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Imported Intermediate Goods and Incomplete Exchange Rate Pass-Through into Export Prices

Alexander Firanchuk*

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Abstract

This paper analyses the effect of imported inputs and the exporting country share on the degree of exchange rate pass-through (ERPT) into export prices. I present a model where firms set variable markups under oligopoly competition and imported inputs affect marginal cost. It makes two predictions: (i) the imported input share reduces ERPT (ii) the exporting country share in a destination market increases ERPT. Using industry-level data, I test the hypotheses for 57 countries over the period 2000-2015. For trade between advanced economies, imported inputs reduce ERPT, but only in the case of producer currency movements. Controlling for exporting country share, the pass-through elasticity is 39% when imported inputs are not used, but 11% when the share of imported inputs in gross exports rises to one half.

JEL codes: F12, F14, F31, F41

Keywords: exchange rate pass-through, international trade, export prices, global value chains

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1 Introduction

The goal of this paper is to analyse how imported inputs and the exporting country share on the destination market affect the degree of exchange rate pass-through (ERPT) into export prices. The effect of imported inputs on ERPT into export prices was earlier shown on French firm-level data by Berman et al. (2012) and more recently on Belgian firm-level data by Amiti et al. (2014). Their results provide evidence imported inputs have a significant impact on ERPT into firms' export prices. Using US import data, Auer and Schoenle (2016) show that the exporting country share increases ERPT.

In addition to focussing on imported inputs, the paper considers the effect of the exporting country share on the destination market. Using industry data, I estimate both effects simultaneously. Significantly, the imported input share and country size exhibit a strong negative correlation. Larger economies: (i) can purchase many intermediate inputs domestically, reducing import-intensity (ii) have higher shares in total exports in destination markets. Thus creates an important econometric issue for empirical testing of ERPT based on a large sample of countries— omitting to control for one channel may induce a substantial bias in the other's estimation. While previous studies have examined the above channels in isolation, this paper considers both channels simultaneously. A related contribution is Ahmed et al. (2015), who use industry-level data show the backward participation in global value chains (GVCs) reduces the exchange rate elasticity of gross manufacturing export volumes.

My theoretical framework is that of firms setting variable markups under oligopolistic competition developed by Atkeson and Burstein (2008). I extend the model to incorporate the effect of imported inputs on ERPT by Amiti et al. (2014), (2017) with the effect of exporting country share in the destination market on ERPT by Auer and Schoenle (2016). The model considers firms which export from the exporting country to the destination market and imports inputs from the special region – the world. It predicts: (i) the use of imported inputs reduces ERPT, (ii) the exporting country share in a destination market increases ERPT.

The model has a number of implications. Because imported inputs are (partially) priced in the foreign (world) currency, they weaken the dependence of the marginal production cost (denominated in the world currency) on producer currency movements. Thus reduces the size of an optimal reaction of export prices (in the destination currency) and ERPT into export prices.

Second, producer currency exchange rate movements are not firm-specific shocks but exporting country specific ones. All companies directly affected by the shock adjust their prices; as a result, the industry price level in a destination market changes. The larger the cumulative share of the exporting country's firms in the destination market, the larger the effect of the producer currency exchange rate movements on the industry price level in the destination market.

Third, both channels appear only in the case of producer currency exchange rate movements, but not a destination one. The use of imported inputs cannot hedge against the destination currency movements, as such movements do not provide any changes in relative costs between domestic and imported inputs¹. In particular, the destination currency movements create the same demand shock for all firms which export to the destination market. As a result, there is no difference across exporting countries, and their shares on the destination market do not affect the industry price level in the market.

The empirical estimations are based on annual industry-level data for 35 advanced economies and 22 developing countries over 2000-2015. There are four sources of data: TiVA (join OECD and WTO database), COMTRADE (UN), IMF and the WB. Compared with firm level data, industry-level data has a number of advantages for quantifying ERPT. First, industry-level data are available for a large sample of countries. By contrast, the lack of detailed firm-level data limits the possibility to extend the empirical results to other countries. In addition, while previous studies use inputs imported by a given firm, the measure here also captures imported inputs which could be purchased domestically, but imported by another firm. This channel may be important for energy-intensive goods, as fuel is normally purchased on domestic market and would be construed as domestic inputs in firm-level data.

Depending on the sample of the exporting countries, the destination markets, and the measure of exchange rates, my estimation yields coefficients of the imported inputs effect in the range from -0.26 to -0.66. These findings are in line with the conclusion which was made by Amiti et al. (2014) based on their analysis of Belgian exporters (using firm-level data)².

The main results support the prediction that imported inputs reduce ERPT into export prices through the cost channel: they lessen the ERPT only in case of producer's currency exchange rate movements, but not a destination one. The regressions provide evidence that omitting the exporting country share biases the estimation of imported inputs effect in favour of the hypothesis. On average, in the case of trade between advanced economies and controlling for exporting country size, the elasticity of export price index (in the destination currency) to a producer currency REER is 0.333 when the share of imported inputs is 12.57% (the 10th percentile of the distribution) and it is 0.118 when the share is 42.95% (the 90th percentile). Additional robustness checks are based on examining the imported inputs effect separately for each industry and each year. This shows the results are durable and present each year.

This paper contributes to the literature in the following ways. First, I evaluate the imported inputs effect on ERPT based on industry-level data for the large country sample. This allows me to show imported inputs play a role in real hedging only against producer currency movement. Second, I evaluate the effects

¹This may happen only if the price of imported inputs correlates with the destination currency exchange rate.

²Amity et al. (2014) estimate the effect in the range from -0.29 to -0.40 depending on controls. However, they do not take into account the aggregate share of firms which export from Belgium (Eurozone). Instead of that they use dummy controls.

of imported inputs and the exporting country share in the destination markets on ERPT together. Without controlling for the exporting country share, the estimation of the imported inputs effect is biased.

The next section provides a theoretical explanation of an empirical specification. Following this, I describe the data in Section 3. Section 4 presents the empirical results and Section 5 concludes.

2 Theoretical framework

The theoretical model using the setup of variable markups under oligopolistic competition by Atkeson and Burstein (2008) combines two effects. The first one is the effect of imported inputs on ERPT by Amiti et al. (2014) — reducing the dependence of the marginal cost on producer currency exchange rate, the use of imported inputs also reduces ERPT. The second is the effect of exporting country share in the destination market on ERPT by Auer and Schoenle (2016). The mechanism underlying this effect is the following. All firms exporting from the same country are directly affected by the producer currency exchange rate shock. Adjusting export prices, they change the industry price level in a destination market. This affects ERPT positively depending on the cumulative share in the destination market.

The next subsection describes the theoretical framework. Later, I develop the imported inputs channel. Further, I combine it with the exporting country size effect using the three-country setup. The last subsection provides a link to the empirical equation.

2.1 Pricing-to-market

First, I describe price setting in a destination market. Following Dornbusch (1987) and Atkeson and Burstein (2008), consumers exhibit a love of variety. They have CES aggregate demand over industries s with the elasticity of substitution across industries $\eta > 1$. Total consumption (demand) C is a composition of total products of each industry Y_s :

$$C = \left(\int_0^1 Y_s^{(\eta-1)/\eta} ds \right)^{\eta/(\eta-1)} \quad (1)$$

Solving the optimisation problem under budget constraint $CP = \int_0^1 Y_s P_s ds$, final demand for each industry is:

$$Y_s = \left(\frac{P_s}{P} \right)^{-\eta} C \quad (2)$$

where P_s - industry price level and $P \equiv \left(\int_0^1 P_s^{(1-\eta)} ds \right)^{1/(1-\eta)}$ - price level of the total output (consumption). Within each sector s there are a finite number N_s of (monopolists) firms which produce unique goods i . The consumers have CES demand over different products i within each industry. The elasticity of substitution within an industry is $\rho_s > \eta$. The last inequality represents the fact that it is easier to substitute one good by another within the industry than to replace it by some products produced in other industries. Total consumption of industry s :

$$Y_s = \left(\sum_{i \in N_s} Q_{is}^{(\rho_s-1)/\rho_s} \right)^{\rho_s/(\rho_s-1)} \quad (3)$$

Under the similar sub-budget constraint $Y_s P_s = \sum_{i \in N_s} Q_{is} P_{is}$ the solution of the optimization problem gives the consumption of each good:

$$Q_{is} = Y_s \left(\frac{P_{is}}{P_s} \right)^{-\rho_s} = P_{is}^{-\rho_s} P_s^{\rho_s-\eta} P^\eta C \quad (4)$$

that is determined by P_{is} - the price of good i , P_s - the industry price level and $P^\eta C$ - demand factor which is common for all goods on the particular destination market³.

Under the assumption of oligopolistic competition, similar to Atkeson and Burstein (2008), the optimal price level depends on marginal cost MC and the elasticity of quantity with respect to price $\sigma_{is} = -\frac{d \ln Q_{is}}{d \ln P_{is}}$. The markup \mathcal{M}_{is} under price (Bertrand) and quantity (Cournot) competition is the same function of σ_{is} :

$$P_{is}^* = \frac{\sigma_{is}}{\sigma_{is} - 1} MC_{is}; \quad \mathcal{M}_{is} \equiv \frac{P_{is}}{MC_{is}} = \frac{\sigma_{is}}{\sigma_{is} - 1} \quad (5)$$

However, σ_{is} is different⁴:

$$\text{Cournot :} \quad \sigma_{is} = \left[\frac{1}{\rho_s} (1 - S_{is}) + \frac{1}{\eta} S_{is} \right]^{-1} \quad (6)$$

$$\text{Bertrand :} \quad \sigma_{is} = \rho_s (1 - S_{is}) + \eta S_{is} \quad (7)$$

where S_{is} is a firm's share on the particular market:

$$S_{is} = \frac{Q_{is} P_{is}}{\sum_{j \in s} Q_{js} P_{js}} = \left(\frac{P_{is}}{P_s} \right)^{1-\rho_s} \quad (8)$$

³The integral in (1) shows that there is a continuum of industries. As a result, P does not react to changes of any industry price level.

