectional variation in time-averaged firm import intensity φ_f is nearly six times larger than the average time-series variation in $\varphi_{f,t}$ for a given firm. When we regress the change in $\varphi_{f,t}$ on firm fixed effects and the lags of the log change in firm-level import-weighted exchange rates, the contemporaneous effect is significant with a semi-elasticity of only 0.057, and with offsetting, albeit marginally significant, lag effects. That is, a 10 percent depreciation of the euro temporarily increases import intensity by 0.57 of a percentage point. Furthermore, we find that the firm hardly adjusts its imports on the extensive margin in response to changes in its import-weighted exchange rate.[28] All of this evidence provides support for our assumption in Section I that the set of imported goods is a sunk decision at the horizons we consider, and hence the extensive margin plays a very limited role in the response of a firm's marginal cost to exchange rate movements, justifying the use of φ_f as a time-invariant firm characteristic in the empirical regressions that follow.

To summarize, we find substantial variation in import intensity among exporters, and this heterogeneity follows patterns consistent with the predictions of our theoretical framework. Next, guided by the theoretical predictions, we explore the implications of this heterogeneity for the exchange rate pass-through patterns across Belgian firms.

III. Empirical Evidence

This section presents our main empirical results. We start by introducing and estimating our main empirical specification. We then provide nonparametric evidence and explore the forces behind our empirical results, confirming the specific mechanisms identified by the theory. We conclude with a battery of robustness tests.

A. *Empirical Specification*

We now turn to the empirical estimation of the relationship between import intensity, market share, and pass-through in the cross section of exporters (Proposition 3). The theoretical pass-through regression equation (15) cannot be directly estimated since pass-through $\Psi^*_{k,i}$ is not a variable that can be observed in the data. Therefore, we step back to the decomposition of the log price change in equations (12)–(14), which we again linearize in import intensity and market share. After replacing differentials with changes over time Δ, we arrive at our main empirical specification, where we regress the annual change in log export

[28] We measure the extensive margin as the change in firm imports due to adding a new variety or dropping an existing variety at CN 8-digit-country level.

price on the change in the log exchange rate, interacted with import intensity and market share:

$$\Delta p^*_{f,i,k,t} = [\alpha_{s,k} + \beta\varphi_{f,t-1} + \tilde{\gamma} S_{f,s,k,t-1}]\Delta e_{k,t} + \delta_{s,k} + b\varphi_{f,t-1} + cS_{f,s,k,t-1} + \tilde{u}_{f,i,k,t}, \tag{21}$$

where $p^*_{f,i,k,t}$ is the log euro *producer price* to destination k (as opposed to local-currency price), and an increase in the log nominal exchange rate, $e_{k,t}$, corresponds to the bilateral depreciation of the euro relative to the destination-k currency.[29] In our analysis we estimate parameters β and $\tilde{\gamma}$ with values averaged across sector-destination-years. In order to keep the pool of averaged coefficients $(\beta_{s,k}, \gamma_{s,k})$ relatively homogenous, we focus on manufacturing exports to high-income OECD countries in our benchmark specifications. The regression equation (21) is a structural relationship that emerges from the theoretical model of Section I, and $S_{f,s,k,t-1}$ corresponds to our measure of market share defined in equation (20). Under a mild assumption that $\Delta e_{k,t}$ is uncorrelated with $(\varphi_{f,t-1}, S_{f,s,k,t-1})$, we prove the following proposition in the online Appendix:

PROPOSITION 4: *The OLS estimates of β and $\tilde{\gamma}$ in* (21) *identify the weighted averages across sector-destination-years of $\beta_{s,k}$ and $\gamma_{s,k}\hat{S}_{s,k,t-1}$ respectively, where $\hat{S}_{s,k,t-1}$ is the sector-destination-time-specific cumulative market share of all Belgian exporters and $(\beta_{s,k}, \gamma_{s,k})$ are the theoretical coefficients in the pass-through relationship* (15).

This result shows that, despite the fact that we cannot directly estimate the theoretical regression (15), we can nonetheless identify the theoretical coefficients in the relationship between pass-through, import intensity, and market share. Furthermore, it formally confirms the validity of our measure of the market share relative to other Belgian exporters.

Equation (21) is our benchmark empirical specification. Note that it is very demanding in that it requires including sector-destination dummies and their interactions with exchange rate changes at a very disaggregated level. Therefore, we start by estimating equation (21) with a common coefficient α, and later replace sector-destination fixed effects $\delta_{s,k}$ with sector-destination-year fixed effects $\delta_{s,k,t}$ which absorb $\alpha_{s,k}\Delta e_{k,t}$.We also estimate (21) for exports to a single destination (United States) only. In our main regressions we replace $\varphi_{f,t-1}$ with a time-invariant φ_f to reduce the measurement error, and also to maximize the size of the sample since some of the lagged $\varphi_{f,t-1}$ were unavailable. This has little effect on the results since, as we show, $\varphi_{f,t}$ is very persistent over time. In the main specifications we also replace $S_{f,s,k,t-1}$ with the contemporaneous $S_{f,s,k,t}$, as both give the same results.[30] In the robustness section we report the estimates from the specification with the lagged $\varphi_{f,t-1}$ and $S_{f,s,k,t-1}$.

[29] The nominal exchange rates are average annual rates from the IMF. These are provided for each country relative to the US dollar, which we convert to be relative to the euro.

[30] We do not use the time-averaged market share as firms move in and out of sector-destinations over time.

