Dominant Currencies
How firms choose currency invoicing and why it matters[*]

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Abstract

Large movements in exchange rates have small effects on the prices of internationally traded goods. Using a new dataset on currency invoicing of Belgian firms, we study how the currency of invoicing interacts with firm characteristics in shaping the extent of exchange rate pass-through at different time horizons. The US dollar and the Euro are the dominant currencies in both Belgium's exports and imports, with substantial variation in currency choice across firms and products even within narrowly defined manufacturing industries. We find that smaller, nonimport-intensive firms tend to denominate their exports in euros (producer currency pricing) and exhibit nearly complete exchange-rate pass-through into destination currency prices at all horizons. In contrast, the largest most import-intensive firms, and in particular with imports denominated in US dollars, tend to also denominate their exports in US dollars (dominant currency pricing) and exhibit very low pass-through in the short run, which gradually increases to 40–50% pass-through at the annual horizon. We show that these empirical patterns are in line with the predictions of a theoretical framework featuring heterogeneous firms with variable markups, endogenous international input sourcing and staggered price setting with endogenous currency choice. We plan to use a variant of a such model, disciplined with the Belgian firm-level data, for counterfactual analysis of the gradual increase in the use of the euro in international trade flows.

1 Introduction

Large movements in exchange rates have small effects on the prices of internationally traded goods. Using a new confidential dataset on Belgium firms, which combines information on the currency invoicing at the firm-product-country-month level with firm characteristics, we analyze how the currency of invoicing interacts with firm characteristics in determining the degree of exchange rate pass-through into export prices. It is generally difficult to obtain trade data that specifies the currency of invoice, and the ones that are typically available are at the product level with no information about firm characteristics, which theory emphasizes are critical for understanding the currency choice — a firm-level decision. Therefore, the Belgium firm-product-country-level trade data with information on values, quantities and currency of invoicing, merged with domestic datasets on general firm characteristics is uniquely suitable for this analysis.

Amiti, Itskhoki, and Konings (2014) identified firm-level variables — primarily firm size and firm import intensity — as the main determinants of medium- and long-run exchange rate pass-through. The theory predicts that the same characteristics must be the key determinants of the currency invoicing choice of the firms, which in turn shapes the short-run exchange rate pass-through. Therefore, incorporating currency choice into the empirical analysis of the firm-level export pricing is a crucial step in delivering a complete picture of the dynamic patterns of exchange rate pass-through, which is essential to resolve the puzzles surrounding the low aggregate exchange rate pass-through into prices and the heterogeneity in pass-through rates across different countries and industries.

Our empirical analysis is grounded in a theoretical framework which combines heterogeneous firms with variable desired markups (as in Amiti, Itskhoki, and Konings 2018) and endogenous international input sourcing (as in Amiti, Itskhoki, and Konings 2014) and staggered price setting with endogenous currency choice (as in Gopinath, Itskhoki, and Rigobon 2010). This framework predicts that the desired (flexible-price) exchange rate pass-through is shaped by the markup variability and import intensity of the firm, as well as strategic complementarities in price setting with other firms in the industry. The currency choice, in turn, is determined by the desired pass-through of the firm during the period of price non-adjustment. Since the currency choice mechanically shapes the short-run pass-through of the firm, it feeds back — by means of strategic complementarities — into the currency choice and price adjustment decisions of other firms affecting the equilibrium exchange rate pass-through at the industry level. Thus, changes in the equilibrium environment — in particular related to the prevalence in the use of different currencies — can have profound implications for the overall patterns of exchange rate pass-through into export prices and international transmission of shocks.

In the data, we find that the US dollar and the Euro are the two dominant currencies for both Belgian imports and exports — accounting for over 90% of import invoicing and nearly 90% of export invoicing. Therefore, producer (source) currency pricing (PCP) is uncommon for Belgian imports and local (destination) currency pricing (LCP) is uncommon for Belgian exports. Thus the invoicing patterns in the data do not fit well with the conventional international macro models with exogenous PCP or LCP alternatives, but rather fit the framework with endogenously emerging dominant currencies — namely, the dollar as the global dominant currency and the euro as the regional dominant currency.

The recent literature has emphasized the dominance of the US dollar in international trade flows (see e.g. Gopinath 2016). However, the detailed empirical evidence has largely focused on countries which almost exclusively rely on the dollar in both their exports and their imports: e.g., Gopinath, Itskhoki, and Rigobon (2010) examine the evidence for the US and Casas, Díez, Gopinath, and Gourinchas (2016) study the case of Colombia. The euro, being rather a regional currency, is not used intensively in trade flows of these countries. The advantage of studying a Euro country, which is unique to our work, is that we have a much greater variation in currency choice, with the euro used at least as intensively as the dollar. Furthermore, this focus allows us to shed light on the interactions between two dominant currencies — an established global leader and a regional contender.

We find that, for Belgian exports, the euro dominates in accounting for the overall count of transactions, yet it plays a roughly equal role with the US dollar in value terms, reflecting that the larger firms adopt the dollar and the smaller firms predominantly use the euro. This pattern is less prevalent with imports, since large Belgian firms source from both small and large foreign suppliers. The variation across destination countries and detailed industries accounts for less than a half of the variation in the currency use across firm-product-destination-months (corresponding to observations in our panel dataset). In contrast, the variation across firms within industry-destinations accounts for over half of the overall variation in the currency use in our panel. The currency choice is very persistent, and the variation over time is largely absent. These patterns justify our focus on the firm-level analysis of the joint determination of the currency choice and exchange rate pass-through.

We find that the import intensity of the firm and the size of the firm (measured by firm employment) are the prime determinants of the currency choice in our micro-level panel dataset. In particular, small firms with no imported inputs tend to denominate their exports in euros and exhibit nearly complete exchange-rate pass-through into destination currency prices at all horizons. In contrast, large import-intensive firms, and in particular with imports denominated in the US dollar, tend to denominate their exports in the US dollar (dominant currency pricing) and exhibit very low pass-through in the short run, which gradually increases to 40–50% pass-through at the annual horizon. Currency choice by competitor firms is another empirical determinant of the firm's currency choice and pass-through, emphasizing the role of strategic complementarities in currency choice and pricing decisions.

The rest of the paper is organized as follows. We finish the introduction with a brief description of the related literature on currency choice. Section 2 presents our theoretical framework and derives the estimating equations for currency choice and exchange rate pass-through. Section 3 contains our empirical analysis. It starts by introducing our dataset and describing the construction of the variables for the empirical analysis. It then proceeds by documenting a number of stylized facts on the currency use in import and export transactions of Belgian firms. Finally, it presents the main results of our empirical analysis of exchange rate pass-through and currency choice. In Section ?? we plan to explore the quantitative implications and counterfactuals related to the endogenous shifts in the currency choice across firms. Section 5 concludes.

Literature review   on endogenous currency invoicing:

- Theory: one-period general framework in Engel (2006), surveying earlier models; dynamic multi-period framework in Gopinath, Itskhoki, and Rigobon (2010); multi-country general-equilibrium framework in Mukhin (2017).

- Empirical evidence: Goldberg and Tille (2008), Gopinath and Rigobon (2008), Gopinath, Itskhoki, and Rigobon (2010), Goldberg and Tille (2016), Cravino (2017), Gopinath (2016), Boz, Gopinath, and Plagborg-Møller (2017), Chung (2016), Casas, Díez, Gopinath, and Gourinchas (2016), Chen, Chung, and Novy (2018), Auer, Burstein, and Lein (2018), Drenik and Perez (2018)

2   Theoretical Framework

In this section, we draw on new insights developed in the recent literature to provide a unified theoretical framework of currency choice and exchange rate pass-through in order to derive a structural empirical framework. We consider an industry equilibrium in a given industry s in foreign destination k. In what follows, we omit notation s and k when it causes no confusion, and we focus on a problem of a given home (Belgian) firm i exporting to market k. In particular, we consider in turn the firm's desired price, its optimal preset price and optimal currency choice.