⁴Here is used the assumption that a price of any good has infinity small effect on the price level of total consumption $dP/dP_{is} = 0$

Following Auer and Schoenle (2016) I define the elasticity of markup with respect to firm's share on the market $\Gamma(S_{is}) \equiv \frac{d \ln \mathcal{M}_{is}}{d \ln S_{is}}$:

$$\text{Cournot :} \quad \Gamma(S_{is}) = \frac{(\rho_s - \eta)S_{is}}{\eta(\rho_s - 1) - (\rho_s - \eta)S_{is}} \quad (9)$$

$$\text{Bertrand :} \quad \Gamma(S_{is}) = \frac{(\rho_s - \eta)S_{is}}{((\rho_s - 1) - (\rho_s - \eta)S_{is})(\rho_s - (\rho_s - \eta)S_{is})} \quad (10)$$

Under the assumption that the elasticity of quantity with respect to price σ_{is} is positive, both expressions of the markup elasticity are positive and increasing functions of a market share⁵. The intuition is that a large firm has a bigger markup and adjusts it more intensively trying to preserve market share. A small firm has low markup and a limited opportunity for adjustment. It is possible to solve the equilibrium response of a firm's price using the log-linearized form of the recursive relationship between a firm's price, a market share, marginal cost and an industry price level. The lower case letters are used for notation of log functions.

$$\Delta p_{is} = \Gamma(S_{is})\Delta s_{is} + \Delta mc_{is} \quad (11)$$

$$\Delta s_{is} = (\rho_s - 1)(\Delta p_s - \Delta p_{is}) \quad (12)$$

$$\frac{\partial p_s}{\partial p_{is}} = S_{is}; \quad \Delta p_s = \sum_{i \in s} S_{is} \Delta p_{is} \quad (13)$$

The system solution gives the following equation for equilibrium price changes⁶

Proposition 1. *The equilibrium change of the firm's price is:*

$$\Delta p_{is} = \underbrace{\gamma_{is}}_{\text{response to } \Delta p_s} \times \underbrace{\frac{\sum_{j \in s} S_{js} \alpha_{js} \Delta mc_{js}}{1 - \sum_{j \in s} S_{js} \gamma_{js}}}_{\text{total effect on } p_s} + \underbrace{\alpha_{is} \Delta mc_{is}}_{\text{direct response to } \Delta mc} \quad (14)$$

where:

$$\gamma_{is}(S_{is}) = \frac{\Gamma(S_{is})(\rho_s - 1)}{1 + \Gamma(S_{is})(\rho_s - 1)} \quad (15)$$

$$\alpha_{is}(S_{is}) = \frac{1}{1 + \Gamma(S_{is})(\rho_s - 1)} \quad (16)$$

This proposition identifies the effect of marginal cost changes on prices⁷. There are two main possible

⁵The monotonically decreasing markup elasticity does not provide monotonic ERPT as a function of a market share because the firm has its effect on overall industry price index, Auer and Schoenle (2016), also Devereux et al. (2017).

⁶Proposition 2 in Auer and Schoenle (2016)

⁷Prices and marginal costs could be denominated in any currency. The log changes in price and marginal cost could be rewritten in any currency w in the following way: $\Delta p_{is} = \Delta p_{is}^w - \Delta e^w$ and $\Delta mc_{is} = \Delta mc_{is}^w - \Delta e^w$. $\Delta e^w > 0$ means appreciation of currency against some world benchmark. It is easy to show, that $\gamma_{is} \times \frac{\sum_{j \in s} S_{js} \alpha_{js}}{1 - \sum_{j \in s} S_{js} \gamma_{js}} + \alpha_{is} = 1$. As a result, the log changes in nominal exchange rates Δe^w could be cancelled.

situations when exchange rate movements affect marginal cost: destination currency exchange rate movements against some international benchmark (weighted basket of trade partners' currencies or USD/XDR) and exporting country exchange rate movements against an international benchmark. In the first case, all exporters are affected, so the equilibrium effect on industry price level (denominated in the destination currency) will be bigger than in the second case where only exporters from one country are affected.

2.2 Imported inputs

The three-country model contains: a destination country - d , an exporting country - c and the rest of the world - w (the same notations are used for the corresponding currencies). The first two are (by assumption) small open economies. It means that the world benchmark does not react to the movements of their currencies. Moreover, I assume that the foreign inputs which an exporting country uses for producing gross export are imported only from the rest of the world.

A firm that exports from country c to a destination market d has a production cost function which contains two parts: a domestic part (wages and domestic inputs) - H and an imported part - imported intermediate goods - F . I consider goods and services as imported inputs if they: are imported directly by the firm, are bought on the domestic market (imported by another firm), or they are used in the production of domestic goods. In all these three cases - backward participation into GVCs - there is ERPT of bilateral (country of origin - firm's country) exchange rates into their prices. It is assumed for simplicity that a firm cannot change production function and does not switch from domestic inputs to imported ones (and back). A firm's total variable cost function⁸ denominated in some world currency w , similar to Amiti et al. (2017).

$$TVC_{ict}^w = (H_{ict}^{1-\phi_{ict}} F_{ict}^{\phi_{ict}} Y_{ict}^{a_{ic}}) E_{ct}^w \quad (17)$$

The TiVA database contains industry-level data about the imported inputs share in total cost of production (gross export). The lack of information about marginal cost (along with inconsistency of this measure for industry-level data) forces to use changes in average variable cost as a proxy for changes in marginal cost (weighted by firms' size within exporting industry):

$$\Delta m_{ict}^w = (1 - \phi_{ict}) \Delta h_{ict} + \phi_{ict} \Delta f_{ict} + \Delta \phi_{ict} (f_{ict} - h_{ict}) + \Delta e_{ct}^w + a_{ic} \Delta y_{ict} \quad (18)$$

where E_{ct}^w - a country c exchange rate against world benchmark w ⁹; ϕ_{ict} - a share of imported inputs in total(marginal) cost of production; Δh_{ict} - log changes in average expenditure on domestic value added

⁸Amity et al. (2017) use a more general form of marginal cost which includes firm-specific idiosyncratic productivity.

⁹ $\Delta e_{ct}^w > 0$ means appreciation of producer's currency against world benchmark.

(denominated in producer currency) required for producing one unit of output (export); Δf_{ict} - log changes in expenditure on imported inputs (denominated in producer currency); $\Delta \phi_{ict}$ - changes of the structure of a production function¹⁰; $a_{ic} > 0$ - parameter of return-to-scale; y_{ict} - level of output.

There is a log change of firm's (exporter's) country exchange rate to the weighted basket of currencies of origin (k):

$$\Delta e_{ict}^{\bar{k}} = \frac{\sum_{k \neq c} \Delta e_{ct}^k * \varphi_{kict}}{\sum_{k \neq c} \varphi_{kict}} \quad (19)$$

φ_{kict} is a share of expenditure on intermediate inputs which is imported from a source country k in total cost of production ($\sum_{k \neq c} \varphi_{kict} = \phi_{ict}$). Under the assumption that all foreign inputs are imported from the rest of the world, $\Delta e_{ict}^{\bar{k}} = \Delta e_{ct}^w$. The changes of expenditure on imported inputs (denominated in producer currency) could be expressed using ξ_{ic} - producer (exporter's) currency ERPT into imported inputs cost. More generally, the coefficient of ERPT could be firm-specific, but for simplicity, I assume it is the same for all firms and exporting countries:

$$\frac{\partial f_{ic}}{\partial e_c^w} = -\xi_{ic} = -\xi; \quad 0 < \xi \leq 1 \quad (20)$$

The alternative assumption is just to assume that imported inputs costs are fixed in world currency ($\xi = 1$); it is a reasonable approximation for small open economies, Fauceglia et al. (2012).

Under these assumptions, the changes of marginal cost could be divided into a part which is related to nominal exchange rate and another part Δr_{ict} which is not:

$$\Delta mc_{ict}^w = \Delta e_{ct}^w (1 - \xi \phi_{ict}) + \Delta r_{ict}, \quad \Delta r_{ict} \perp \Delta e_{ct}^w \quad (21)$$

The same expression could be obtained based on the assumption of fixed quantities of imported and domestic inputs (and labour)¹¹.

2.3 Homogeneous and equal-sized firms

In the simplest case, all exporting firms in a country c and an industry s are homogeneous in terms of the imported inputs share (ϕ_{cs}) and ERPT into costs of imported inputs (ξ_{cs}). Moreover, I assume that all

¹⁰Under assumption that the production function is a Cobb-Douglas, this is equal to 0.