TABLE 5—IMPORT INTENSITY, MARKET SHARE, AND PASS-THROUGH

Dependent variable: $\Delta p^*_{f,i,k,t}$	(1)	(2)	(3)	(4)	(5)	(6)	(7)
$\Delta e_{k,t}$	0.203***	0.127***	0.157***	0.149***	0.098***	0.057*	—
	(0.026)	(0.027)	(0.028)	(0.037)	(0.030)	(0.031)	
$\Delta e_{k,t} \cdot \varphi_f$		0.604***	0.370***	0.341*	0.263**	0.473***	0.470**
		(0.112)	(0.117)	(0.201)	(0.115)	(0.104)	(0.236)
$\Delta e_{k,t} \cdot S_{f,s,k,t}$					0.238***	0.284***	0.299***
					(0.060)	(0.063)	(0.100)
$\Delta mc^*_{f,t}$			0.512***		0.506***		
			(0.030)		(0.031)		
Fixed effects:							
$\delta_{s,k} + \delta_t$	Yes	Yes	Yes	No	Yes	Yes	No
$\delta_{s,k,t}$	No	No	No	No	No	No	Yes
$\delta_{f,i,t} + \delta_k$	No	No	No	Yes	No	No	No
Observations	93,395	93,395	93,395	93,395	93,395	93,395	93,395
R^2	0.057	0.057	0.062	0.487	0.062	0.057	0.344

Notes: Observations are at the firm-destination-product-year level. Δ corresponds to annual changes. Columns 2–3 and 5–7 include a control for the level of φ_f, and columns 5–7 also include a control for the level of the market share, $S_{f,s,k,t}$. Fixed effects: $\delta_{s,k} + \delta_t$ is the combination of sector-destination and year fixed effects; $\delta_{s,k,t}$ are sector-destination-year fixed effects; $\delta_{f,i,t} + \delta_k$ is the combination of firm-product-year and country fixed effects (the sector is defined at HS-4 and the product at HS-8-digit level). The results without the year fixed effects are almost identical. Standard errors are clustered at the country-year level, reported in brackets. Alternative clustering at the firm level and at the country-HS-4-digit level yield the same conclusions.

***Significant at the 1 percent level.

**Significant at the 5 percent level.

*Significant at the 10 percent level.

B. *Main Empirical Findings*

To explore the underlying mechanisms behind the equilibrium relationship between pass-through, import intensity, and market shares, we begin with a more simple specification and build up to the specification in equation (21). Table 5 reports the results. We include industry-destination specific effects (where industry is defined at the HS 4-digit level) to be consistent with the theory, and year effects to control for common marginal cost variation. First, in column 1, we report that at the annual horizon the unweighted average exchange rate pass-through elasticity into producer prices in our sample is 0.2, or, equivalently, 0.8 ($= 1 - 0.2$) into destination prices. We refer to it as 80 percent pass-through.

In column 2, we include an interaction between exchange rates and a firm's import intensity. We see that the simple average coefficient reported in column 1 masks a considerable amount of heterogeneity, as firms with different import intensities have very different pass-through rates. Firms with a high share of imported inputs relative to total variable costs exhibit lower pass-through into destination-currency export prices—a 10 percentage point higher import intensity is associated with a 6 percentage point lower pass-through. A typical firm with zero import intensity has a pass-through of 87 percent ($= 1 - 0.13$), while a firm with a 38 percent import intensity (in the ninety-fifth percentile of the distribution) has a pass-through of only 64 percent ($= 1 - 0.13 - 0.60 \cdot 0.38$).

Next, we explore whether import intensity operates through the marginal-cost channel or through selection and the markup channel. In columns 3 and 4, we add controls for the marginal cost of the firm to see whether the effect of import intensity on pass-through persists beyond the marginal cost channel. In column 3, we control for the change in marginal cost $\Delta mc^*_{f,t}$, measured as the import-weighted change in the firm's import prices of material inputs (see equation (19)), which is likely to be sensitive to exchange rate changes if the firm relies heavily on imported intermediate inputs. Comparing columns 2 and 3, we see that the coefficient on the import intensity interaction nearly halves in size once we control for marginal cost, dropping from 0.6 to 0.37, but still remains strongly significant with a *t*-stat of 3.2. We confirm this finding with an alternative control for marginal cost changes, by including firm-product-year fixed effects $(\delta_{f,i,t})$ in column 4. In this specification, the only variation that remains is across destinations for a given firm and hence, among other things, controls for all components of the marginal cost of the firms.[31] The coefficient on the import intensity interaction in column 4 is almost the same as that in column 3, but much less precisely estimated with a *t*-stat of 1.7. This result is impressive, given that this specification is saturated with fixed effects, and the similarity of the results in columns 3 and 4 provides confidence in our measure of marginal cost.

The results in columns 3 and 4 suggest that, although the marginal cost is an important channel through which import intensity affects pass-through (see Proposition 2), there is still a considerable residual effect operating through the markup channel after conditioning on the marginal cost. This finding is consistent with the theoretical predictions, since import intensity correlates with market share in the cross section of firms and market share determines the markup elasticity, causing omitted variable bias. To see this, in column 5 we augment the specification of column 3 (controlling for $\Delta mc^*_{f,t}$) with a market share interaction with the log change in exchange rate to proxy for markup elasticity, as suggested by Proposition 3. Given that we now control for both marginal cost and markup, we expect import intensity to stop having predictive power. Although the effect of import intensity does not disappear completely, the coefficient does fall in size (from 0.37 to 0.26) and becomes less significant.[32]

Finally, column 6 implements our main specification in equation (21) by including the import intensity and market share interactions, without controlling for marginal cost. Proposition 3 suggests that import intensity and market share are two prime predictors of exchange rate pass-through, and indeed we find that the two interaction terms in column 6 are strongly statistically significant. Interpreting our results quantitatively, we find that a firm with a zero import intensity and a nearly zero market share (corresponding respectively to the fifth percentiles of both

[31] Although firm-product-year fixed effects $(\delta_{f,i,t})$ arguably provide the best possible control for marginal cost, the disadvantage of this specification is that it only exploits the variation across destinations and thus excludes all variation within industry destinations that is the main focus of our analysis. Consequently, we cannot use our measure of market share in specifications with $\delta_{f,i,t}$ since our market share measure only makes sense within industry destinations, as we discuss in Section IIA.