Desired price   Firm i's profit from exporting to destination k at price p_i^* in the destination currency is denoted by $\Pi_i(p_i^*) = \Pi_i(p_i^*|\Omega)$, given the state of the world Ω. The state of the world includes the exogenous shocks (e.g. productivity), the endogenous shocks (e.g. exchange rate movements) and the prices of the firm's competitors. The log *desired* price of firm i in the destination currency is given by:

$$\tilde{p}_i^* = \arg\max \Pi_i(p_i^*). \tag{1}$$

That is, $\tilde{p}_i^* = \tilde{p}_i^*(\Omega)$ is the price that the firm would choose if it were setting prices flexibly.

In the producer currency (euro), the log desired price is:

$$\tilde{p}_i = \tilde{p}_i^* + e, \tag{2}$$

where $e = e_k$ is the log bilateral exchange rate of euro with the currency of the destination country k. Following convention, an increase in e denotes a *depreciation* of the home currency (euro) and an appreciation of the destination currency. More generally, we can express the desired price in any other currency ℓ as:

$$\tilde{p}_i^\ell = \tilde{p}_i^* + e - e_\ell, \tag{3}$$

where e_ℓ is the bilateral exchange rate of euro with currency ℓ. In particular, we will be interested in the case where $\ell = d$, corresponding to the US dollar, the common vehicle currency.

The desired price defines the desired markup of the firm $\tilde{\mu}_i$, which satisfies:

$$\tilde{p}_i = \tilde{\mu}_i + mc_i, \tag{4}$$

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where mc_i is the marginal cost of the firm in the producer currency. We follow Amiti, Itskhoki, and Konings (2018) and adopt the following decomposition of the change in the desired price of the firm, which applies across a general class of models of monopolistic and oligopolistic competition:

$$\mathrm{d}\tilde{p}_i = \frac{1}{1+\Gamma_i}\mathrm{d}mc_i + \frac{\Gamma_i}{1+\Gamma_i}\mathrm{d}(z_k^* + e) + \varepsilon_i, \tag{5}$$

where z_k^* is the competitor price index in the destination currency (in a given industry-destination), ε_i is the demand (markup) shock, and Γ_i is the elasticity of the desired markup with respect to price, $\Gamma_i \equiv -\partial\mu_i/\partial p_i$. As a result, $1/(1+\Gamma_i)$ is the own cost pass-through elasticity of the firm and the coefficient $\Gamma_i/(1+\Gamma_i)$ reflects the strength of strategic complementarities in price setting.

We define the desired pass-through of the firm as the elasticity of the desired price $\tilde{p}_i$ with respect to the exchange rate e:[1]

$$\tilde{\psi}_i \equiv \frac{\mathrm{d}\tilde{p}_i}{\mathrm{d}e} = \frac{1}{1+\Gamma_i}\varphi_i + \frac{\Gamma_i}{1+\Gamma_i}(1 - \Psi_k^*), \tag{6}$$

where $\varphi_i = \mathrm{d}mc_i/\mathrm{d}e$ is the exposure of the firm's marginal cost to the exchange rate and $\Psi_k^* \equiv -\mathrm{d}z^*/\mathrm{d}e$ is the response of the industry-destination price index to the exchange rate (in the destination currency). We assume that firm idiosyncratic shocks are orthogonal to the exchange rate ($\mathbb{E}\{\mathrm{d}\varepsilon_i/\mathrm{d}e\} = 0$).

For convenience of interpretation, we can rewrite (6) as:

$$\tilde{\psi}_i = \varphi_i + \frac{\Gamma_i}{1+\Gamma_i}[(1 - \Psi_k^*) - \varphi_i].$$

Firms with no cost exposure to the exchange rate ($\varphi_i = 0$) and zero markup elasticity ($\Gamma_i = 0$) have a zero desired pass-through in the producer currency ($\tilde{\psi}_i = 0$). Note that this case corresponds to *complete* pass-through in the destination currency, with the destination-currency desired price $\tilde{p}_i^*$ moving one-to-one with the exchange rate. As soon as either the firm's marginal cost moves with the exchange rate ($\varphi_i^* > 0$) or it has strategic complementarities in price setting with other firms supplying the market ($\Gamma_i > 0$), the firm's desired pass-through is positive in the producer currency ($\tilde{\psi}_i > 0$), or equivalently the pass-through is incomplete in the local destination currency.[2]

Lastly, in a broad class of oligopolistic and monopolistic competition models, the markup elasticity Γ_i is increasing with the size of the firm, and in particular with the destination-specific market share of the firm: $\Gamma_i = \Gamma(S_i^*)$ with $\Gamma'(\cdot) > 0$ (see Amiti, Itskhoki, and Konings (2014, 2018)). For example, in the Atkeson and Burstein (2008) oligopolistic competition model with CES demand, under the assumption of the Cobb-Douglas preference aggregator across sectors, the markup elasticity is simply $\Gamma_i = (\rho - 1)S_i^*$, where $\rho > 1$ is the within-industry elasticity of substitution.

Price stickiness and preset prices   We consider a single-period model with a period of arbitrary length Δ, with $\Delta = 1$ corresponding to an annual horizon, and denote with θ the annual Calvo probability of price adjustment. Hence, over a period of arbitrary length Δ, $\pi_\Delta = 1 - e^{-\theta\Delta}$ is the probability

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[1]Note that it is not a causal response, but rather a measure of equilibrium comovement between two endogenous variables.

[2]Also note that the local price stability in the destination market corresponds to $\Psi_k^* \approx 0$. This makes the markup adjustment of firm i approximately given by $\frac{\Gamma_i}{1+\Gamma_i}(1 - \varphi_i)$.

of price adjustment and $1 - \pi_\Delta = e^{-\theta\Delta}$ is the probability of no price adjustment. Note that for a small Δ, we have $\pi_\Delta \approx \theta\Delta$, an approximation that we use for convenience. Our analysis generalizes to a fully dynamic model as in Gopinath, Itskhoki, and Rigobon (2010; henceforth GIR) and a model of state-contingent price adjustment as in Gopinath and Itskhoki (2010).

The firm presets its price before the shocks in Ω are realized, and it then faces the Calvo probability of not being able to adjust the preset price once it observes the shocks. If the firm presets its price in currency of country ℓ, we denote the preset price $\bar{p}_i^\ell$, so that the corresponding destination-currency price upon the realization of the exchange rates $\{e, e_\ell\}$ is $p_i = \bar{p}_i^\ell + e_\ell - e$. Note that ℓ can correspond either to the destination (local) currency (with $e_\ell = e$), the producer currency (euro; with $e_\ell = 0$), or the vehicle currency (dollar; with $e_\ell = e_d$). We use the conventional abbreviations LCP, PCP and DCP, respectively, for these three currency pricing regimes. The preset price in currency ℓ solves:

$$\bar{p}_i^\ell = \arg\max_{\bar{p}_i^\ell} \mathbb{E}\,\Pi_i(\bar{p}_i^\ell + e_\ell - e|\Omega), \tag{7}$$

where the expectation is taken over the possible realizations of the state vector Ω. Apart from the DCP case with $\ell = d$, we emphasize two special cases, namely PCP with $e_\ell = 0$ and LCP with $e_\ell = e$, and we use the following notation for the optimal preset prices in these two cases respectively:

$$\bar{p}_i = \arg\max_{\bar{p}_i} \mathbb{E}\,\Pi_i(\bar{p}_i - e) \qquad \text{and} \qquad \bar{p}_i^* = \arg\max_{\bar{p}_i^*} \mathbb{E}\,\Pi_i(\bar{p}_i^*).$$