¹¹The average(marginal) cost of production could be presented as a sum of domestic inputs cost $H = P^H Q^H$ and imported ones $F = P^F Q^F$ weighted by shares of those inputs in total cost of production ($1 - \phi = \frac{H}{MC}$ and $\phi = \frac{F}{MC}$, correspondingly).

$$\frac{\partial MC_{ct}^c}{\partial E_{ct}^w} = -\xi \frac{P^F Q^F}{E_{ct}^w}; \quad \frac{\partial mc_{ict}^w}{\partial e_{ct}^w} = \frac{\partial (mc_{ict}^c + e_{ct}^w)}{\partial e_{ct}^w} = 1 - \xi \phi$$

firms on a destination market have the same size. This simplification allows me to analytically solve the equilibrium response of different exchange rate movements holding the effect of pricing-to-market (in case the share of domestic firms on destination market is bigger than 0). Following Auer and Schoenle (2016) I consider N_{ds} equal-sized firms on a destination market d in industry s ¹², the number of firms is a constant. There are three types of firms (with corresponding fractions): domestic firms (n_d), firms which export goods from exporting country c on this destination market (n_c), and other foreign firms (which export from the rest of world) - (n_w).

Under the assumption of the equal-sized firms on the market, the elasticity of markup with respect to price is the same for any firm $\bar{\Gamma} \equiv \Gamma(\frac{1}{N})(\rho - 1)$; moreover, the price changes will be the same for all firms which are exporting from the country c on destination market d in industry s . Thus, the equation in Proposition 1 for the firm i from the exporting country c could be rewritten in the following form:

$$\begin{aligned}\Delta p_i &= \frac{\bar{\Gamma}}{1 + \bar{\Gamma}} \times \frac{\sum_{j \in sd} S_j \frac{1}{1 + \bar{\Gamma}} \Delta mc_j}{1 - \frac{\bar{\Gamma}}{1 + \bar{\Gamma}}} + \frac{1}{1 + \bar{\Gamma}} \Delta mc_i \\ \Delta p_c &= \bar{\gamma} \sum_x n_x \Delta mc_x + \bar{\alpha} \Delta mc_c, \quad \text{where } x \in \{D, C, W\}\end{aligned}\quad (22)$$

The equation (22) has the same form for any currency.

Proposition 2. *Under the assumption of homogeneous equal-sized firms, the equilibrium response of price index of goods exported from country C to destination market D (Δp_{cd}^w) (denominated in world currency) is the following:*

- in case of the destination currency exchange rate movements e_d^w against the world benchmark:

$$\Delta p_{cd}^w = \bar{\gamma} n_d \Delta e_d^w (1 - \xi \phi_d) = \beta_d \Delta e_d^w \quad (23)$$

where $\beta_d = \bar{\gamma} n_d (1 - \xi \phi_d) > 0$

- in case of exporting country's currency exchange rate movements e_c^w against the world benchmark:

$$\begin{aligned}\Delta p_{cd}^w &= \bar{\gamma} n_c \Delta e_c^w (1 - \xi \phi_c) + \bar{\alpha} \Delta e_c^w (1 - \xi \phi_c) \\ &= \bar{\alpha} \Delta e_c^w + \bar{\gamma} n_c \Delta e_c^w + \theta_c \phi_c \Delta e_c^w\end{aligned}\quad (24)$$

where $\theta_c = -\xi(\bar{\alpha} + \bar{\gamma} n_c) < 0$

¹²Later I drop the indexes ds which identify that the industry s on the market d is considered

The appreciation (depreciation) of the destination currency would have only indirect positive (negative) effect on prices¹³ of goods exported from country c to this destination marked d : Δp_{cd}^w . The value of the effect is determined by the destination market characteristics (share of domestic firms on the destination market n_d and their import intensity ϕ_d) and the parameters $\bar{\gamma}$ and ξ . The appreciation of an exporting country's currency would have the following effects: a positive "simple direct" one ($\bar{\alpha}$), a positive size effect ($\bar{\gamma}n_c$) and a negative imported inputs effect ($\theta_c\phi_c$). Actually, $\bar{\alpha}$ (the simple direct effect) is equal to the direct effect only if imported inputs are not used in production of goods. A size effect catches the influence of cumulative share of all firms from exporting country c . It is important to emphasize that a firm's share in a destination market and an exporting country's share act on ERPT in opposite directions. On the one hand, under the assumption of strategic competition, the optimal response to an exchange rate movement depends negatively on a firm's share in the market. Larger and more productive exporters significantly adjust their markups to preserve market share, Atkeson and Burstein (2008). On the other hand, for equal-sized firms, their optimal response is positively related to the total share (number) of firms which are directly affected by the exchange rate shock. As a result, the bigger n_c , the higher total influence of exporting country's exchange rate e_c^w on industry price level on destination market d .

The imported inputs effect emphasizes the fact, that usage of imported inputs reduces the influence of producer's currency exchange rate movements (against some world benchmark or against a weighted basket of origin countries' currencies) on marginal cost function¹⁴.

Combining both cases from the proposition 2 the following estimating equation is obtained:

$$\Delta p_{scdt}^w = \alpha_{sd}\Delta e_{ct}^w + \beta_{sd}\Delta e_{dt}^w + \gamma_{sd}n_{scd}\Delta e_{ct}^w + \theta_{sc}\phi_{sc}\Delta e_{ct}^w + r_{scdt} \quad (25)$$

where r_{scdt} is the error term. The coefficients α_{sd} , β_{sd} , γ_{sd} are destination-specific according to the model, but later I will assume that they are the same across industries and countries or they are only industry-specific.

To see the intuition behind the imported inputs effect (θ), imagine a simple situation where one-third of a company's total cost is imported intermediate materials priced in the foreign currency (world benchmark), and the remaining two-thirds is wages priced in the producer currency. In this case, 10% appreciation of the producer currency (against the world benchmark) will raise the total cost of production (denominated in the destination currency) by 6.7%. As a result, one may observe incomplete ERPT into export prices since the total cost is partially denominated in foreign currency¹⁵. The use of imported inputs reduces ERPT only in

¹³all prices are denominated in some world benchmark (currency of the rest of the world)

¹⁴The coefficient θ_c contains the measure of cumulative share n_{cd} . However, as far as $\bar{\alpha} > \bar{\gamma}$ this part gives the second order effect. I will neglect the fact that θ_c is a function of n_{cd} .

¹⁵This effect increases incompleteness of ERPT which is provided by oligopolistic competition under variable markups

the case of a producer currency movements (against some world benchmark). Otherwise, in the case of the destination currency movements, there is no change in an exporting firm's expenditure on domestic inputs relative to imported ones.

To see the main idea of the exporting country share effect, consider UK as an exporting country and two destination markets: Norway and Australia. The exchange rate movements of the sterling relative to the Norwegian krone and the Australian dollar will have the same direct effect on the exporting firm's marginal cost (in destination currencies). However, the indirect effect would be higher in the Norwegian market: a larger share of importers are exposed directly to the sterling movement and will change their prices. For this reason, the effect of the sterling exchange rate movement on industry price level will be higher in the Norwegian market. Moreover, there is an asymmetry in the effect of exchange rate movements. The destination currency movements equally affect firms exporting from any country, so the share of any particular exporting country is irrelevant in that case.

3 Data description

Empirical estimation uses four primary sources of international data. TiVA (join WTO and OECD) database is used for calculation of the imported value added share in gross export for each exporter-industry pair. The IMF database of yearly average exchange rates is used for calculating changes of bilateral nominal exchange rates, exporting country's and destination currencies exchange rates against US dollar (USD) and Special Drawing Rights(XDR). The WB database provides information about changes in real effective exchange rate indexes for most of countries in my sample. The COMTRADE database contains information about values and volumes of trade flows between countries for each 6-digit HS commodity group which is used for calculation of exporter-industry-destination price indexes. A sample is divided into two groups of countries: advanced economies and other countries. The classification (according to IMF) is presented in Table 1.

3.1 Trade in value-added database

The indicator "Origin of Value Added in Gross Exports" from TiVA database is used¹⁶. It is available for 1995-2011 years. The structure of original data is presented in Table 2.

Value added is expressed in millions of US dollar (in current prices) based on OECD's Inter-Country Input-Output (ICIO) system. It is important to mention that COMTRADE data is also expressed in current US dollars.

¹⁶There are four more public datasets of Value-Added Exports which cover different samples of countries or regions during different periods of time, see. Table 1 on p.123 in Johnson (2014)

The indicator “Origin of Value-Added in Gross Exports” provides information about value added which was produced by source industry l^{17} in source country k and was embodied in gross exports of country c in industry s in year t . Firstly, I expressed the value-added share of each source country k as a percentage of gross exports of country c in industry s in year t - φ_{ksct} . Obviously, $\sum_{k \neq c} \varphi_{ksct} = \phi_{sct}$ is a share of imported value added in gross export from country c in industry s in year t . In the case where a source country is an exporting one ($k = c$), this variable measures a share of domestic value-added. The significant restriction is that the same share ϕ_{sct} for all destinations d is used due to the lack of information about value added composition on an exporter-industry-destination level.

However, for Eurozone countries, I consider imported inputs from other Eurozone countries as domestic ones. There are no bilateral exchange rate movements between exporting and source countries when both countries are Eurozone members. Imported from other Eurozone countries value added behaves as domestic one in case of Euro appreciation (depreciation); thus, (19) could be rewritten:

$$\Delta e_{sct}^{\bar{k}} = \frac{\sum_{curr \ k \neq curr \ c} \Delta e_{ct}^k * \varphi_{ksct}}{\sum_{curr \ k \neq curr \ c} \varphi_{ksct}} \quad (26)$$

there $curr \ k \neq curr \ c$ means that only imported inputs from source countries k (which have currencies different from country c) are taken into consideration. A share of imported value added, which is produced in countries that use other currency, in gross export from country c in industry s in year t is $\tilde{\phi}_{sct}$ ¹⁸.