[32] The coefficient on $\Delta mc^*_{f,t}$ in both specifications of columns 3 and 5 is remarkably stable at 0.51. The theory suggests that this coefficient should be $1/(1+\bar{\Gamma})$, that is the average pass-through elasticity of idiosyncratic shocks into prices, corresponding to an average markup elasticity of $\bar{\Gamma} \approx 1$, close to the estimates provided in Gopinath and Itskhoki (2011) using very different data and methods.

distributions) has a pass-through of 94 percent (= 1 − 0.06). Complete (100 percent) pass-through for such firms cannot be rejected at the 95 percent confidence level. A hypothetical nonimporting firm with a 75 percent market share relative to other Belgian exporters within sector-destination (corresponding to the ninety-fifth percentile of the firm-level distribution of market shares) has a pass-through of 73 percent, that is 21 percentage points (= 0.28 · 0.75) lower. Holding this market share constant and increasing the import intensity of the firm from zero to 38 percent (corresponding again to the ninety-fifth percentile of the respective distribution) reduces the pass-through by another 18 percentage points (= 0.47 · 0.38), to 55 percent. Therefore, variation in import intensity and market share explains a vast range of variation in pass-through across firms. The marginal cost channel (proxied by import intensity) and the markup channel (proxied by market share) contribute roughly equally to this variation in pass-through.

Column 7 concludes this analysis by estimating our main specification (as in column 6) controlling for the industry-destination-year fixed effects ($\delta_{s,k,t}$). Therefore, the only variation used in this estimation is within industry-destination- year, as suggested by our theory in Section ID. In this regression, the coefficient on the exchange rate is effectively allowed to vary at the industry-destination level (i.e., $\alpha_{s,k}$) but is absorbed in the fixed effects. Comparing columns 6 and 7, we see that the point estimates on the import intensity and market share barely change, and the estimates remain strongly statistically significant in column 7 despite thousands of fixed effects.

C. *Nonparametric Results*

Our main empirical findings in Table 5 provide strong support for the theoretical predictions developed in Section I. However, we want to ensure that these results are smooth (e.g., not driven by outliers) and are not artifacts of the linearized specification. We re-estimate the specifications in Table 5 nonparametrically, by splitting the distribution of import intensity φ_f into quartiles. Specifically, we estimate a separate pass-through coefficient for each quartile of the import intensity distribution and plot these coefficients in Figure 1. All estimated coefficients, standard errors, and *p*-values are reported in Table A1 in the online Appendix. The graph shows that the coefficient is estimated to be monotonically higher (thus lower pass-through) as we move from low to higher import intensity bins when we do not include both marginal cost and market share controls. The steepest line corresponds to the unconditional regression (a counterpart to column 2 of Table 5), and is somewhat flatter with controls for marginal cost (column 3), and it is much flatter after controlling jointly for the change in the marginal cost and the market share interaction (column 5). The dashed line corresponds to our main specification (column 6), which controls for both market share and import intensity, but not marginal cost, and it also exhibits a considerable slope across the import intensity bins. Furthermore, in all of these cases the difference between the pass-through coefficient in the first and fourth quartiles is significant with a *p*-value of 1 percent, with the exception of when we control for both marginal cost and markup (market share interaction). In this case, consistent with the theory, the profile of pass-through coefficients across the bins of the import intensity distribution becomes nearly flat with the differences between the pass-through values in different bins statistically insignificant.

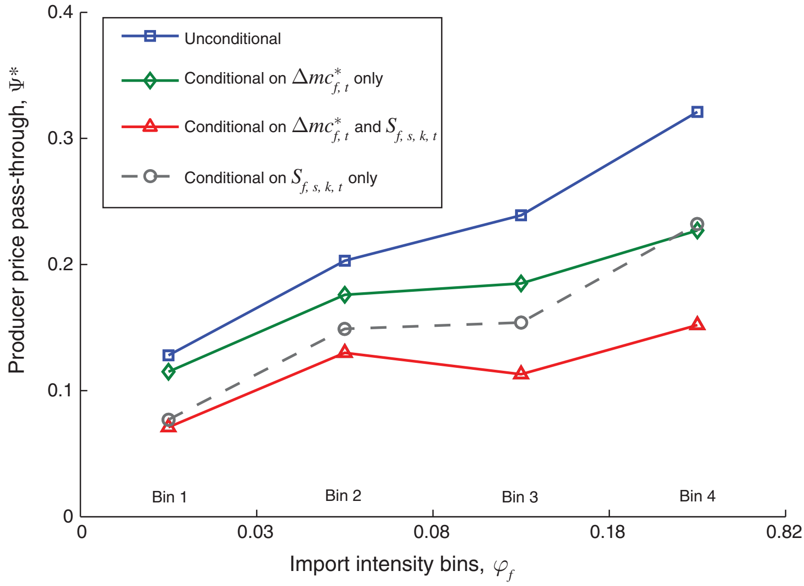

Figure 1. Pass-Through by Quartile of Import Intensity

Notes: Equal-sized bins in terms of firm-product-destination-year observations, sorted by φ_f. The means of φ_f in the four bins are 1.3, 5.5, 13.1, and 30.1 percent, respectively. The figure reports pass-through coefficients of $\Delta p^*_{f,i,k,t}$ on $\Delta e_{k,t}$ within each φ_f quartile, where the regressions include additional controls in levels and interacted with $\Delta e_{k,t}$, as indicated in the legend of the figure, to parallel columns 2–3 and 5–6 of Table 5. The pass-through coefficient in Bin 4 is significantly different from that in Bin 1 at the 1 percent level for all specifications except the third one (controlling for both $\Delta mc^*_{f,t}$ and $S_{f,s,k,t}$) for which it is not significant at the 5 percent level. Additional information is reported in Table A1 in the online Appendix.