Without loss of generality, we normalize the expected values of exchange rates to zero, $\mathbb{E}e = \mathbb{E}e_\ell = 0$. We can then prove the following result (See Proposition 1 in GIR and its generalization to DCP in Mukhin 2017):

Lemma 1 (Preset prices) *The first-order approximation to the optimal preset prices satisfies:*

$$\bar{p}_i = \bar{p}_i^* = \bar{p}_i^\ell = \mathbb{E}\{\tilde{p}_i^\ell + e_\ell - e\} = \mathbb{E}\,\tilde{p}_i^* \qquad \text{for any currency } \ell. \tag{8}$$

In words, under any currency choice, the firm chooses its preset price to target the expected desired price defined in (1). Intuitively, this is a *certainty equivalence* principle: if exchange rates are random walks (in a dynamic version of the model), then (8) is the *law of one price* parity condition for price setting, which corresponds to the profit-maximizing preset prices under different currency choices.[3]

Currency choice   With this setup, we can now consider the currency choice ℓ of a firm, which it makes at the same time as setting the preset price $\bar{p}_i^\ell$, and before it observes the shocks in Ω. Formally,

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[3]Note that this theoretical result corresponds to a hypothetical counterfactual of exogenously changing the currency choice for a given firm pricing in a given destination market. The empirically documented violations of the law of one price correspond either to the variation across firms (see e.g. GIR) or the variation in prices of a given firm across destination markets (see e.g. Fitzgerald and Haller 2014).

the optimal currency choice solves:[4]

$$\ell = \arg\max_\ell \left\{ \max_{\bar{p}_i^\ell} \mathbb{E}\, \Pi_i\big(\bar{p}_i^\ell + e_\ell - e | \Omega\big) \right\}. \tag{9}$$

Following the insights in Engel (2006), GIR and Mukhin (2017), this complex problem with a general profit function $\Pi_i(\cdot)$ can be shown to be approximately equivalent to a simpler problem, connecting the currency choice to the covariance properties of the desired price with the exchange rates. Specifically, we have:

Lemma 2 (Currency choice) *Under a second-order approximation to the general profit function $\Pi_i(\cdot)$, the optimal currency choice in* (9) *is equivalent to:*

$$\ell = \arg\min_\ell \left\{ \mathrm{var}\big(\tilde{p}_i^\ell \big) \right\} = \arg\min_\ell \left\{ \mathrm{var}\big(\tilde{p}_i^* + e - e_\ell \big) \right\}. \tag{10}$$

In words, the optimal currency of pricing ℓ ensures the minimal variation in the desired price $\tilde{p}_i^\ell$ expressed in currency ℓ. This might at first appear as a surprising result, nonetheless, it is very intuitive on reflection. The preset prices attempt to target the desired price (see Lemma 1). When the desired price expressed in currency ℓ is very volatile with the exchange rate changes, currency ℓ is a poor choice for presetting the price as it will result in large profit losses across different states of the world. In contrast, when the desired price is very stable in a given currency ℓ, fixing the price in this currency results in little loss relative to the flexible price setting, which explains the result in Lemma 2.

Note that the variance term in (10) can be expanded as a sum of the variances and covariances, which then can be combined into a linear regression coefficient of the desired price with the exchange rate (see Engel 2006 and GIR). For concreteness, consider producer currency pricing (PCP), which is adopted by the firm if $\mathrm{var}\big(\tilde{p}_i \big) = \min_\ell \left\{ \mathrm{var}\big(\tilde{p}_i^\ell \big) \right\}$. Since $\tilde{p}_i = \tilde{p}_i^* + e$, this choice is favored when the desired price in destination currency $\tilde{p}_i^*$ strongly (negatively) comoves with the bilateral exchange rate e, corresponding to high (nearly complete) pass-through into the export-destination price. That is, if $\tilde{\psi}_i = \partial \tilde{p}_i / \partial e \approx 0$, as defined in (6), the firm chooses producer currency pricing. In contrast, with $\tilde{\psi}_i \gg 0$, the PCP choice is suboptimal, and so the firm chooses either local currency or vehicle currency pricing. Along similar lines, the choice between LCP and DCP then depends on the relative stability of $\tilde{p}_i^*$ and $\tilde{p}_i^d$.

More formally, the choice of PCP over LCP implies $\mathrm{var}\big(\tilde{p}_i \big) < \mathrm{var}\big(\tilde{p}_i^* \big) = \mathrm{var}\big(\tilde{p}_i - e \big)$, or equivalently $\frac{\mathrm{cov}(\tilde{p}_i, e)}{\mathrm{var}(e)} < \frac{1}{2}$. Note that the left hand side in this last inequality corresponds to the unconditional regression coefficient of the desired price on the bilateral exchange rate with the destination currency, which is approximately equal to $\tilde{\psi}_i$ defined in (6). This analysis can be extended to additional third currencies, such that PCP is chosen when $\tilde{\psi}_i \gtrsim 0$, LCP is chosen when $\tilde{\psi}_i \lesssim 1$, and DCP *may* be chosen in the intermediate range (for further details see Mukhin 2017). We summarize these insights in the

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[4]The analysis here goes through if the profit function $\Pi_i(\cdot)$ is replaced with the joint surplus function of the supplier and the buyer of product i, and hence the currency choice is not necessarily a unilateral decision of the supplier, but could also be the outcome of a bilateral bargaining game.

following stylized way:

$$\iota_i = \begin{cases} 0 \text{ (PCP)}, & \text{if } \tilde{\psi}_i \gtrsim 0 \\ 1 \text{ (LCP or DCP)}, & \text{otherwise, i.e. if } \tilde{\psi}_i \gg 0, \end{cases} \tag{11}$$

with the desired pass-through $\tilde{\psi}_i$ defined in (6).

Exchange rate pass-through   The realized exchange rate pass-through of the firm is shaped by two forces — the currency choice if the price is not adjusted and the desired pass-through if price is adjusted. A firm that choses PCP will have a zero (complete) pass-through into the destination (local) currency price before it resets the price, and vice versa for an LCP firm. A DCP firm will have its short-run pass-through in some intermediate range between zero and one. Conditional on price adjustment, the firm will adjust according to its desired pass-through, independently of its currency choice.

Formally, we can write the realized pass-through of the firm as follows:

$$\psi_i = (1 - \pi_\Delta)\iota_i \chi_i + \pi_\Delta \tilde{\psi}_i, \tag{12}$$

where recall that π_Δ is the probability of price adjustment over a period Δ and we introduce $\chi_i = 1$ for LCP firms and $\chi_i \in [0, 1]$ for DCP firms, while for PCP firms $\iota_i \chi_i = 0$ as $\iota_i = 0$. Therefore, (12) combines the mechanical pass-through during the period of no price adjustment, which depends on the endogenous currency choice, with the endogenous pass-through conditional on price adjustment.

In the short run, as Δ and π_Δ approach zero, exchange rate pass-through is entirely determined by currency choice. Over very long horizons, when prices are flexible ($1 - \pi_\Delta \approx 0$), currency choice should not matter directly, and can only be correlated with the observed exchange rate pass-through ψ_i due to selection into currency choice based on desired pass-through $\tilde{\psi}_i$, as emphasized in (11).