Moreover, instead of using the imported inputs share in year t , I use imported inputs share two years before or the last available data (2011) for 2014 and 2015 years $\tau \leq t - 2$. It is necessary because the value of imported inputs itself depends on current exchange rate. The usage of data for previous years avoids this causality problem¹⁹. Justification of such replacement is based on the fact that total import value-added share in gross export is quite stable for a lot of countries, so previous values are the valid instrument for current ones.

3.2 Exchange rates

The IMF database contains information about almost all national currencies of countries that are presented in TiVA database for all necessary years (since 1999). Annual average nominal exchange rates of national currencies to the US dollar (USD) are used for calculating log changes of annual average nominal exchange

¹⁷In most of the regressions the information about a source industry is not used, instead of that sum of all sources industries ($ctotal$) is applied.

¹⁸It is also possible to broaden this idea and consider as a domestic value added not only other Eurozone members but also countries that use ERM regimes. Instead of that, I deleted countries which use ERM to Euro out of sample. The results are very similar to the reported ones.

¹⁹Two-year lag is necessary as exchange rate in a previous year is used as a base for calculating changes in exchange rates.

rates of exporting country c against USD – $\Delta e_{ct}^{\$}$. Meanwhile, annual average exchange rates of USD to the special drawing rights (XDR) are used for constructing exporting country exchange rates against XDR – Δe_{ct}^X ($e_{ct} > 0$ means appreciation of producer currency). The log changes of bilateral nominal exchange rates of producer currency c to destination currency d in year t to previous year is: $\Delta e_{cdt}^B = \Delta e_{ct}^{\$} - \Delta e_{dt}^{\$}$.

According to the model, an exporting country exchange rate movement against the weighted basket of origin currencies is a direct measure of the effect of imported inputs on the marginal cost of production. TiVA database allows me to calculate movements of the weighted (by shares in imported inputs in gross export) basket of origin currencies against USD. The difference between this measure and changes of exporting country currency against USD is equal to Δe_{cst}^W , defined in (26)²⁰.

The second possible measure of the marginal cost channel is the changes of the real effective exchange rate (REER) of an exporting country Δe_{ct}^R . REER indexes for 1999-2015 years (2010 is a base year) are taken from the World Bank database²¹.

The correlation table for all five used exchange rates and data sources is presented in Table 4.

3.3 Export price index

COMTRADE annual trade data on gross exports from country c to a partner d at 6-digit level (HS96²²) is used. The data contains the following information about trade flows: reporter (exporter), partner (destination), product code (6-digit), year, trade value in USD (in current prices)²³, net weight (kg), quantity units²⁴ (units, m^3 , kg, others), quantity (in quantity units). It is well-known that export data quite often are different from import data for the same trade flows, so only export data is used. There is no issue because of possible differences in evaluations of gross exports between TiVA and COMTRADE databases: the first one is used for expressing imported inputs shares and the second one – for export prices.

I calculate unit weight prices in USD for each commodity i that was exported from reporter c to a partner d in year t . There are around 5000 different 6-digit HS groups of commodities and 16 manufacture industries in the TiVA database. The list of the industries of TiVA database and concordance code of TiVA industries to ISIC (rev. 3) is downloaded from the TiVA²⁵. The concordance code of HS(96) to ISIC (rev. 3) is downloaded from the WITS²⁶. Using those two keys 6-digit HS groups are matched to TiVA (manufacture and raw material) industries, as a result, each industry s contains from 55 to 884 different HS 6-digit groups

²⁰It is worthy to remind, that this exchange rate is an industry-specific, so it is defined for an industry s of exporting country c in year t .

²¹The use of prices in nominal term (current USD) is correct as the industry-year dummies are applied.

²²Harmonized Commodity Description and Coding Systems, rev. 1996

²³All observations less than \$ 10 thousand are deleted. They contains less around 1% of total trade.

²⁴In most cases quantity units is equal to kg

²⁵http://www.oecd.org/sti/ind/TiVA_2015_Industry_List.pdf

²⁶http://wits.worldbank.org/product_concordance.html

i_s (see Table 3).

In the empirical specification, the log changes of Paasche price index are used as a proxy for the changes of exporting country firms' prices on destination market Δp_{scdt} . There are several reasons for it. First, Paasche index weights values of trade flows of commodities which are exported from c to d within an industry. The alternative possible measure is unweighted average or separate consideration of all prices for different commodities (HS 6-digit groups) within each industry. Such a measure would overestimate the influence of small and volatile commodities on overall prices on destination market. A significant difference between unweighted and weighted (by trade) ERPT was observed by Amity et al. (2014). Second, imported inputs shares in gross export are available only on industry level (but not on HS6-digit level). In such situation, it is possible that distribution of φ_{iscd} could be in a wide range. As a result, unweighted average of φ_{iscd} among the commodities i within industry s could be quite far from the available value of imported inputs share ϕ_{scd} .

For each industry s and exporter-destination pair log changes of Paasche index (ΔEPI_{scdt}) are calculated. It uses core trade groups J_{icpt} . A commodity group i_{scdt} is included in a core if it satisfies the following conditions: 1) its trade flows from the exporting country to the destination market were positive in current and previous years; 2) the unit prices satisfy the inequality: $-0.5 < \ln\left(\frac{UWP_{icd,t}}{UWP_{icd,t-1}}\right) < 0.5$. The bigger difference in price may mean a commodity group i contains different goods and such crucial change in prices reflects changes of commodity composition of that trade flow rather than changes in prices for the same goods. It is difficult to imagine the manufacturing (or even agricultural) goods which suffer 65% price growth or 40% price drop. However, such changes are quite often for raw materials such as metals or fuel. But they are traded mostly on a stock exchange and have universal world prices (varies because of transportation costs) and exchange rate pass-through is significantly less important in such case. Dummies for each industry-year pair are included for controlling world prices of stock commodities.

It is worth mentioning that core groups are not the same for different years. Moreover, a core group weight CGW_{scdt} is calculated as a ratio of core groups value to the total trade flow of industry s from exporter c to destination d in year t . The bigger part of core group means more stable trade flows in terms of trade composition. I use CGW_{scdpt} as a weight for corresponding trade flows in some regressions.

3.4 Exporting country share in a destination market

Also using COMTRADE data, I calculated a proxy variable to measure the total share of firms from exporting country c on destination market d in industry s . Precisely, Z_{scdt-1} is the share of country c in world exports to destination market d in previous year $t-1$. The main difference between Z_{scdt-1} and n_{scd} is that the last

one also takes into account the total sales of domestic firms on the destination market d . Similar to imported inputs share, \tilde{Z}_{scd} is the total share of countries which use the same producer currency in destination market.

4 Empirical findings

This section is organized in the following way. The first subsection is devoted to the discussion about the asymmetry of the influence of producer and destination currency movements on an export price index. The second one outlines the effect of imported inputs on bilateral (the producer currency against the destination one) exchange rate pass through. The third subsection tests the main predictions using exporter and destination exchange rates against different world benchmarks (USD and XDR), weighted by imported inputs exchange rates and real effective ones. The fourth subsection considers the heterogeneity of ERPT among industries. The last one discusses the time stability of ERPT.

4.1 Asymmetry between producer and destination currency ERPT

There is a broad literature which is devoted to estimation of ERPT²⁷. Bussière and Peltonen (2014) estimate one-quarter ERPT into export prices to be around 33% for a sample of 41 countries (advanced economies and emerging markets). This means that after 10% appreciation of a producer currency against a destination one, the export price index (denominated in producer currency) will go down by 3.3%. However, they do not distinguish between appreciation of the producer currency (against some world benchmark) and depreciation of the destination currency (against it). As it was shown in model, these movements will have different effect on export price index. The producer currency ERPT may be limited by the fact that imported inputs are used in production. Moreover, in the case of a destination currency depreciation, all exporters on that destination market are in the same situation and they will expect the bigger changes of industry price level on the market (in destination currency). However, in the case of producer currency appreciation, exporters (from that country) have to take into account that firms which export from other countries and domestic firms will keep their prices (in destination currency) quite stable. Using annual data, I estimate long-run or medium-run ERPT, as the long-run ERPT typically is up to 2 years, Burstein and Gopinath (2013). For showing this asymmetry I run the three simple regressions. The first one estimates the classical ERPT (based on nominal exchange rates): it regresses export price indexes (Paasche indexes denominated in producer currency) - Δp_{scdt}^c on bilateral (exporter against destination) exchange rates Δe_{cdt}^B . The only control I added in the first regression is the industry-year dummy S_{st} . The second regression estimates the

²⁷See the literature review by Burstein and Gopinath (2013), or the estimation of ERPT for big sample of developing countries and emerging markets by Bussière and Peltonen (2014)

producer currency ERPT. It also contains the destination-year dummy D_{dt} which catches the variation of destination exchange rates²⁸. Similarly, the third regression evaluates the destination currency ERPT using the exporting-country-year dummy C_{ct} instead of D_{dt} .

$$\Delta p_{scdt}^c = \alpha \Delta e_{cdt}^B + S_{st} + \{D_{dt}\} + \{C_{ct}\} + r_{scdt} \quad (27)$$

The results are presented in Table 5 for the whole sample - all countries (ALL) and two separate groups: advanced economies (ADV) and developing ones (DEV). Regressions based on trade between all countries in the sample (ALL-ALL) find that bilateral ERPT into export prices is -43.3% on average, column (1.1). That is quite similar to the findings by Bussière and Peltonen (2014). However, the ERPT controlling for destination exchange rate movement (D_{dt}) is significantly larger in absolute value: - 80.9%. It means that in the case of a producer currency appreciation (against some world benchmark) by 10%, the export price (denominated in producer currency) will go down by 8.1%. The very different result is observed when the regression contains a control for producer currency exchange rate movements (C_{ct}): ERPT in that case is only -6.2%. In other words, in case of the destination currency depreciation by 10% the export price (denominated in producer currency) will go down only by 0.6%.