An alternative nonparametric specification is to divide the observations by both import intensity and market share. In Table 6, we split all firms into low and high import intensity bins at the median import intensity, and all observations into low and high market share bins depending on whether the firm-sector-destination market share is below or above the seventy-fifth percentile of the market share distribution within-sector-destination. With this split, roughly 50 percent of firm-product-destination-year observations fall within each market share bin. For each of the four bins, we estimate a simple pass-through regression of the change in producer export prices on the change in the exchange rate. Consistent with the results in column 6 of Table 5, we find that pass-through into destination-currency export prices decreases significantly either as we move toward the bin with a higher market share or toward the bin with a higher import intensity. The lowest pass-through of 66 percent (= 1 − 0.34) is found for the bin with high market share and above-median import intensity, compared with the pass-through of 87 percent (= 1 − 0.13) for firms with below-median import intensity and low market share, quantitatively consistent with the results in Table 5.

From Table 6, we see that there are more observations along the main diagonal (around 30 percent in each bin) relative to the inverse diagonal (around 20 percent in each bin), which is due to the positive correlation between the market share and the import intensity in the cross section of firms. This notwithstanding, the share of

TABLE 6—PASS-THROUGH BY IMPORT-INTENSITY AND MARKET-SHARE BINS

	Low import intensity	High import intensity
Low market share	0.131***	0.194***
Fraction of observations	0.30	0.21
Share in export value	0.08	0.10
High market share	0.214***	0.339***
Fraction of observations	0.20	0.29
Share in export value	0.21	0.61

Notes: Coefficients from regression of $\Delta p^*_{f,i,k,t}$ on $\Delta e_{k,t}$ in respective bins without fixed effects; bin-specific intercepts included (all estimated to be close to zero). Firms are sorted by import intensity φ_f into below and above median equal to 8.1 percent; and by market share $S_{f,s,k,t}$ averaged across the years the firm served a given sector-destination into below and above the seventy-fifth percentile within each sector (HS4)-destination, which ensures a roughly even number of firm-product-destination-year observations in each high and low category. The coefficient in the high-high bin is significantly different from the other coefficients at least at a 2 percent level.

export value in the first bin with both low market share and low import intensity is only 8 percent. The fourth bin with both above-median import intensity and high market share accounts for the majority of exports, over 61 percent. This suggests that the pass-through coefficient into destination prices from a regression weighted by their respective export values should be substantially lower than from a regression in which observations are unweighted. Indeed, when weighting by export values, we find a pass-through coefficient of 62 percent, much lower than the 80 percent result in the unweighted specification (column 1 of Table 5). Our evidence further shows that part of this difference is due to greater markup variability among the large exporters, but of a quantitatively similar importance is the higher import intensity of these firms.

Finally, we explore the possibility of nonmonotonic and nonlinear effects of market share and import intensity on pass-through by augmenting the main specification in column 6 of Table 5 with second-order terms. We find that the coefficient on the squared market share term interacted with exchange rate is negative, but insignificant and small. Even using the point estimate, the estimated relationship between pass-through and market share remains monotonically increasing over the whole range [0, 1] of the market share variable, which confirms the theoretical prediction in Proposition 1. Further, although the coefficient on the interaction of import intensity with market share is positive, it is also small and insignificant. These results justify our focus on the linear specification of Table 5 (see discussion in footnote 19).

D. *Deciphering the Mechanism*

Now that we have established that high-import-intensive firms have lower pass-through into export prices, we delve into the underlying mechanisms. According to the theory, higher import intensity is associated with higher marginal cost sensitivity to exchange rates (Proposition 2). We test this directly by regressing the change in the marginal cost $\Delta mc^*_{f,t}$ on the change in the destination-specific exchange rate $\Delta e_{k,t}$ and separately on the change in the firm-level import-weighted exchange rate

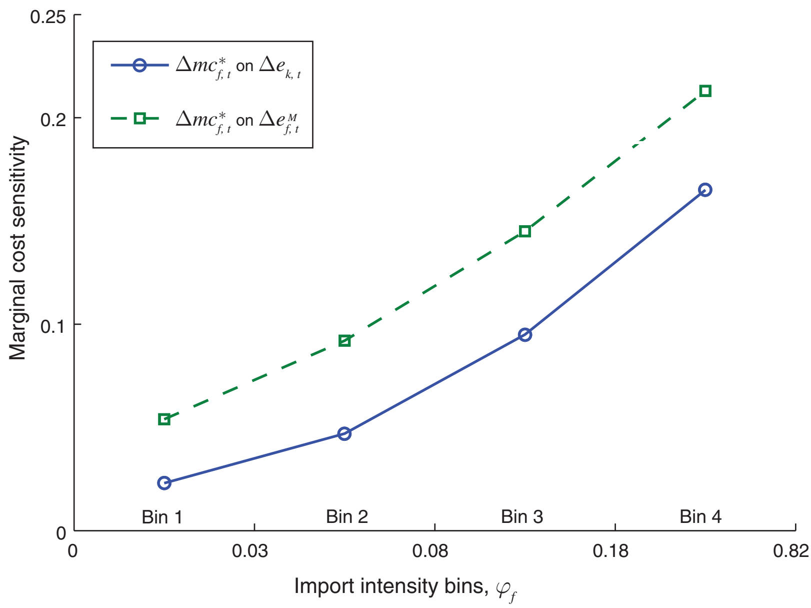

Figure 2. Marginal Cost Sensitivity to Exchange Rates

Notes: The figure plots the pass-through coefficients from regressions of the log change in our measure of the marginal cost of the firm $\Delta mc^*_{f,t}$ on both bilateral export exchange rates $\Delta e_{k,t}$ and firm-level import-weighted exchange rate $\Delta e^M_{f,t}$, by quartiles of the φ_f distribution (as in Figure 1). Additional information is reported in Table A1 in the online Appendix.