Over the short and medium run, prior to full price adjustment, currency choice has a direct effect on the realized exchange rate pass-through of the firms in a given industry-destination. This, in turn, feeds back into the desired pass-through of every individual firm supplying this market, as captured by the term Ψ_k^* in (6). As a result, there are strategic complementarities in the currency choice decision, and the choice ι_i of any individual firm depends on the choices of its competitors ι_{-i}. Indeed, more firms adopting local currency pricing reduces pass-through into destination currency (lower Ψ_k^*), increasing $\tilde{\psi}_i$ and making LCP choice by any individual firm a more likely outcome.[5]

Estimating equations   In our empirical analysis, we focus on the two key outcomes for the firm: the currency choice ι_i characterized by (6) and (11) and the realized pass-through ψ_i characterized in (12). We, therefore, take the first order approximations of these relationships, which results in our estimating

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[5]Formally, the strategic interaction in currency choice are captured by the presence of competitor prices in the firm's state vector Ω. As a result, the optimality conditions for the firm's problems in (7) and (9) characterize the firm's best response to the strategies of its competitors captured in Ω. The full industry equilibrium corresponds to the fixed point of the currency choice and price setting game between all firms in the industry. Our empirical focus makes it sufficient to describe the firm's best response, leaving out the full equilibrium characterization (see Amiti, Itskhoki, and Konings 2018, Mukhin 2017).

equations. In particular, for currency choice, we estimate a linear probability specification:

$$\mathbb{P}\{\iota_i = 1\} = \mathbf{1}\{\tilde{\psi}_i \gg 0\} \approx \alpha_{sk} + \beta\varphi_i + \gamma S_i, \tag{13}$$

where α_{sk} is the industry-destination fixed effect, φ_i is a measure of the firm's cost exposure to the exchange rate (e.g. import intensity) and S_i is a measure of the firm's size, which proxies for the variation in markup elasticity Γ_i. Equation (13) describes the within industry-destination variation in currency choice across firms. In some specifications we also control for the currency choice of the firm's competitors ι_{-i}, which should explain part of the equilibrium variation across industry-destinations.

For the exchange rate pass-through we augment the specification in Amiti, Itskhoki, and Konings (2014) with the currency choice ι_i and estimate the following price-change regression:

$$\mathbb{E}\Delta p_i \approx a_{sk} + \Big[b\varphi_i + cS_i + d\iota_i\Big]\Delta e \tag{14}$$

As we vary the horizon Δ, we expect b and c to become significant, and d to become less significant.

3 Empirical Analysis

In this section, we describe our dataset and the construction of the main variables. We then present new stylized facts on currency invoicing and describe our main empirical results.

3.1 Data Description

The novel data we use for our analysis is the information on the currency choice at the firm-product-country-month level for all import and export transactions from February 2017 to March 2018. The Belgian Customs Office only began to collect these data in a systematic way at the beginning of 2017, which were then processed by the National Bank of Belgium. Because the Customs Office only records extra-EU transactions, the currency data are only available for trade transactions with countries outside of the European Union. All international trade transactions that take place within the European Union are collected by a different authority, the Intrastat Survey, which does not report the currency of invoicing. Importantly, we have the invoicing information for both exports and imports at the firm-product level, with the importing side rarely observed in other datasets. For all extra-EU transactions, we have the value, quantity and currency of invoice for exports and imports. These data are reported at the firm level by destination and source country for each product classified at the 8-digit combined nomenclature (CN) in values and quantities, with around 10,000 distinct products. The first 6-digits of the CN codes correspond to the World Harmonized System (HS).

For the baseline exchange rate pass-through analysis, we use annual data on trade flows and firm characteristics for the period 2012 to 2017, as we are interested in studying the equilibrium relations following the theoretical framework described in Section 2. Since our data does not include information on the currency of invoicing prior to 2017, we take the currency of invoicing from the monthly trade data in 2017 and 2018 and extrapolate it to the years 2012-2016. In doing so, we calculate each firm's

share of exports by destination invoiced in noneuro currency, and assume that it is persistent over time in the previous 5 years.[6] As the theory arguably best describes the differentiated manufacturing products in developed countries, our baseline focus is on the high-income non-euro trade partners of Belgium: Australia, Canada, Iceland, Israel, Japan, the Republic of Korea, New Zealand, Norway, Switzerland, and the United States. However, we will also present summary statistics and robustness for the full sample of countries and industries.

The dependent variable in the exchange rate pass-through regressions is the log change in a firm f's export price of good i to destination country k at time t (we omit index f for brevity), proxied by the change in a firm's export unit value, defined as the ratio of export values to export quantities:

$$\Delta p_{ikt}^* \equiv \Delta \log \left(\frac{\text{Export value}_{ikt}}{\text{Export quantity}_{ikt}} \right), \tag{15}$$

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. Despite the high degree of disaggregation in the CN product codes, unit values may still be an imprecise proxy for prices because there may be more than one distinct product within a CN 8-digit code resulting in some unit value changes arising due to compositional changes within a product code or due to errors in measuring quantities. To try to minimize this problem, we clean the data by dropping the observations with abnormally large price jumps, namely with year-to-year price ratios above 3 or below 1/3. Summary statistics for all variables are provided in the Appendix Table A1.

To understand the determinants of currency choice, we combine these data with firm characteristics drawn from annual income statements of all incorporated firms in Belgium. This combination of invoicing data with the firm characteristics is unique to Belgium. It is straightforward to merge these datasets as both include a unique firm identifier. In particular, we use the quarterly VAT declarations, which all firms are required to submit to the tax office. This comprises information on the cost of total material inputs used. We also rely on data from the Social Security Office, where all firms have to report their employment and wages paid. Using these data, we construct two key variables: the import intensity from outside the eurozone φ_{it} and the firm's market share S_{ikt}, following Amiti, Itskhoki, and Konings (2014). Specifically,

$$\varphi_{it} \equiv \frac{\text{Total non-euro import value}_{it}}{\text{Total variable costs}_{it}}, \tag{16}$$

where total variable costs comprise a firm's total wage bill and total material cost. We usually average this measure over time to obtain a firm-level average import intensity denoted by φ_i. Note that this variable is measured at the firm level and applies to all products i produced by firm f.

We further split this variable by the currency of invoicing, to get a measure of the share of imports invoiced in euros and noneuros. For the EU countries with missing currency information, i.e. the United

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[6]For most firms, this is a zero-one dummy variable, with zero corresponding to producer-currency (euro) exports; however, for a small share of firms, this variable takes fractional values on $(0, 1)$, if the firm sells multiple products to a given destination invoiced in different currencies.

Kingdom and Sweden, we assign the firm's overall currency share to those source countries for the construction of this variable. We denote the euro and non-euro invoiced import with E and X superscripts respectively, so that the overall import intensity of the firm can be decomposed as $\varphi_i = \varphi_i^E + \varphi_i^X$.

The firm's market share is constructed as follows:

$$S_{ikt} \equiv \frac{\text{Export value}_{ikt}}{\sum_{j \in F_{skt}} \text{Export value}_{jkt}}, \tag{17}$$

where s is the sector in which firm f sells product i and F_{skt} is the set of Belgian exporters to destination k in sector s at time t; the numerator (Export value$_{ikt}$) measures the total exports of all products of firm f to destination k in sector s corresponding to product i of the firm. Therefore, S_{ikt} 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 absorbed into industry-destination fixed effects), and hence our measure of S_{ikt} captures all relevant variation for our analysis. We define sectors at the HS 4-digit level, at which we both obtain a nontrivial distribution of market shares and avoid having too many sector-destinations served by a single firm.

3.2 Stylized facts on currency choice

We start by documenting the overall incidence of different currencies in imports and exports. The currency data is available only for the extra-EU trade, which accounts for 34% of total Belgian imports and 28% of exports. Belgian main trade partners are the EU members, and it is reasonable to assume that the trade flows within the EU are predominantly invoiced in euros. Belgium, however, is a very open economy, with the trade (imports plus exports) to GDP ratio of 169% in 2017, and hence its ex-EU trade flows, while accounting for about a third of its total trade flows, are still important as a share of GDP.