This proves the presence of difference between the elasticity of the export price indexes to exporting country appreciation and its elasticity to the destination currency depreciation. The results for the export flows from advanced economies to all countries predictably shows the lower ERPT. Moreover, when only trade between advanced economies are considered, the main conclusion remains the same: the export price elasticity to exporting country exchange rate is bigger than its elasticity to the destination currency exchange rate (68.5% and 13.1%, correspondingly).

4.2 Bilateral ERPT

To my knowledge there are a limited number of articles which consider the effect of imported inputs on the ERPT into export prices based on the data about only one exporting country²⁹. The estimated coefficients of ERPT are quite different from each other. One of the possible explanation for that could be invoicing currency³⁰. In current work I consider 57 countries that allow me to evaluate unweighted average (among countries) value of the effect. According to the model, both the marginal cost channel (the effect of imported

²⁸One may argue that it may catch not the nominal exchange rate movements, but a real one. In later subsections I divide the bilateral exchange rate into two components: producer currency exchange rate against some world benchmark and destination one. The main conclusion will be the same.

²⁹See, for example, Fauceglia et al. (2012) for Swiss export prices (2004-2011); Amiti et al. (2014) for Belgian(2000-2008); or Berman et al. (2012) for French ones (1995-2005).

³⁰France and Belgium more likely set export prices in their own currency than Switzerland which trades mostly with Eurozone countries. However, Gopinath et al. (2010) argue that currency choice is endogenous.

inputs) and the size channel (the effect of exporting country share on a destination market) should affect only the export price elasticity to producer currency exchange rate (exporter part of ERPT). As a result, the export price elasticity to producer currency exchange rate is the main interest. The second part of bilateral exchange rate movements - the destination currency movements (again some benchmark) - will be controlled by D_{dt} . The world average export price elasticity to producer currency exchange rate is α and the average effect of imported inputs on it is θ , so both coefficients are neither country nor industry specific:

$$\Delta p_{scdt}^c = \alpha \Delta e_{cdt}^B + \theta \tilde{\phi}_{sct} \Delta e_{cdt}^B + \gamma \tilde{Z}_{scdt-1} \Delta e_{cdt}^B + D_{dt} + S_{st} + r_{scdt} \quad (28)$$

All regressions contain variables $\tilde{\phi}_{sct}$ and \tilde{Z}_{scdt-1} when the multiplicative variables with them are used. The results are presented in Table 6³¹.

The results for the whole sample of the countries are driven by the developing countries (including emerging markets). Excluding these economies from the set of exporting countries changes the sign of coefficient θ . The expected results are observed for trade between advanced economies. Without controlling for the destination currency movements the estimation of the imported inputs channel (θ) is very sensitive to presence the control for a share of exporting country on a destination market (\tilde{Z}_{scdt-1}). This is due to the fact that $\tilde{\phi}_{sct}$ and \tilde{Z}_{scdt-1} have a strong negative correlation. On the one hand, the bigger economies, ceteris paribus, use less imported inputs as their firms have better opportunity to cover their need in intermediate inputs by domestic ones. On the other hand, the bigger economies normally have a more significant average share on destination markets. More precisely, the additional control for a size channel $\tilde{Z}_{scdt-1} \Delta e_{cdt}^B$ drops the coefficient θ roughly twice (from -0.486 to -0.294, columns (2.1) and (2.2) in Table 6). However, in case of controlling for the destination currency exchange rate movements (by destination-year dummies) the coefficient θ particularly does not react on excluding or including the control for a size channel (-0.335 and -0.347, correspondingly). Moreover, controlling for the destination currency movements, the coefficient of imported inputs channel is significant even after excluding US and Eurozone members from the sample (-0.26)³².

The main conclusion based on these results is that *imported inputs play a role of real hedging against producer currency exchange rate movements*. Usage of foreign intermediate goods makes export prices (denominated in some world benchmark) more stable in case of producer currency exchange rate movements.

³¹The results for α are not presented as it mixes two different values. In some regressions (without destination-year dummies) it represents bilateral ERPT. In others (with destination-year dummy) it represents the reaction of export price index on the movement of exporting country exchange rate (against some benchmark) only. The difference between these two situations is discussed in previous subsection and Table 5.

³²It is well known that the US as the biggest economies is a some kind of specific case from the point of its reaction on exchange rate movements. The Eurozone members may provide the bias as they all use the same currency and have an extremely high market share in a lot of destination markets. Excluding from the sample does not mean recalculating the imported inputs shares or market shares.

Numerically, in case of trade between advanced economies and controlling for the destination currency exchange rate, the elasticity of export price index (in destination currency) to a producer currency exchange rate is 0.379 when the share of imported inputs is 12.57% (the 10th percentile of the distribution) and it is 0.274 when $\tilde{\phi}_{sc\tau}$ is 42.95% (the 90th percentile).

D_{dt} captures not only the movements of the destination currency exchange rates but also another destination specific changes, such as: period of business cycle in the destination country, inflation rate and others. Later I present evaluations of the effect of exchange rate movements of producer currency and destination one separately. Such consideration excludes possibility for using destination-time specific dummy D_{dt} .

4.3 Two-component ERPT

Bilateral exchange rate movement contains two components: a movement of the producer currency against some international benchmark (USD or XDR) and a movement of the destination currency against it. As it was shown in the model, the effect of this two movements could be different due to the fact the price-to-market effect is asymmetric.

The consideration of two-components exchange rate is necessary because the marginal cost channel could work only against movements of producer currency. Fauceglia et al. (2012) find that ERTP into imported intermediate goods prices is close to full³³. It means the imported inputs prices are quite stable (denominated in the basket of foreign currencies, USD or XDR). The possible explanation is that the distribution cost share for intermediate goods is lower than for consumer goods, Goldberg and Campa (2010). It is important because used database considers as imported inputs: all foreign goods and services which were bought on domestic market and imported value added embodied in domestic products along with goods which were imported directly by a firm. The coefficient for imported inputs channel (θ) should be close (in absolute value) to the coefficient for simple direct effect (α) as the cost of imported inputs are not affected by the changes of exporting country's currency exchange rate movement.

The key simplification which is used here: $\Delta e_{sc\tau}^{\bar{k}} \approx \Delta e_{ct}^{\$} (\approx \Delta e_{ct}^X)$. It assumes that weighted by trade (of imported inputs) producer currency exchange rate movement is close to one against USD (or XDR). There are several reasons that justify this assumption: a lot of inputs (especially raw materials) are pricing in USD; ERPT into imported inputs price index depends on invoicing currency, type of the goods or commodities, so equation (26) is also an approximation of measure of ERPT into imported inputs price index. Under this assumption the effect of imported inputs on ERPT should be caught by the coefficient for an imported value

³³"Our import side results... suggest that prices of imported inputs faced by Swiss output/export industries are mainly invoiced in currencies of the foreign supplier."

added share multiplied by exporting country's exchange rate against USD or XDR:

$$\Delta p_{scdt} = \alpha \Delta e_{ct} + \beta \Delta e_{dt} + \theta \tilde{\phi}_{sc\tau} \Delta e_{ct} + \gamma \tilde{Z}_{scdt-1} \Delta e_{ct} + S_{st} + r_{scdt} \quad (29)$$

The regression results are presented in Table 7. The coefficients for the destination currency part of ERPT (β) are quite similar in all columns. The coefficients for exporting country (producer currency) exchange rates (α) are higher when XDR is used as the benchmark. The bias in the estimations of the imported inputs effect is observed. Without control for the share of exporting country on the destination market (columns 1.1 and 2.1), there is significant coefficient for the imported inputs effect θ : -0.255 when USD is the benchmark and -0.479 when XDR. However, the including the control for the share of exporting country on the destination market (columns 1.2 and 2.2) drops the coefficient θ substantially. Precisely, there is no significant effect of imported inputs when USD is used as a benchmark; the effect is still significant, but lower in absolute value (-0.282) when XDR is applied. The next step considers the possibility that an imported inputs share just catches the difference between industries rather than marginal cost changes. The idea is that the group of industries like machineries, computers or transport is different from the other one like mining or basic metal. These industries have different average imported inputs shares in gross exports and may have different levels of ERPT. For checking this I run the regression (29) with the industry-specific price elasticities to exporter and destination exchange rates (α_s and β_s), see columns 1.3 and 2.3. The imported inputs effect is less in absolute value (-0.156) but still significant when XDR is used as a benchmark.

The evaluations of the size effect (γ) - the importance of an exporting country share on destination market - are similar in value and significance whether USD or XDR is used as a benchmark. The US and Eurozone countries are some kind of outliers in the sense on their share on destination markets. Excluding them from the sample reduces the absolute value and significance of the estimated effect of imported inputs, see columns 1.4-1.6 and 2.4-2.6.