$\Delta e^M_{f,t}$, within each quartile of the import-intensity distribution.[33] Figure 2, which plots these coefficients, illustrates a very tight monotonically increasing pattern of marginal cost sensitivity to the destination-specific exchange rates across the bins with increasing import intensity (and columns 5 and 6 in Table A1 in the online Appendix report additional details). Quantitatively, an increase in import intensity from 1 percent on average in the first quartile to 30 percent on average in the fourth quartile leads to an increase in marginal cost sensitivity to the exchange rate from 0.02 to 0.17. This variation is quantitatively consistent with the effects of import intensity on pass-through we studied earlier (see Figure 1). The response of the marginal cost to the import-weighted exchange rate is also monotonically increasing in φ_f and lies strictly above the response to the destination-specific exchange rate, ranging from 0.05 to 0.21.

The theory predicts the patterns depicted in Figure 2 hold when both the correlation between export and import-weighted exchange rates and the pass-through into import prices are positive (see equations (14) and (16)). We now provide evidence for each of these two key structural determinants of the relationship between import intensity and pass-through. Column 7 of Table A1 shows there is a positive correlation between import and export exchange rates by reporting the projection coefficients of firm-level import-weighted exchange rates $\Delta e^M_{f,t}$ on destination-specific exchange rates $\Delta e_{k,t}$ across the quartiles of import-intensity distribution. We

[33] The import-weighted exchange rate $\Delta e^M_{f,t}$ is a weighted average of bilateral exchange rates with weights equal to the import expenditure shares from outside the euro zone at the firm level.

find these projection coefficients to be stable at around 0.45, with no statistically detectable variation across bins of import intensity. Therefore, we find no systematic relationship between import intensity and the extent to which firms align their import sources and export destinations to hedge their exchange rate risks (i.e., *real hedging*).

We next show the importance of this positive correlation between import and export exchange rates for exchange rate pass-through into export prices. Intuitively, we would expect the effects of import intensity to be stronger when inputs are imported from the same country to which the firm sells its products. To capture this idea systematically, we split all source-destination pairs of countries into a high and a low correlation bin depending on whether the correlation between (the annual log changes in) the two respective exchange rates is above or below 0.7. For each firm destination we create two measures of import intensity, $\varphi_{f,k}^{High}$ and $\varphi_{f,k}^{Low}$, from high- and low-correlation source countries respectively.[34] The average correlation between exchange rates in the two bins is 0.92 and 0.25 respectively, and according to the theory (see equation (16)) this difference should directly translate into the differential effect of the two import intensities on the exchange rate pass-through of the firm. This is exactly what we find in column 1 of Table 7, which estimates the augmented specification (21) splitting the firm import intensity into the two components just introduced. The estimated coefficients on the high- and low-correlation import intensity interactions are 0.86 and 0.38 respectively.

We further show that the effect of import intensity on export price pass-through is stronger when the pass-through into imported input prices is higher. We construct the different import intensity measures by splitting all non-euro import source countries in our sample into three groups: high pass-through, low pass-through, and other. The group of other countries contains source countries for which there are either insufficient observations or not enough variation in the exchange rate to estimate import price pass-through accurately. The remaining countries are assigned to the high bin if pass-through exceeds 0.5, and the results are robust to alternative choices of this cutoff. With this procedure we have 19 countries in the high pass-through bin with average pass-through into Belgian import prices of 63 percent and accounting for 38 percent of Belgian firm imports. The low pass-through bin contains 32 countries with average pass-through of 25 percent and accounting for 42 percent of Belgian firm imports. The list of countries, their pass-through and import shares are reported in Table A3 in the online Appendix. We use the three corresponding import intensity variables to estimate an augmented specification (21) in column 2 of Table 7. As predicted by the theory, we find a higher coefficient,

[34] Note that our overall measure of import intensity equals $\varphi_f \equiv \varphi_{f,k}^{High} + \varphi_{f,k}^{Low}$ for all destinations k served by firm f. Table A2 in the online Appendix reports information on the pairs of high- and low-correlation countries. Our results are robust to alternative correlation thresholds, however raising it too high (e.g., setting it at 1, which amounts to placing in the high bin only the imports from the destination country itself in most cases), leaves the high-correlation bin too thin for reliable statistical inference, while reducing it below 0.7 does not allow us to discriminate effectively between very high correlation countries (near pegs) and average correlation countries given the substantial noise associated with the correlation measures. With the threshold of 0.7, the set of high-correlation source countries accounts for 22 percent of total imports.

Table 7—Which Imports Matter?