In Table 1, we report the shares of currency use (for euro, dollar and other currencies combined) in Belgian ex-EU imports and exports. We report the shares of both the observed transactions (at firm-product-country-month level) and the value of trade flows. In exports, the euro accounts for nearly 70% of observations, yet only 39% of the value of the trade flows, suggesting that it is the smaller transactions that are denominated in euros. In contrast, the dollar accounts for just 21% of observations, yet almost a half (48%) of the value of exports, making the dollar the dominant export currency. The other currencies combined account for just over 10% of Belgian exports, both in count and in value terms. Therefore, the incidence of local (destination) currency pricing — other than the dollar — is not very high in Belgian exports.[7]

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[7]While the US is the largest trade partner of Belgium outside the EU, it still accounts for a modest share of total Belgian trade — namely, 7.2% of imports and 4.7% of exports. The prevalence of the US dollar in Belgian trade invoicing considerably exceeds these shares. For example, if we drop the US as an export destination, the share of the dollar use in export invoicing falls only from 47% to 42%. This emphasizes the dominant role of the US dollar as the vehicle currency in international trade,

Table 1: Currency use in exports and imports

| | Exports | | | | Imports | | | |
| | Count | Value share | | | Count | Value share | | |
	share	All	Diff	Non-diff	share	All	Diff	Non-diff
Euro	0.691	0.388	0.425	0.324	0.418	0.414	0.512	0.283
Dollar	0.207	0.475	0.374	0.645	0.495	0.501	0.354	0.701
Other	0.102	0.137	0.201	0.031	0.087	0.084	0.134	0.017

For imports, the value shares are almost the same as for exports: euro accounts for 42% of the value of imports, dollar accounts for 49% and all other currencies combined account for 9%. For imports, however, there is no discrepancy between the shares in terms of observations and in the value terms, suggesting that on average there is no difference in the size of the transactions across the three currency bins that we consider.[8] The limited role of the other currencies (accounting for under 9% of imports) suggests that producer currency pricing — again outside of the case of the dollar — is an infrequent phenomenon in Belgian imports.

Differentiated goods (defined by the Rauch classification) account for about 85% of both Belgian imports and exports by count of observations, and therefore the overall count shares reported in Table 1 also approximately equal the count shares for the differentiated goods. In terms of value, however, differentiated goods account for around 60% of trade — specifically, 63% of exports and 57% of imports. Not surprisingly, for the non-differentiated goods — many of which are commodities or homogeneous goods — the dollar is a much more prevalent currency, accounting for 70% of imports and 65% of exports. The role of the dollar is, however, much more modest in the differentiated trade flows — accounting for around 35% of both imports and exports, with the euro being more important and accounting for 43% of exports and 41% of imports. Also note that the use of the third currencies, which are nearly absent in the non-differentiated trade invoicing, becomes more prevalent for differentiated goods — accounting for 20% of exports and 13% of imports.

Across countries What is the pattern of invoicing for exports vs imports for a given trade partner? Grassman (1973) found that Swedish exports were mostly invoiced in Swedish kronas and Swedish imports were mostly invoiced in the producer's currency. The intuition behind *Grassman's law* is that a firm with more bargaining power will choose its own currency to avoid exchange rate risk. Of course, this presumes that the exporter has more bargaining power, an assumption that would be difficult to test given the lack of data on both sides of the transaction. Nevertheless, the Grassman's law would suggest that Belgian exporters are more likely to invoice their exports in euro (producer currency) than their imports. However, we find that this pattern does not hold in our dataset. Instead, we find that for each country, the euro share of Belgian imports is on average higher than for Belgian exports. We can see this in Figure 1, where we plot each country's share of exports invoiced in euros against the euro

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consistent with the patterns documented by Gopinath (2016).

[8] If we focused on differentiated goods, the share of Belgian imports invoiced in euros is 41% in count terms and 51% in value terms (and in dollars 50% and 35% respectively), suggesting that the local currency transactions are larger on average.
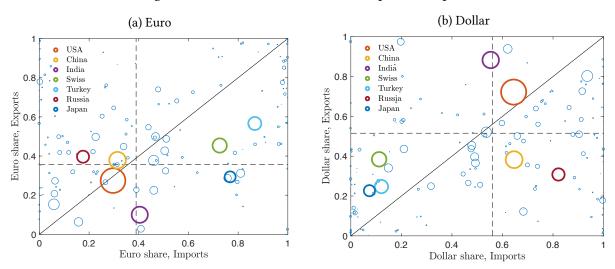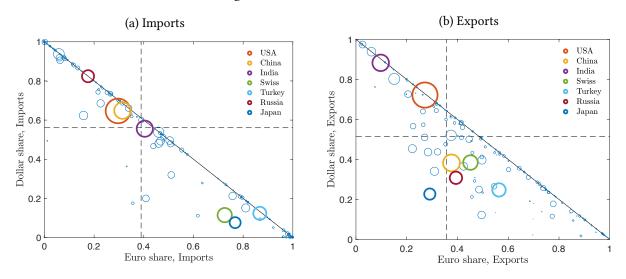
Figure 1: The use of euro and dollar: imports vs exports

(a) Euro

(b) Dollar

Figure 2: Dominant currencies

(a) Imports

(b) Exports

Note: Each circle corresponds to a country — a Belgian trade partner outside of the EU — with the size of the circles proportional to the share of the country in total trade flows (exports plus imports). The import and export shares are in value terms. The countries identified with individual colors correspond to the Belgium's top seven trade partners. The dashed lines identify the average currency shares across all countries, as reported in Table 1.

share in its imports, with the size of the circle representing the relative trade. With most points below the 45 degree line, the right panel indicates that the home currency (euro) is more commonly used for imports than for exports. This is true even though Belgian imports are more commodity-intensive than exports, with commodities and homogenous goods being more commonly invoiced in US dollars. One reason that Grassman's law fails to hold relates to the increasing use of a *dominant* currency in trade transactions. This dominant currency is usually considered to be the US dollar, but it could also be the euro, especially for the transactions involving a eurozone country on one end of the trade.

To check for the importance of a dominant currency, we plot the dollar share of imports against the euro share of imports in the left panel of Figure 2 and provide a similar plot for exports in the right panel. Each point denotes the currency share of trade between Belgium and a specific country, with the size of the circles representing the relative size of the trade. The fact that most points for importing (left panel) lie on the negative diagonal implies there is little use of a the producer currency in importing by Belgian firms, that is imports are either invoiced in euros or dollars. Almost all countries are on the diagonal — except for Switzerland and Japan among the main trade partners — very few major industrial countries use their own currency when exporting to Belgium. A similar pattern, but not as tight, appears for exports on the right panel. Again, countries lying on the negative diagonal implies little use of a third currency, here denoting local currency, with exports mostly denominated in euros or dollars. However, for Belgian exports there are a few more countries off the diagonal, most notably Switzerland, Japan, Russia, China and Turkey, as well as a number of other smaller trading partners.

Variance decomposition   We now explore the patterns of variation in currency choice in our panel of firm-product-country-month observations, for both exports and imports. We define a currency dummy variable for firm-product i, export-destination or import-source country k, in month t:

$$\iota_{ikt} = \left\{ \begin{array}{ll} 0, & \text{if transaction is in euro,} \\ 1, & \text{otherwise, if transaction is in non-euro.} \end{array} \right.$$

From Table 1 we know that $\iota_{ikt} = 1$ for nearly 70% of export observations which account for about 40% of export value. First, in the time-series dimension, we observe only 3.4% of observations that change the currency of pricing over the 13-month period in our sample, and therefore the currency choice is a very persistent characteristic.

Next, we explore the patterns of cross-sectional variation in currency choice — across countries, industries and firms. In particular, in Table 2, we project the currency dummy ι_{ikt} for export observations on various subsets of fixed effects, and report the adjusted R^2 from a value-weighted projection. The patterns of the results for unweighted projections and for imports are quantitatively similar, with the share of the explained variation in the unweighted projections being somewhat lower.