The decreasing in marginal cost of production (denominated in producer currency) after appreciation of producer currency is proportional to exchange rate of producer currency against the weighted basket of origin currencies (26). This may explain the difference in estimation of the cost channel effect based on USD and XDR, in case the movement relative to XDR is a better approximation of such weighted producer currency exchange rate movement.

For testing this explanation I applied two measures of changing in marginal cost of production: weighted exchange rate e^W and real effective exchange rate e^R . The first one is an exporting country exchange rate movement against weighted basket of origin currencies, see the equation (26). The regression results for

(29) using e_{sct}^W – exporter weighted exchange rate³⁴ – are presented in Table 8. Comparison the result for trade between advanced economies with previous based on USD or XDR (see Table 7) supports the suggested explanation. First, the estimated coefficient for imported inputs effect on ERPT is bigger (in absolute value) and more significant in all regressions, see columns 2.1-2.4³⁵. Precisely, the estimations of $\hat{\theta}$ are quite similar in all regressions: they are in the range from -0.531 to -0.633 and statistically significant at 1% level. Moreover, in that case, the omitting control for exporting country’s share in a destination market creates lower bias (compare columns (2.1) and (2.2)). Other coefficients mostly are in line with the previous estimations. Regressions without the US and Eurozone members give similar result, see columns (3.1)-(3.4).

However, all four used nominal exchange rates fail to find any evidence in favour of imported inputs effect in case of trade between all countries (including emerging markets and developing economies), see columns (1.1)-(1.4). It may reflect the fact that inflation is higher in such countries than in advanced ones. For this reason, I run the regression (29) using the annual changes of real effective exchange rate (REER) – Δe^R . The results are presented in Table 9. In case of trade between advanced economies (columns 2.1-2.3 in Table 9), the estimations of the imported inputs effect are slightly bigger than the ones based on weighted exchange rate (columns 2.1-2.3 in Table 8). However, the estimations of the exporting country share effect are substantially bigger. The important difference is that the regressions based on REER reveal the negative imported inputs effect on ERPT for all considering groups of countries (columns 1.1-1.3 in Table 9). Thus, omitting inflation rate significantly changes the estimation of the imported inputs effect on ERPT for developing countries. The relatively lower difference of the results based on REER and weighted by imported inputs shares for advanced economies may be just reflect the fact that these countries have lower and more stable inflation rates.

It is worthy to mention, that I use the same exchange rate of exporting country within any regression as the first independent variable and in the multiplicative independent variables.³⁶ Additional robustness check (columns (1.4, 2.4, 3.4)) includes two multiplicative variables. The first one is the intersection of an imported inputs share with a destination exchange rate ($\tilde{\phi}_{sct} \Delta e_{dt}^R$); and the second one - the intersection of an exporting country share in a destination market with a destination exchange rate ($\tilde{Z}_{sct-1} \Delta e_{dt}^R$). These variables substantially reduce the estimated coefficient of export price elasticity to the destination currency exchange rate (β). Moreover, the intersection of an imported inputs share with a destination exchange rate is significant only at 10% level in case of trade between advanced economies³⁷. Thou, imported inputs play

³⁴Destination weighted exchange rate is defined through the exporter-destination bilateral ER: $\Delta e_{sdt}^W \equiv \Delta e_{sct}^W - \Delta e_{cdt}^B$.

³⁵The regression (2.4) checks that the results are not driven by the used definition of the destination weighted exchange rate.

³⁶It is necessary for avoiding possible bias because of correlation between these different measures of exchange rate. The including different measures of exchange rates in the same regression significantly increase an absolute values of the coefficients in some cases, which are not reported.

³⁷It is insignificant in case of trade between advanced economies without the US and Eurozone member.

a role in real hedging only in case of producer currency movements. It coincides with the assumption that imported inputs act through cost channel.

Remind, there is a strong relationship between two main parameters: the imported inputs share in gross export and the share of an exporting economy on a destination market. The bigger economies, *ceteris paribus*, have both: bigger shares in a destination market and a smaller imported inputs share in gross export. The correlation between them is -0.37. The presented results clearly show that omitting control for the exporting country share create a bias in the estimation of the imported inputs effect.

The results provide evidence in favour of the negative effect of imported inputs on the producer currency ERPT into destination market prices. The effect acting through marginal cost channel as it decreases ERPT only in case of producer currency movement. The direct (nominal) measure of marginal cost changes – weighted exchange rate – provides the strongest evidence of the effect among all nominal exchange rates, but only for trade between advanced economies. Only the real effective exchange rate shows the presence of the imported inputs effect for the whole sample of the countries. In case of trade between advanced economies and controlling for the destination currency exchange rate, the elasticity of export price index (in destination currency) to a producer currency REER is 0.333 when the share of imported inputs is 12.57% (the 10th percentile of the distribution) and it is 0.118 when $\tilde{\phi}_{sct}$ is 42.95% (the 90th percentile). That is quite similar to the result based on bilateral exchange rate.

4.4 Industry specific ERPT

The ERPT has a significant amount of variation across industries. They are vary in: the average share of imported inputs, intensity of processing trade and share of final goods in gross export - all that define the common place in the global value-added production chains. Industries also have different transportation cost, heterogeneity of goods within one commodity position, and other characteristics that may affect the value of the effect of import intensity on ERPT. There are trade data for 17 industries represented in TiVA database³⁸. For considering industry-specific ERPT in case of trade between advanced economies (excluding USA) I run regression (29) for each industry separately.

$$\Delta p_{sctd} = \alpha_s \Delta e_{ct} + \theta_s \tilde{\phi}_{sct} \Delta e_{ct} + \gamma_s \tilde{Z}_{sctd-1} \Delta e_{ct} + D_{sctd} + r_{sctd} \quad (30)$$

The results based on weighted exchange rates³⁹ are presented in Figure 1, export price indexes are in US dollar. All industries (except wood) have positive and statistically significant coefficients of exporting

³⁸See Table 3

³⁹The results based on real affective exchange rate are very similar.

country's currency ERPT into destination market prices (α_s). The range of its absolute values is wide: from 0.19 to 0.72, Figure 1, the left side. Wood industry is the only one for which the regression does not find any relationship between producer's exchange rate and export prices. It is also the smallest industry, its share in total trade between advanced economies (without USA) is only 0.9%.

All industries (except wood industry, again) have negative estimated values of the imported inputs effect on ERPT (θ_s). The coefficients are negative and statistically significant for 9 out of 17 industries⁴⁰, Figure 1, the right side. The estimated effect of imported inputs is positive for wood industry. However, this coefficient becomes insignificant without Canada which is quite important exporter of wood.

The size effect γ_s measures the influence of simultaneous shock, which is common for all exporters from some country, on the industry price level in destination market. Thus, the usage of destination-year dummy catches the variation of that industry price level (in the regressions which are run for each industry separately). As a result, the regressions results (30) without direct controlling of the exporting country share in destination market are quite similar to the presented ones. Nevertheless, the positive effect of exporting country share in destination market on ERPT is detected for 6 out of 17 industries⁴¹.

4.5 Time variety of ERPT

The one more robustness check considers time dynamic of the imported inputs effect on ERPT. I run the following regression for trade between advanced economies (without US) using weighted by imported inputs shares exchange rates (Δe_{sct}^W):

$$\Delta p_{sct} = \alpha_t \Delta e_{ct}^W + \theta_t \tilde{\phi}_{sct} \Delta e_{ct} + \gamma_t \tilde{Z}_{sct-1} \Delta e_{ct} + D_{sct} + r_{sct} \quad (31)$$

The results for time variance of coefficient α_t is presented on Figure 2, the left side. Producer currency ERPT into export prices is positive and statistically significant for 2001-2015 years, except 2004 and 2006. The results for coefficient θ_t is presented on Figure 2, the right side. The imported inputs effect on ERPT is negative for 13 out of 15 years. However, it is statistically significant only for 10 periods. The same regression based on real effective exchange rate gives very similar results.

5 Conclusion

This paper theoretically and empirically analyses the effects of imported inputs and the exporting country share in a destination market on the degree of ERPT into export prices.

⁴⁰for 11 when the real effective exchange rate is used

⁴¹for 10 when the real effective exchange rate is used

Using industry-level data for 35 advanced economies and 22 developing countries over 2000-2015, I test both effects applying clustered errors. The results provide evidence in favour of the both predicted effects on producer currency ERPT into export prices: (I) the negative effect of imported inputs and (II) a positive one of the exporting country share. The results also show imported inputs reduce ERPT into export prices through the cost channel: they lessen the ERPT only in case of producer's currency exchange rate movements, but not a destination one.

The empirical estimations use five different measures of exchange rates. The first one is the bilateral producer-destination exchange rate which measures the ERPT by definition. The preliminary estimation gives average bilateral ERPT from 57% to 76% depending on the country sample. It is similar to the results by Bussière and Peltonen (2014) based on the big sample of advanced economies and emerging markets⁴².