Dependent variable: $\Delta p^*_{f,i,k,t}$	Exchange rate correlation (1)	Import pass-through (2)	Euro area imports (3)	OECD versus non-OECD (4)
$\Delta e_{k,t}$	0.053*	0.058*	0.044	0.044
	(0.031)	(0.031)	(0.040)	(0.040)
$\Delta e_{k,t} \cdot \varphi_f$	—	—	0.481***	—
			(0.110)	
$\Delta e_{k,t} \cdot \varphi^{High}_{f,k}$	0.864***	0.778***	—	0.472***
	(0.277)	(0.242)		(0.154)
$\Delta e_{k,t} \cdot \varphi^{Low}_{f,k}$	0.376***	0.341	—	0.505**
	(0.131)	(0.241)		(0.210)
$\Delta e_{k,t} \cdot \varphi^{Other}_{f}$	—	0.027	—	—
		(0.316)		
$\Delta e_{k,t} \cdot \varphi^{Euro}_{f}$	—	—	0.060	0.057
			(0.126)	(0.126)
$\Delta e_{k,t} \cdot S_{f,s,k,t}$	0.284***	0.286***	0.282***	0.282***
	(0.063)	(0.063)	(0.063)	(0.064)
FE: $\delta_{s,k} + \delta_t$	Yes	Yes	Yes	Yes
Observations	93,395	93,395	93,395	93,395
R^2	0.058	0.058	0.058	0.058

Notes: Results from the augmented specification

$$\Delta p^*_{f,i,k,t} = \left[\alpha + \beta^{High}\varphi^{High}_{f,k} + \beta^{Low}\varphi^{Low}_{f,k} + \beta^{Other}\varphi^{Other}_{f,k} + \gamma S_{f,s,k,t}\right]\Delta e_{k,t} + \cdots + \epsilon_{f,i,k,t}.$$

Column 1: splits imports into high and low correlation bins for each firm-destination depending on whether the correlation (based on annual log changes) between import and export exchange rate is above 0.7; decomposition of import intensity: $\varphi_f \equiv \varphi^{High}_{f,k} + \varphi^{Low}_{f,k}$ for every destination k. Column 2: splits imports by pass-through into import prices into three bins: high (above 0.5), low (below 0.5), and other (imprecisely estimated), as explained in the text $\left(\varphi_f \equiv \varphi^{High}_f + \varphi^{Low}_f + \varphi^{Other}_f\right)$. Column 3: does not split imports from outside the euro area (φ_f), but instead additionally includes import intensity from within the euro area (φ^{Euro}_f). Column 4: splits non-euro imports into imports from high-income OECD and low-income non-OECD countries ($\varphi_f \equiv \varphi^{High}_f + \varphi^{Low}_f$), also controlling for non-euro imports (φ^{Euro}_f). All regressions additionally control for the levels of all interaction terms and include country-destination and time fixed effects. Other details as in Table 5.

equal to 0.76, for import intensity from high-pass-through countries, while the coefficient for the low-pass-through imports is 0.35 and insignificant.[35]

In column 3 of Table 7, instead of splitting the import intensity from outside the euro area (φ_f), we additionally control for the import intensity from within the euro area (denoted with φ^{Euro}_f). As expected, we find that import intensity from within the euro area has no effect on pass-through, since the prices of these imports, just like those of the Belgium inputs, are insensitive to the euro exchange rate. This regression can be viewed as a placebo test confirming that our import intensity measure φ_f indeed picks up the marginal cost sensitivity to exchange rates rather than proxying for other dimensions of heterogeneity across firms related to import intensity. The

[35] While the share of high-correlation imports is stable at around 22 percent across firms with different import intensity, the share of high-pass-through imports increases from 34 to 44 percent across import intensity quartiles, slightly reinforcing the role of import intensity in our main specification.

results in columns 1, 2, and 3 of Table 7 provide direct evidence of the theoretical mechanisms linking import intensity and exchange rate pass-through.

Lastly, we ask whether there may be additional forces correlated with the firm's import intensity that could potentially confound its relationship with the exchange rate pass-through. A noticeable difference across firms is in their share of imports that comes from non-OECD countries, which tends to be substantially higher for the high-import-intensive firms. The import share from non-OECD countries in total non-euro imports increases monotonically from 25 to 45 percent across the quartiles of import intensity.[36] Column 4 of Table 7 explores the effects of this heterogeneity by splitting the overall measure of the firm's import intensity φ_f into the import intensities from the high-income OECD and low-income non-OECD countries, both outside the euro area. Surprisingly, we find no difference in the effects of import intensity from OECD and non-OECD countries, with both coefficients estimated to be around 0.5. As expected, OECD countries tend to have higher pass-through into import prices of Belgian firms: 44 percent on average versus 15 percent on average from non-OECD countries, though there is significant variation within these groups as reflected in Table A3 in the online Appendix. However, the effects of these import pass-through differences are counterbalanced by the correlation pattern between import and export exchange rates. Indeed, almost all source countries in the high-correlation pairs with destination countries are non-OECD, which is to a large extent driven by the full or partial exchange rate pegs adopted by many non-OECD countries. Overall, we find that the composition of imports from OECD versus non-OECD countries has no detectable effect on the export pass-through of Belgian firms.[37]

To summarize, the data strongly support the specific mechanisms identified by the theory, and we find no evidence that our import intensity measure proxies for other mechanisms or variables that may affect pass-through.

E. *Robustness*

In this section, we consider three sets of robustness tests: including additional controls, considering alternative definitions of import intensity, and using alternative samples in terms of included destinations, firms, and products. We conclude the section by a discussion of the possible selection and measurement issues.

Additional Controls.—In Table 8, we check whether our results are robust to adding in alternative proxies for markup and marginal cost variability such as firm

[36] Both patterns are consistent with the presence of a fixed cost of importing which increases with the geographic and economic distance to the source country, making it worthwhile only for the largest importers to source inputs from the distant countries.

[37] The other two possibilities we explored were whether pass-through into import prices of Belgian firms varies by the type of the product imported (manufactured or not) and/or by the type (size) of the importing firm. Although the share of manufactured products in imports decreases from 95 to 86 percent across the quartiles of import intensity, we find no systematic difference in pass-through for manufacturing and nonmanufacturing imports, once we control for the source country of imports. Similarly, controlling for the source country, we find no systematic difference in import pass-through between small and large firms. Section IIIE presents further robustness tests controlling for the size of the firm and types of imported inputs.