Table 2 shows that the variation across destination countries accounts for a small share, under 13%, of the variation in the currency choice in our panel. At the same time, combining the country fixed effects with industry fixed effects explains around 40% (39% with 4-digit and 46% with 8-digit industry fixed effects) of the variation in the currency choice. The interaction of the country and 4-digit industry

Table 2: Variance decomposition: exports

	(1)	(2)	(3)	(4)	(5)	(6)
Adjusted R^2	0.126	0.386	0.461	0.539	0.563	0.681
Fixed effects:						
country	✓	✓	✓		✓	
HS-4 industry		✓				
HS-8 industry			✓			
country×HS-4				✓		✓
firm					✓	✓

Note: Value-weighted projections of a currency dummy equal to zero if the currency of a given firm-product-country-month observation is euro and equal to one otherwise (non-euro) on different sets of fixed effects.

fixed effects accounts for 54% of variation in the currency choice in the full panel, with about half of the variation remaining at the within country-industry level. The firm fixed effects, together with the country fixed effects, explain over 56% of variation, suggesting that the firm-level variation is central for explaining the currency choice. This is consistent with the focus of our theoretical framework on the within-market across-firm variation in pass-through and currency choice. Lastly, the firm fixed effects combined with country×industry fixed effect explain nearly 70% of the panel variation in the currency choice, with the remaining variation at the product-country level.

3.3 Empirical Results

In this section, we first analyze the determinants of currency choice and then estimate how the currency choice affects the exchange rate pass-through into export prices, after controlling for other firm-level determinants of desired pass-through, following the theoretical framework of Section 2.

Currency choice   Theory suggest that currency of invoicing is an endogenous choice that depends on the firm's share of imported inputs in total costs φ_i and its markup elasticity $\Gamma_i = \Gamma(S_i)$, which is increasing with the size (market share) of the firm. We expect that firms with low φ_i and Γ_i are more likely to choose the producer currency (euros in our case). We estimate the (linear) probability of a Belgium firm invoicing its exports to an OECD country in non-euros as a function of these two key firm characteristics and report the results in Table 3. All standard errors are clustered at the firm level. The dependent variable is a dummy equal to 1 if the Belgian exporter invoices in non-euros and zero otherwise. The observations are at the firm-HS8-country-month level, with about a third of the observations invoiced in non-euros. We have a direct measure of the firm's imported input intensity φ_i, which we construct as the share of the firm's non-eurozone imports in total costs. However, our measure of the firm's markup elasticity Γ_i is indirect, which we proxy with the firm's size. In these specifications, we use the firm's employment, averaged across 2016, as a proxy for the size of the firm.[9] All of the specifications include time fixed effects to absorb macroeconomic variation.

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[9]We also experimented with the firm's market share and, while the point estimate was positive as expected, it was not significant at conventional levels.

Table 3: Currency choice

Dep. var.: ι_{ikt}	(1)	(2)	(3)	(4)	(5)	(6)	(7)
φ_i	0.403**	0.275**	0.239*				
	(0.187)	(0.130)	(0.140)				
φ_i^E				0.222	0.161	0.110	0.186
				(0.282)	(0.193)	(0.206)	(0.280)
φ_i^X				0.637***	0.419***	0.398***	0.565***
				(0.165)	(0.130)	(0.142)	(0.171)
$\log \mathrm{Empl}_i$	0.098***	0.085***	0.085***	0.099***	0.086***	0.086***	0.100***
	(0.030)	(0.017)	(0.019)	(0.029)	(0.017)	(0.019)	(0.029)
ι_{-ikt}							0.119***
							(0.024)
# obs.	138,913	138,146	137,988	139,109	138,341	138,185	125,327
R^2	0.259	0.440	0.495	0.263	0.441	0.496	0.275
Fixed Effects:							
year	✓	✓	✓	✓	✓	✓	✓
country	✓	✓		✓	✓	✓	✓
HS8		✓			✓		
country×HS4			✓			✓	✓

Notes: The observations are at the firm-HS8-destination-month. Standard errors are clustered at the firm-level. The dependent variable ι_{ikt} is equal to 1 if the currency choice is non-euros, and zero if it is euros: $\iota_{ikt} = 1$ for 33% of the observations; ι_{-ikt} is the sales-weighted-average currency choice of firm i's Belgian competitors exporting to the same HS4-destination. There are 10 destination countries: Australia, Canada, Iceland, Israel, Japan, South Korea, New Zealand, Norway, Switzerland, US.

The first three columns of Table 3 show positive significant coefficients on φ_i and firm size, consistent with theory. In column 1, which also includes destination-country fixed effects to absorb any average trends, shows that a firm with an import share that is 10 percentage points higher is 4 percent more likely to invoice exports in non-euros; and firms that are 10% larger are 1% more likely to invoice in non-euros. The coefficient on firm size is stable across all specifications. However, the coefficient on φ_i falls somewhat as we add additional HS 8-digit product fixed effects in column 2 and HS4×country fixed effects in column 3.

In the next three columns, we split the overall import intensity from outside the eurozone into its two components invoiced respectively in euros and non-euros, $\varphi_i = \varphi_i^E + \varphi_i^X$. We expect the portion invoiced in foreign currencies to matter particularly strongly for the adoption of non-euros for the firm's exporting invoicing. Consistent with this, we find that it is the non-euro portion of imports in total costs that is critical for determining the currency of invoicing in exports. The more imports a firm has invoiced in dollars the more likely it is to invoice its exports in dollars, coordinating the pass-through into export prices with the movements in its marginal costs, aking to *real hedging*. As in the first three columns, the magnitude of this coefficients falls as we include more fixed effects, but remains sizeable and significant even when we include time and country×HS4 fixed effects in column 6, where the coefficient equals 0.4.

Finally, in column 7 we explore whether the invoicing choices of a firm's competitors within HS4-destination influence its own currency choice, where we include both year and country fixed effects. We find that this coefficient is positive and significant.[10]

To provide a better sense of the economic significance of the results in Table 3, we consider the implied variation in the probability of the currency choice as its determinants vary across their empirical range (reported in the Appendix Table A1). The overall extra-EU import intensity of the Belgian exporters varies in our sample from zero at the 5th percentile to 44% at the 95th percentile, with a mean of 13% percent. Using the estimates from the linear probability regression in column 1 of Table 3, the variation across these percentiles of import intensity corresponds to an increase of 17.5 percentage points in the probability of non-euro pricing of exports.[11] There is a wide range of variation in the size of the firms—the employment of Belgian exporters increases by over 500 log points from the 5th to the 95th percentile (that is, almost 200 times). Applying the estimates from Table 3, this corresponds to an entire 50 percentage points increase in the probability of non-euro pricing comparing a small to a large firm. In other words, euro invoicing is disproportionately characteristic of the smaller firms, as we already anticipated with the comparison of the value-weighted and unweighted incidence of the currency use in Table 1. Finally, in the cross section of industries, the average incidence of the use of euros by competitor firms goes up from zero at the 5th percentile to 100% at the 95th percentile. According to our estimate of the strength of strategic complementarity in currency choice in column 7 of Table 3,

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[10]This coefficient is slightly larger if we replace country fixed effects with product fixed effects, but becomes insignificant with both country and product fixed effects, which end up absorbing mvost of the variation in the share of competitors' non-euro invoicing.

[11]We obtain a similar range using estimates from column 4, where we split the overall import intensity by the currency of invoicing of imports, with the share of imports invoiced in non-euros varying from zero at the 5th percentile to 27% at the 95th percentile.