The other four measure distinguish two components: a producer currency movement against some benchmark and a destination one against it. Two simple world benchmarks are used: the US dollar and the Special Drawing Rights. Next, I apply the weighted exchange rate which measures the producer currency movements against the basket of currencies of origin, weighted by imported inputs shares. It directly catches the changes in the price of a weighted basket of imported inputs. All these measures of exchange rates support the theoretical predictions for advanced economies. However, only the estimations based on real effective exchange rates (REER) provides evidence in favour of the imported inputs effect for developing countries. It may reflect the fact that inflation is higher and has a more significant impact on nominal export prices in developing economies than in advanced ones. The weighted exchange rate and REER have highest predictive powers.

For trade between advanced economies, controlling for an exporting country share, after a 10% appreciation of the producer currency, the export price index goes up: it rises by 3.3% when the share of imported inputs is 12.57% (the 10th percentile of the distribution), and by 1.2% when the share is 42.95% (the 90th percentile). The results also show the 10 ppt higher exporting country share in the destination market, *ceteris paribus*, is associated with roughly 5 ppt higher ERPT. Because of the negative correlation between imported inputs and the exporting country share, it is important to control both channels – omitting one induces a substantial bias in the other's estimation.

⁴²Bussière and Peltonen (2014) find average ERPT into export prices in producer currency around 35% that is $1 - 0.35 = 65\%$ ERPT in destination currency.

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Table 1: The list of countries and currencies

Country	Currency	Advanced	Country	Currency	Advanced
Argentina	ARG	0	Israel	ISR	1
Australia	AUS	1	Italy	EURO	1
Austria	EURO	1	Japan	JPN	1
Belgium	EURO	1	Cambodia	KHM	0
Bulgaria	BGR	0	Korea, Rep.	KOR	1
Brazil	BRA	0	Lithuania	LTU	1
Canada	CAN	1	Luxembourg	EURO	1
Switzerland	CHE	1	Latvia	LVA	1
Chile	CHL	0	Mexico	MEX	0
China	CHN	0	Malta	MLT/EURO since 2008	1
Colombia	COL	0	Malaysia	MYS	0
Costa Rica	CRI	0	Netherlands	EURO	1
Cyprus	CYP/EURO since 2008	1	Norway	NOR	1
Czech Republic	CZE	1	New Zealand	NZL	1
Germany	EURO	1	Philippines	PHL	0
Denmark	DNK	1	Poland	POL	0
Spain	EURO	1	Portugal	EURO	1
Estonia	EST/EURO since 2011	1	Russian Federation	RUS	0
Finland	EURO	1	Saudi Arabia	SAU	0
France	EURO	1	Singapore	SGP	1
United Kingdom	GBR	1	Slovak Republic	SVK/EURO since 2009	1
Greece	EURO	1	Slovenia	MLT/EURO since 2007	1
Hong Kong, China	HKG	1	Sweden	SWE	1
Croatia	HRV	0	Thailand	THA	0
Hungary	HUN	0	Turkey	TUR	0
Indonesia	IDN	0	United States	USA	1
India	IND	0	Vietnam	VNM	0
Ireland	EURO	1	South Africa	ZAF	0
Iceland	ISL	1	Rest of the World		0

Source: IMF, World Economic Outlook, April 2016

Table 2: Description of the original data from TiVA database

Description	Original name	Used name	Unique values
Year	v_1	year	17: 1995-2011
Source country – country where this part of VA was produced	v_2	VA_ORGN	81: 63 countries and rest of the world, 15 groups of countries, DXD (domestic) and WOR (total)^a
Source industry – industry that was used in the production of that part of VA	v_3	VA_IND	51: 34 industries and 17 groups of (the same) industries ^b , including CTOTAL – the sum of all source industries
Exporter – country which gross export is analysed	v_4	EXPORTER	79: 63 countries , 15 groups of countries and rest of the world
Export industry – industry which gross export is analysed	v_5	EXPORT_IND	51: 34 industries and 17 groups of (the same) industries
Value added	v_6	VA	$17 * 81 * 51 * 79 * 51 = 2.8 * 10^8$

^a http://www.oecd.org/sti/ind/tiva/TiVA_2016_CountriesRegions.pdf

^b http://www.oecd.org/sti/ind/tiva/TiVA_2016_ISIC3_Industries.pdf

Source: TiVA

Table 3: The result of matching TiVA industries and HS commodity groups

Industry description (TiVA, 2015)	Exporting industry (ISIC, rev.3)	Number of HS 6-digit commodity groups
Agriculture, hunting, forestry and fishing	C01T05	307
Mining and quarrying	C10T14	106
Food products, beverages and tobacco	C15T16	423
Textiles, textile products, leather and footwear	C17T19	853
Wood and products of wood and cork	C20	69
Pulp, paper, paper products, printing and publishing	C21T22	156
Coke, refined petroleum products and nuclear fuel ^a	C23	20
Chemicals and chemical products	C24	884
Rubber and plastics products	C25	122
Other non-metallic mineral products	C26	164
Basic metals	C27	359
Fabricated metal products except machinery and equipment	C28	219
Machinery and equipment n.e.c	C29	528
Computer, electronic and optical products	C30T33X	350
Electrical machinery and apparatus n.e.c	C31	136
Motor vehicles, trailers and semi-trailers	C34	55
Other transport equipment	C35	81
Manufacturing n.e.c; recycling	C36T37	188
Electricity, gas and water supply ^a	C40T41	3
Research and development and Other Business Activities ^a	C73T74	5
Other community, social and personal services ^a	C90T93	10

^a these industries are not include in the analysis because of the lack of trade data

Source: author's calculation

Table 4: The correlation table for used exporting country exchange rates

The measure of annual changes in exchange rate	(1) bilateral (against the destination currency)	(2) against USD	(3) against XDR	(4) against weighted basket origin currencies	(5) real effective exchange rate
Δe_{ct}	Δe_{cdt}^B	$\Delta e_{ct}^{\$}$	Δe_{ct}^X	Δe_{cst}^W	Δe_{ct}^R
Data source:	IMF	IMF	IMF	IMF & TiVA	World Bank
bilateral against USD	1	1			
against XDR	0.3990	0.9818	1		
weighted ER	0.3313	0.8255	0.7350	1	
REER	0.5261	0.7237	0.6147	0.8788	1

Table 5: The regression results of (27), EPI in exporter currency, bilateral exchange rate

Dep. var.: Δp_{scdt}^c	(1.1) ^d	(1.2) ^c	(1.3) ^d	(2.1) ^d	(2.2) ^c	(2.3) ^d	(3.1) ^d	(3.2) ^c	(3.3) ^d
Exporting countries:		ALL			ADV			ADV without US	
Destination markets:		ALL			ALL			ADV without US	
Δ Bilateral ER: Δe_{cdt}^B	-0.433*** (-9.24)	-0.809*** (-25.32)	-0.0620*** (-4.93)	-0.242*** (-6.78)	-0.664*** (-22.18)	-0.0698*** (-5.03)	-0.393*** (-16.91)	-0.685*** (-21.50)	-0.131*** (-9.47)
Industry-year dummy	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Destination-year dummy		Yes			Yes			Yes	
Exporter-year dummy			Yes			Yes			Yes
N	547875	547875	547875	340113	340113	340113	183339	183339	183339
adj. R^2	0.169	0.257	0.289	0.096	0.140	0.167	0.114	0.142	0.176

t statistics in parentheses

* $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

Note: CGW_{scdt} is used as a weight for each observation. ^d - standard errors are clustered at the destination-year level; ^c - standard errors are clustered at the exporter-year level. Alternative clustering at the destination level and at the exporter level provides the same conclusion.

Table 6: The regression results based on bilateral exchange rate (28)

Dep. var.: Δp_{scdt}^c	(1.1) ^d	(1.2) ^d	(1.3) ^c	(1.4) ^c	(2.1) ^d	(2.2) ^d	(2.3) ^c	(2.4) ^c	(3.1) ^d	(3.2) ^d	(3.3) ^c	(3.4) ^c
Exporting countries:	ALL				ADV				ADV without US and EZ			
Destination markets:	ALL				ADV				ADV without US and EZ			
Δ Bilateral ER \times Imported inputs share: $\tilde{\phi}_{scr} \Delta e_{cdt}^B$	0.631*** (8.43)	0.762*** (12.67)	0.167 (1.94)	0.189* (2.12)	-0.486*** (-9.09)	-0.294*** (-4.59)	-0.335*** (-3.64)	-0.347*** (-3.59)	-0.108 (-1.37)	-0.0737 (-0.91)	-0.262** (-2.79)	-0.260** (-2.70)
Δ Bilateral ER \times Share in dest-n market: $\tilde{Z}_{scdt-1} \Delta e_{cdt}^B$		0.841*** (14.51)		0.115*** (3.83)		0.490*** (8.57)		-0.0267 (-0.57)		0.499** (2.89)		0.0325 (0.20)
Destination-year dummy			Yes	Yes			Yes	Yes			Yes	Yes
Industry-year dummy	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
N	547873	547873	547873	547873	199819	199819	199819	199819	69551	69551	69551	69551
adj. R^2	0.174	0.183	0.257	0.257	0.118	0.121	0.145	0.145	0.127	0.127	0.162	0.162

t statistics in parentheses

* $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

Note: CGW_{scdt} is used as a weight for each observation. ^d - standard errors are clustered at the destination-year level; ^c - standard errors are clustered at the exporter-year level. Alternative clustering at the destination level and at the exporter level provides the same conclusion.