Table 8—Robustness with Additional Controls

Dependent variable: $\Delta p^*_{f,i,k,t}$	(1)	(2)	(3)
$\Delta e_{k,t} \cdot \varphi_f$	0.413***	0.433***	0.418***
	(0.106)	(0.109)	(0.119)
$\Delta e_{k,t} \cdot S_{f,s,k,t}$	0.219***	0.249***	0.245***
	(0.065)	(0.064)	(0.065)
$\Delta e_{k,t} \cdot \log L_{f,t}$	0.044***		
	(0.012)		
$\Delta e_{k,t} \cdot \log TFP_{f,t}$		0.070***	0.080***
		(0.023)	(0.024)
$\Delta \log W^*_{f,t}$			0.004*
			(0.002)
$\Delta \log TFP_{f,t}$			0.035***
			(0.007)
FE: $\delta_{s,k} + \delta_t$	Yes	Yes	Yes
Observations	92,576	92,106	87,608
R^2	0.058	0.058	0.061

Notes: The same specification as in column 6 of Table 5, augmented with additional controls. $L_{f,t}$ is firm employment, $W^*_{f,t}$ is firm average wage rate, and $TFP_{f,t}$ is the estimate of firm total factor productivity.

employment size and measured TFP.[38] The results reported in columns 1 and 2 of Table 8 show that the coefficients on the main variables of interest are hardly affected by the inclusion of these additional interaction terms. Controlling for employment and TFP interactions reduces slightly the estimated coefficients on import intensity and market share interactions, but they remain large and strongly statistically significant. The coefficients on employment and TFP interactions are also positive and significant, indicating that other factors outside our model also influence exchange rate pass-through. Column 3 of Table 8 augments the specification in column 2 by controlling for the local component of the marginal cost—proxied by the log changes in the measure of the firm-level wage rate and the firm TFP—to isolate the effect of import intensity through the foreign-sourced component of the marginal cost of the firm. These additional controls have essentially no effect on the estimated coefficients.

Alternative Definitions of Import Intensity.—To ensure that the results are not sensitive to our definition of φ_f, we experimented extensively with alternative definitions. We report these robustness checks in Table A4 in the online Appendix, where we estimate our main empirical specification using different definitions of import intensity. First, in column 1, we verify that our results are unchanged when as in specification (21) we use lagged time-varying $\varphi_{f,t-1}$ and $S_{f,s,k,t-1}$, as suggested by

[38] In theories where productivity is the only source of heterogeneity, market share, employment, and productivity itself are all perfectly correlated. However, when there is more than one source of heterogeneity, these variables are correlated positively but imperfectly (as we document in Table 4), which allows us to jointly include these variables in one specification. Our empirical results are consistent with Berman, Martin, and Mayer (2012), which focus on firm productivity as a measure of markup variability—we also find that more productive firms have lower pass-through, but we split this effect into the markup and marginal cost channels by controlling separately for market share and import intensity.

Proposition 4, instead of φ_f and $S_{f,s,k,t}$ respectively. Remarkably, the estimated coefficients are virtually the same as in Table 5.

Next, in column 2 of Table A4 we include only manufacturing products in the construction of the import intensity variable. In columns 3 and 4, we respectively restrict the definition of imports to exclude consumer goods and capital goods. In the subsequent columns, we use IO tables to identify a firm's intermediate inputs. In column 5, we include only imports identified as intermediate inputs in the IO tables for all of the firm's exports, and in column 6 we only include IO inputs for a firm's IO major exports. Finally, in column 7, we exclude any import at the CN-8-digit industrial code if the firm simultaneously exports in this category. In all cases, the results are essentially unchanged, except that in the last case the coefficient on the import intensity substantially increases, but it should be noted that the average import intensities here are much lower as we drop a large share of imports from the import intensity calculation.

Alternative Samples.—We further check the robustness of our results within alternative subsamples of the dataset, both in the coverage of export destinations and in the types of products and firms. Table A5 in the online Appendix reports the results in eight alternative subsamples. By and large, it reveals the same qualitative and quantitative patterns we find in our benchmark sample.

Columns 1–3 of Table A5 report the results for three alternative sets of export destinations—all non-euro countries, non-euro OECD countries excluding the United States, and the United States only. It is noteworthy that for the US subsample we estimate both a lower baseline pass-through (for firms with zero import intensity and market share) and a stronger effect of import intensity on pass-through, than for other countries.[39] Our analysis in Section IIID suggests that the larger effect of import intensity on pass-through into export prices to the United States is at least in part due to the stronger correlation between the euro-dollar exchange rate and a typical Belgian firm's import-weighted exchange rate (see Table A2).

The remaining columns in Table A5 consider different sets of products and firms. So far, all of the specifications have been restricted to the subsample of only manufacturing firms because our φ_f measure is likely to be a better proxy of import intensity in manufacturing than for wholesalers, who may purchase final goods within Belgium to export them or alternatively import final goods for distribution within Belgium. In column 4, which adds in all wholesale firms to our baseline sample, we see that although the import intensity and market share interactions are still positive and significant, their magnitudes and *t*-stats are smaller. The wholesalers represent around 40 percent of the combined sample. Next, in column 5, we drop all intra-firm transactions from our baseline sample (around 15 percent of observations), and this has little effect on the estimated coefficients.[40]

[39] Specifically, small nonimporting firms exporting to the US market pass-through on average only 82 percent of the euro-dollar exchange rate changes, while the firms with high import-intensity and high market share (at the ninety-fifth percentile) pass-through only 33 percent. This low pass-through is consistent with previous work using US data.

[40] Using data from the Belgium National Bank, we classify intra-firm trade as any export transaction from a Belgium firm to country *k* in which there is either inward or outward foreign direct investment to or from that country.