Table 4: Exchange rate pass-through

Dep. var.: Δp_{ikt}	(1)	(2)	(3)	(4)	(5)
Δe_{kt}	0.002	−0.044	−0.048	0.001	−0.048
	(0.031)	(0.030)	(0.032)	(0.032)	(0.032)
$\Delta e_{kt} \cdot \varphi_i$	0.609***	0.366**	0.350**		
	(0.187)	(0.163)	(0.161)		
$\Delta e_{kt} \cdot \varphi_i^E$				0.332	0.144
				(0.266)	(0.274)
$\Delta e_{kt} \cdot \varphi_i^X$				0.846***	0.534***
				(0.253)	(0.192)
$\Delta e_{kt} \cdot S_{ik}$	0.110*	0.098	0.094	0.110*	0.094
	(0.058)	(0.059)	(0.059)	(0.059)	(0.059)
$\Delta e_{kt} \cdot \iota_{ikt}$		0.264***	0.295***		0.291***
		(0.046)	(0.064)		(0.062)
# obs.	73,514	73,514	73,514	73,514	73,514
R^2	0.063	0.064	0.064	0.063	0.064
Fixed Effects:					
year	✓	✓	✓	✓	✓
country×HS4	✓	✓	✓	✓	✓

Notes: Annual data for log change in unit values for period 2013-2017. Currency data is from monthly data for period February 2017 to March 2018. All regressions are clustered at the country-year level.

this would increase the probability for a given firm to invoice its exports in euros by 12 percentage points. To summarize, the determinants of currency choice that we identify in Table 3 explain a wide range of variation in the probability of the currency use in export transactions observed in the data.

Exchange rate pass-through We explore the implications of the currency choice for exchange rate pass-through in Table 4 by regressing the change in the annual log export price Δp_{ikt} on the change in the log bilateral exchange rate Δe_{kt} and its interactions with the pass-through determinants, as suggested by the theory (see equation (14)). Among the determinants of the exchange rate pass-through we include the firm's extra-EU import intensity φ_i and its sales share within an HS4-destination, as in Amiti, Itskhoki, and Konings (2014). Confirming our earlier findings, column 1 shows a positive association of the pass-through into producer prices with the firm's import intensity and market share. In other words, the pass-through into local prices is close to complete for small firms with zero exposure to foreign intermediate inputs, while it is significantly incomplete for larger exporters and exporters that rely intensively on foreign intermediate inputs.

In columns 2–5 of Table 4, we additionally include an interaction of the exchange rate with the currency choice of the firm. If prices were entirely flexible at this annual horizon, the currency choice of the firm should not have any additional predictive power for pass-through beyond the determinants of the desired pass-through of the firm. The fact that we find a sizeable and significant role for the currency choice variable ι_{ikt} in shaping the firm's exchange rate pass-through has two possible interpretations. One, prices may still be sticky at the annual horizon that we focus on. Alternatively, prices may already be flexible, however our proxies for the desired pass-through of the firm — the import intensity and the market share of the firm — might fail to provide an exact sufficient statistic, and thus the currency choice dummy may be proxying for the unobserved determinants of the desired exchange rate pass-through.

In column 2 of Table 4, we observe that including the currency choice dummy reduces the coefficient on the import intensity and makes the coefficient on the market share insignificant. This latter effect should not be over-interpreted though, as the size of the point estimate of the coefficient goes down very mildly and the standard error increases only slightly. However, going from euro to non-euro currency choice is associated with a 25–30 percentage points increase in the observed exchange rate pass-through at the annual horizon. The only difference between column 3 and column 2 is in the construction of the currency choice variable ι_{ikt}, which in column 3 can take fractional values in the infrequent cases where the firm sells multiple products in the same HS8 category s to destination k and prices them in different currencies. Since such cases are rare, the results barely change between the two columns. Finally, in columns 4 and 5 we split the overall extra-EU import intensity of the firm into the two components invoiced in euros and non-euors and, as in the currency choice Table 3, we find that it is particularly the import intensity in non-euros which accounts for the variation in the observed pass-through of the firms.

To summarize, our results confirm the endogeneity of the firms' currency choice, in line with the predictions of the theory, as well as the role of the currency choice in shaping the observed pass-through patterns. This feedback mechanism gives rise to strategic complementarities in the currency choice, which create a persistent equilibrium with dominant currency pricing.

Dynamics of pass-through   Lastly, we study the dynamics of pass-through by bins of currency choice. In particular, we estimate a simple regression of the producer export price changes Δp_{ikt} on the change in the bilateral exchange rate Δe_{kt}, increasing the horizon of the changes from 4 to 12 months.[12] We split all firm-product-destination observations into the PCP (euro), LCP and DCP (dollar) currency bins. For the exports to the United States, dollar invoicing is classified as the case of LCP, as we expect the LCP patterns of pass-through in this case. All regression are value-weighted and we include no additional controls. Including controls does not materially change the results.

We report the results in Figure 3. The pass-through in the PCP (euro) currency bin is not statistically different from zero at all horizons, and the point estimates are approximately zero starting at the six months horizon, and noisy prior to it. This corresponds to complete pass-through into destination-currency prices at all horizons. It is in line with our earlier findings in Tables 3 and 4, according to which

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[12]The regressions with shorter horizons result in very noisy estimates.
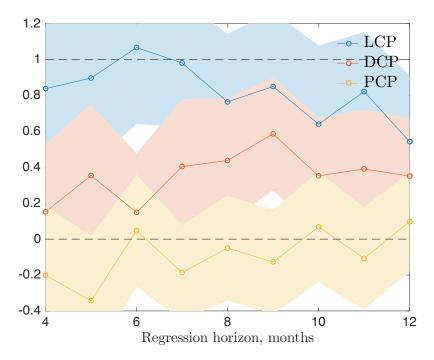
Figure 3: Dynamics of exchange rate pass-through across currency bins

Note: The figure plots the regression coefficients (and standard-error bands) from the projections of producer export price changes Δp_{ikt} on the bilateral exchange rate changes Δe_{kt} at different time horizons (using monthly price data), by bins of currency choice at the firm-product-destination level. All regressions are value weighted.

small non-import-intesive firms select into producer currency pricing and exhibit complete desired pass-through into destination prices at the annual frequency.

In contrast, the LCP firms exhibit complete pass-through into producer prices (i.e. zero pass-through in destination currency) in the short run, which after 6 months starts to gradually fall to under 60% pass-through at the annual horizon, and statistically different from 1. This is again consistent with our earlier results, with large import-intensive firms selecting into non-euro pricing and exhibiting incomplete desired pass-through at annual horizon. As can be expected, patterns of the DCP firms fall in the intermediate range, with the pass-through estimated around 40% at all horizons.

Our overall results suggest that the sticky-price modeling approach we adopt in Section 2 provides a good approximation to the currency choice, cross-sectional variation in pass-though at the annual horizon and the short-run dynamic patterns of pass-through we observe in the data. Our earlier evidence in Amiti, Itskhoki, and Konings (2014) suggests that at one-year horizon and beyond, the data does not reject flexible-price models. The evidence here emphasizes the importance of sticky prices to square the dynamic patterns of price adjustment at the sub-annual frequencies.

3.4   The response of quantities to the exchange rate

We now explore whether the currency choice of the firms is consequential for the real equilibrium allocation. In particular, we are concerned whether the currency choice of the firms during the period of price stickiness is consequential for the response of export quantities to the exchange rate movements. This addresses the fundamental question in the sticky price and currency choice literatures whether the

preset prices are allocative. In an ideal experiment, we are interested whether an otherwise identical firm, which switches currency of invoicing from, say, US dollars to euros, has the same response of quantities to the exchange rate, or it changes together with the switch in the currency of invoicing, thus establishing the causal effect of the currency of invoicing on real equilibrium outcomes. If this is the case, it confirms, among other things, the allocative role of sticky prices, in the business-to-business transactions. The answer to this question has largely been open in the literature.

Our empirical approach so far is to estimate a counterpart to the pass-through equation (14), but for the firm-product-destination-time quantities sold by the firms, a variable which we used in the construction of unit values. In particular, we project the change in annual log export quantities onto the change in the log exchange rate and its interactions with various firm characteristics, as in Table 4, and we report the results from this estimation in Table 5.