Finally, our sample has included only the firm's major export products, based on its largest IO code, in order to address the issue of multiproduct firms. In columns 6–8, we show that the results are not sensitive to this choice of "main products." In column 6, we include all of the firm's manufacturing exports rather than restricting it only to IO major products. In column 7, we adopt an alternative way to identify a firm's major products, using the HS 4-digit category, which is much more disaggregated than the IO categories. And in column 8, we only include a firm if its HS 4-digit major category accounts for at least 50 percent of its total exports. In all three cases, we find the magnitudes on the import intensity and market share interactions are very close to our main specification.

Sticky Prices and Currency Choice.—We now briefly comment on the interpretation of our results in an environment with sticky prices, where exporters choose to fix their prices temporarily either in local or in producer currency. Since we cannot condition our empirical analysis on a price change or split the sample by currency of pricing, our results confound together the change in the desired markup with the mechanical changes in markup induced by the exchange rate movements when prices are sticky in a given currency.[41] Therefore, one should keep in mind that our results suggest that import intensity and market share contribute either to flexible-price pass-through incompleteness or to the probability of local currency pricing, which in turn leads to low pass-through before prices adjust. In reality, both these forces are likely to contribute to incomplete pass-through in our data, however such a decomposition is beyond the scope of this paper. Nonetheless, Gopinath, Itskhoki, and Rigobon (2010) show that the sticky price determinants of incomplete pass-through are largely shaped by the same underlying primitives as the flexible price determinants, and they reinforce each other in the cross section of firms (as we explain in footnote 9).

Measurement and Selection.—We conclude the empirical section with a brief discussion of measurement error and selection bias. One concern is that some firms, particularly small ones, may import their intermediate inputs through other Belgian firms (e.g., specialized importers), which we cannot observe in our data, and hence cannot adjust accordingly our measure of import intensity. Note, however, that this would work against our findings since some of the fundamentally import-intensive firms would be wrongly classified into low import-intensity. This measurement error should cause an upward bias in the estimate of our baseline pass-through (coefficient α in (21)) and a downward bias in our estimate of the import-intensity effect on pass-through (coefficient β), which we find to be large nonetheless. Similarly, we expect the measurement error in import intensity for multiproduct firms to work against our findings. The measurement error for the market share variable is likely to have classical properties, and hence we expect to have a downward bias in the estimates of coefficient γ as well.

[41] Our data do not allow us to do a decomposition into these two sources, as we explain in footnote 21, but one can make such an inference by taking a stand on a particular calibrated structural model of incomplete pass-through with sticky prices.

Further, in the online Appendix we provide a formal theoretical argument that sample selection is also likely to lead to an upward bias in the estimates of α and a downward bias in the estimates of β and γ, as well as provide corroborating empirical evidence. Intuitively, the firms that drop out from the sample in response to an exchange rate appreciation ($\Delta e_{k,t} < 0$) are more likely to be the ones simultaneously hit by an adverse marginal cost shock (e.g., negative productivity shock), and hence would want to raise prices more than firms staying in the sample. Censoring of these firms from the sample leads to an upward bias in α. Since the probability of exit decreases with import intensity and market share (proxying for firm's profitability), we expect this upward bias to be less severe for firms with high import intensity and high market shares, in other words a more shallow relationship between these variables and pass-through. To summarize, this analysis suggests that both measurement and selection issues are likely to lead us to estimate lower bounds on both β and γ, and hence our quantitative account of the variation in pass-through should be viewed as conservative.

IV. Conclusion

In this paper, we show that taking into account that the largest exporting firms are also the largest importers is key to understanding the low aggregate exchange rate pass-through and the variation in pass-through across firms. We find that import intensity affects pass-through both directly, by inducing an offsetting change in the marginal cost when exchange rates change, and indirectly, through selection into importing of the largest exporters with the most variable markups. We use firms' import intensities and export market shares as proxies for the marginal cost and markup channels, respectively, and show that variation in these variables across firms explains a substantial range of variation in pass-through. A small firm using no imported intermediate inputs has a nearly complete pass-through, while a firm at the ninety-fifth percentile of both market share and import intensity distributions has a pass-through of just over 50 percent. Around half of this incomplete pass-through is due to the marginal cost channel, as captured by our import intensity measure. Since import intensity is heavily skewed toward the largest exporters, our findings help explain the observed low aggregate pass-through elasticities, which play a central role in the study of exchange rate disconnect. Finally, we show that the patterns we document emerge naturally in a theoretical framework, which combines standard ingredients of oligopolistic competition and variable markups with endogenous selection into importing at the firm level.

Our findings suggest that the marginal cost channel contributes substantially—reinforcing and amplifying the markup channel—to low aggregate pass-through and pass-through variation across firms. The decomposition of incomplete pass-through into its marginal cost and markup components has important implications for the analysis of the welfare consequences of exchange rate volatility (as emphasized by Burstein and Jaimovich 2012) and the desirability to fix exchange rates, for example, by means of integration into a currency union. Furthermore, price sensitivity to exchange rates is central to the expenditure switching mechanism at the core of international adjustment and rebalancing. A complete analysis of these topics requires a general equilibrium framework disciplined by the type of evidence on the importance of marginal cost and markup channels that we provide in this paper.

Controlling for the marginal cost channel, our evidence still assigns an important role for the markup channel of incomplete pass-through. In particular, we find that large high-market-share firms adjust their markups by more in response to cost shocks. This is consistent with a model in which larger firms also choose higher levels of markups, a pattern that can rationalize the evidence on misallocation of resources across firms, as, for example, documented in Hsieh and Klenow (2009). The markup interpretation of this evidence on misallocation differs from the cost-side frictions interpretation conventional in the literature (an exception is Peters 2013). Our evidence, therefore, is useful for calibration and quantitative assessment of the models of misallocation at the firm level.

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