First note that export quantities respond positively to a nominal depreciation of the euro, as one would expect, since depreciation makes Belgian products more competitive on the world market. Recall that the response of the euro export prices was close to zero for non-importing small Belgian exporters, which also correspond to the base category of firms in the quantity regressions. Stable euro export prices correspond to a complete pass-through of the exchange rate into destination-currency prices, which fall one-to-one with the exchange rate depreciation. Therefore, the 0.5 elasticity for quantities of these firms with respect to the exchange rate changes corresponds to a 1/2 elasticity of demand, a puzzlingly low number, yet not out of line with the earlier empirical evidence. Such low elasticity is, perhaps, evidence of the sluggishness in the quantities response, even when prices adjust instantaneously due to the exchange rate movement.

Next, consistent with the theoretical predictions, export quantities response by less to the exchange rate depreciation for larger firms that import foreign intermediate (see columns 1 and 3 of Table 5). In column 5, we include the two interaction terms together, and one of the variables becomes insignificant, without any change in the point estimates.[13] This suggests that the quantity pass-through results are even noisier than the price pass-through results, yet nonetheless we recover theoretically meaningful patterns. When we split the import intensity into the euro-denominated and non-euro denominated import intensities, in column 2 and 6, the interaction terms stop being significant, but again the coefficients are consistent with the theory and the earlier findings in the price pass-through regressions: it is the import that are denominated in non-euros that affect the most the responsiveness of export quantities to the exchange rate.

In terms of the magnitudes, going from the 5th to the 95th percentile of import intensity (from 0 to 0.43; see Table A1), reduces the elasticity of the quantity response to the exchange rate from about 0.5 to 0.3. This magnitude is roughly proportional to the change in the pass-through into prices across the range of import intensity of the firms (compare the estimated interaction terms in Tables 4 and 5), which implies the demand elasticity to prices of about 1. If we explore the role of firm size, the estimated interaction coefficient is 0.2–0.22, exactly twice as large as the estimated interaction term in the price pass-through regressions in Table 4.

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[13]Which of the two variables turns insignificant is sensitive to the sample that we consider. In the reported results, the size interactions remains significant and the import-intensity interaction becomes insignificant.

Table 5: Response of quantities to exchange rate

Dep. var.: Δq_{ikt}	(1)	(2)	(3)	(4)	(5)	(6)	(7)
Δe_{kt}	0.467***	0.465***	0.451***	0.430***	0.530***	0.527***	0.557***
	(0.083)	(0.084)	(0.074)	(0.076)	(0.080)	(0.081)	(0.078)
$\Delta e_{kt} \cdot \varphi_i$	−0.475*				−0.431		
	(0.284)				(0.286)		
$\Delta e_{kt} \cdot \varphi_i^E$		−0.308				−0.185	−0.020
		(0.411)				(0.415)	(0.432)
$\Delta e_{kt} \cdot \varphi_i^X$		−0.633				−0.658	−0.570
		(0.466)				(0.477)	(0.480)
$\Delta e_{kt} \cdot S_{ik}$			−0.219**		−0.210**	−0.215**	−0.200**
			(0.096)		(0.096)	(0.096)	(0.097)
$\Delta e_{kt} \cdot \iota_{ikt}$				−0.214**			−0.211**
				(0.088)			(0.100)
# obs.	243,273	243,273	259,803	259,803	243,273	243,273	243273
R^2	0.091	0.091	0.098	0.089	0.100	0.100	0.100
Fixed Effects:							
year	✓	✓	✓	✓	✓	✓	✓
country×HS4	✓	✓	✓	✓	✓	✓	✓

Notes: Annual data for log change in quantities for period 2013-2017. Currency data is from monthly data for period February 2017 to March 2018. All regressions are clustered at the country-year level. The sample is all export destinations outside the eurozone.

Finally, in columns 4 and 7 we add the interaction term of the exchange rate with the currency of invoicing indicator (as in columns 3 and 5 of Table 4). The estimated interaction term is negative and significant, both when it is included separately and when it is included together with the other interaction terms. A switch from euro to non-euro invoicing reducing the annual quantity response to the exchange by about a half, from 0.43 to 0.22. The interaction term estimate in the quantity regression is about twice as large as that in the price regression (and with an opposite sign), corresponding to an implied elasticity of demand of about 2.

While the currency of invoicing can proxy for other omitted firm characteristics, even in the specification in column 7 with a full set of interaction terms, the evidence presented here is, nonetheless, consistent with the allocative role of the currency choice, and price stickiness more generally, for the real equilibrium outcomes.

4   Quantitative Implications and Counterfactuals

Our current data does not go sufficiently back to allow us to study the trends over time in the currency use. We thank Philip Sauré for sharing with us the Swiss trade currency data. In Figure 4, we present the trend over the previous five years in the use of the three major currencies — Swiss Franc (CHF), the euro and the US dollar – in the bilateral trade between Belgium and Switzerland. The Euro is currently the dominant currency, accounting for 55% of both exports and imports in trade with Switzerland. The role of the Euro in the Belgian exports to Swtizerland has considerably increased from 35% in the beginning of our sample in 2012, squeezing out the US dollar from the dominant position. In imports, the role of the three currencies remained largely stable over these five years, with Euro dominating both in the beginning and in the end of the sample. This provides interesting trends for a quantitative counterfactual analysis, studying the implications of the trends in currency use for the exchange rate pass-through, the transmission of the international shocks and welfare.
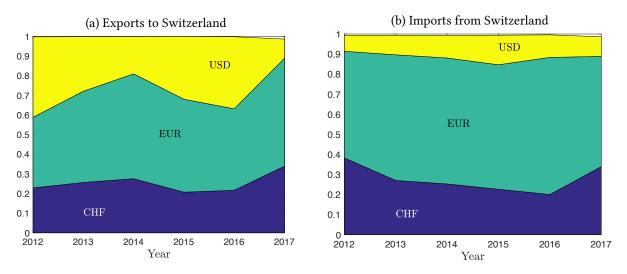

Figure 4: Currency invoicing trends in Belgium-Switzerland trade

Note: Cumulative shares of the top three currency used in the Belgium-Switzerland trade over time, 2012-2017.

5 Conclusion

A   Additional Empirical and Quantitative Results

Table A1: Summary statistics

Variable	5 pctl	Mean	Median	95 pctl	St Dev.
Full Sample (78,467 observations)					
Change in unit value	-0.66	0.01	0.00	0.69	0.36
Intermediate input import share	0.00	0.13	0.09	0.40	0.13
Intermediate input import share in EUR	0.00	0.06	0.02	0.23	0.09
Intermediate input import share in non EUR	0.00	0.07	0.04	0.28	0.10
Market Share	0.00	0.24	0.04	1.00	0.34
Intermediate input import share of industry	0.00	0.73	1.00	1.00	0.40
Current sample (138,913 observations)					
Dependent variable		0.34			
Intermediate input import share	0.00	0.14	0.08	0.43	0.14
log employment	2.40	5.36	5.38	7.83	1.79

Notes:

B   Data Appendix

Data Sources   The international data comprise transactions on intra-EU trade data collected by the Intrastat Inquiry and the extra-EU transactions data by Customs. These data are reported at the firm level by destination and source country for each product classified at the 8-digit combined nomenclature (CN) in values and quantities, with around 10,000 distinct products. The first 6-digits of the CN codes correspond to the World Harmonized System (HS). All transactions that involve a change of "ownership with compensation" (codes 1 and 11) are in our sample. These data include all extra-EU transactions of firms with trade greater than 1,000 euros or whose weights are more than 1,000 kilograms - these thresholds were reduced in 2006; and intra-EU trade with a higher threshold of 250,000 euros, with both these thresholds raised somewhat in 2006.

The firm characteristics data are available on an annual frequency at the firm level, with each firm reporting their main economic activity within a 5-digit NACE industry. However, there is no product level data within firms available from this source.

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