Table 7: The regression results of (29), exchange rates and EPI in USD or XDR

	(1.1)	(1.2)	(1.3)	(1.4)	(1.5)	(1.6)	(2.1)	(2.2)	(2.3)	(2.4)	(2.5)	(2.6)
Benchmark:	USD: $\Delta p_{sctd}^{\$}$, $\Delta e_{ct}^{\$}$, $\Delta e_{dt}^{\$}$						XDR: Δp_{sctd}^X , Δe_{ct}^X , Δe_{dt}^X					
Exporting countries:	ADV			ADV without US and EZ			ADV			ADV without US and EZ		
Destination markets:	ADV			ADV without US and EZ			ADV			ADV without US and EZ		
Δ Exporter ER : Δe_{ct}	0.400*** (28.57)	0.326*** (20.68)		0.319*** (13.01)	0.270*** (10.76)		0.461*** (29.63)	0.380*** (21.91)		0.386*** (14.40)	0.333*** (12.01)	
Δ Destination ER : Δe_{dt}	0.137*** (17.73)	0.132*** (17.41)		0.127*** (10.57)	0.121*** (10.18)		0.137*** (17.75)	0.133*** (17.43)		0.127*** (10.60)	0.122*** (10.20)	
Δ Exporter ER \times Imported inputs share: $\tilde{\phi}_{sct} \Delta e_{ct}$	-0.255*** (-6.16)	-0.0683 (-1.56)	0.0193 (0.41)	-0.0991 (-1.54)	-0.0161 (-0.25)	0.133 (1.89)	-0.479*** (-8.88)	-0.282*** (-5.08)	-0.156* (-2.51)	-0.326*** (-4.01)	-0.244** (-3.01)	-0.0262 (-0.28)
Δ Exporter ER \times Share in dest-n market: $\tilde{Z}_{sctd-1} \Delta e_{ct}$		0.276*** (10.98)	0.300*** (11.59)		1.085*** (6.27)	1.147*** (6.55)		0.457*** (10.98)	0.495*** (11.65)		1.268*** (5.71)	1.372*** (6.24)
Industry-specific alpha			Yes			Yes			Yes			Yes
Industry-specific beta			Yes			Yes			Yes			Yes
Industry-year dummy	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
N	199819	199819	199819	69551	69551	69551	199819	199819	199819	69551	69551	69551
adj. R^2	0.210	0.211	0.212	0.168	0.170	0.171	0.078	0.080	0.080	0.071	0.072	0.073

t statistics in parentheses

* $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

Note: CGW_{sctd} is used as a weight for each observation. Standard errors are clustered at exporter-destination level. Alternative clustering at the destination-year or exporter-year level provides the same conclusion; except that the clustering at exporter-year level finds the coefficient θ are significant only in regressions (1.1) and (1.2).

Table 8: The regression results of (29), weighted exchange rates, EPI in USD

	(1.1) ^d	(1.2) ^d	(1.3) ^d	(1.4) ^y	(2.1) ^d	(2.2) ^d	(2.3) ^d	(2.4) ^y	(3.1) ^d	(3.2) ^d	(3.3) ^d	(3.4) ^y
Exporting countries:	ALL				ADV				ADV without US and EZ			
Destination markets:	ALL				ADV				ADV without US and EZ			
Δ Exporter ER : Δe_{sct}^W	0.136*** (13.24)	0.108*** (11.29)		0.116** (2.64)	0.427*** (26.40)	0.394*** (20.96)		0.422*** (8.51)	0.394*** (13.39)	0.352*** (11.35)		0.356*** (5.68)
Δ Destination ER : Δe_{sdt}^W	0.0669*** (16.77)	0.0640*** (16.24)			0.138*** (16.88)	0.137*** (16.78)			0.128*** (10.10)	0.125*** (9.95)		
Δ Exporter ER \times Imported inputs share: $\tilde{\phi}_{sct} \Delta e_{sct}^W$	0.141*** (4.42)	0.172*** (5.48)	0.350*** (10.65)	0.152 (1.07)	-0.633*** (-11.15)	-0.559*** (-9.39)	-0.531*** (-7.91)	-0.631*** (-4.06)	-0.540*** (-6.17)	-0.472*** (-5.38)	-0.339*** (-3.36)	-0.487*** (-2.65)
Δ Exporter ER \times Share in dest-n market: $\tilde{Z}_{scdt-1} \Delta e_{sct}^W$		0.516*** (11.99)	0.523*** (11.83)	0.434*** (6.92)		0.186*** (5.16)	0.198*** (5.39)	0.114 (1.26)		1.005*** (4.45)	1.107*** (4.95)	0.962*** (3.51)
Destination-year dummy				Yes				Yes				Yes
Industry-specific alpha			Yes				Yes				Yes	
Industry-specific beta			Yes				Yes				Yes	
Industry-year dummy	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
N	547863	547863	547863	547863	199812	199812	199812	199812	69549	69549	69549	69549
adj. R^2	0.177	0.179	0.180	0.183	0.205	0.205	0.206	0.208	0.163	0.164	0.164	0.167

t statistics in parentheses

* $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

Note: CGW_{scdt} is used as a weight for each observation. ^d - standard errors are clustered at the exporter-destination level; ^y - standard errors are clustered at the exporter-year level.

Table 9: The regression results of (29), real effective exchange rates, EPI in USD

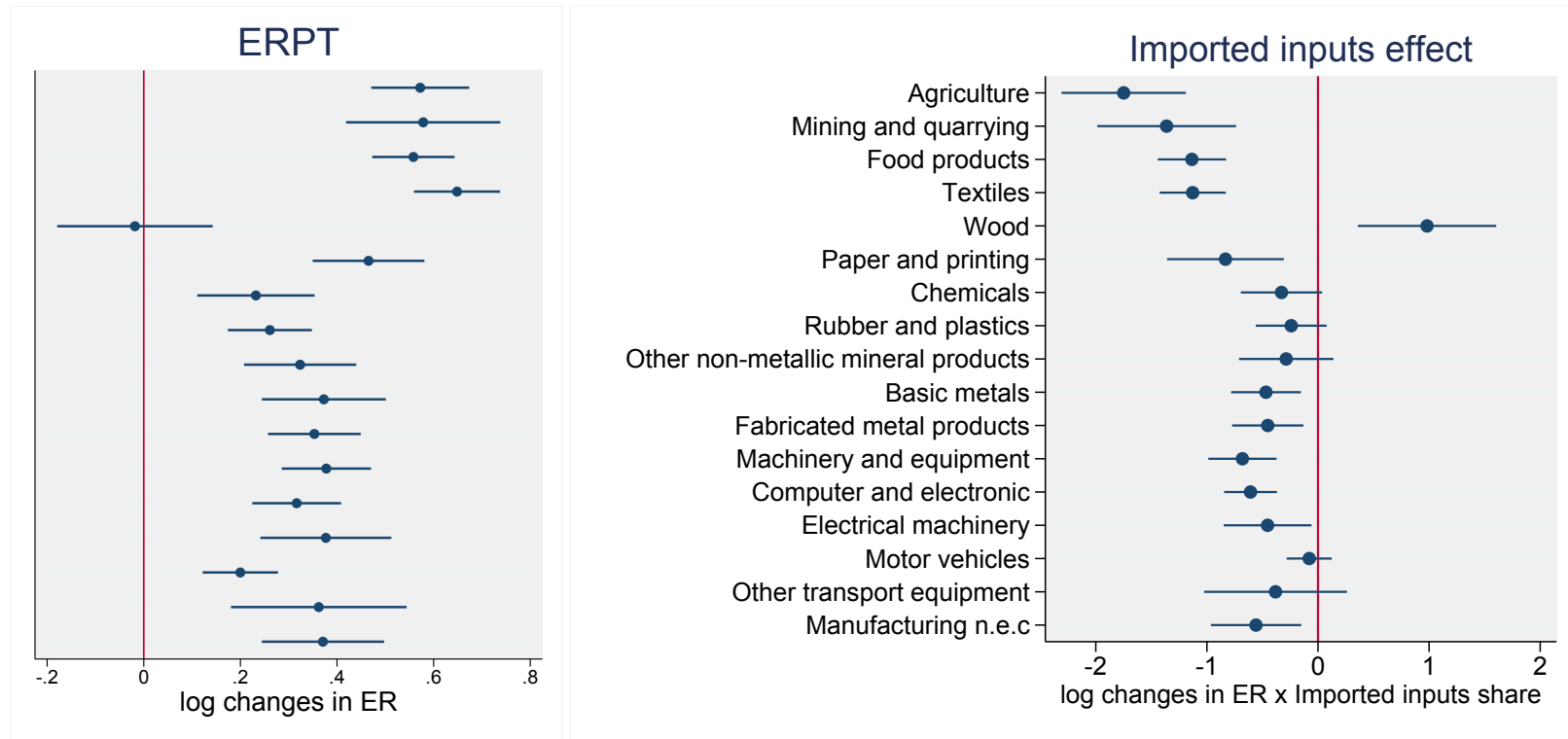
	(1.1)	(1.2)	(1.3)	(1.4)	(2.1)	(2.2)	(2.3)	(2.4)	(3.1)	(3.2)	(3.3)	(3.4)
Exporting countries:	ALL				ADV				ADV without US and EZ			
Destination markets:	ALL				ADV				ADV without US and EZ			
Δ Exporter ER : Δe_{ct}^R	0.412*** (35.80)	0.361*** (31.07)		0.362*** (31.29)	0.475*** (24.72)	0.422*** (20.29)		0.421*** (20.36)	0.396*** (13.59)	0.353*** (11.78)		0.357*** (12.09)
Δ Destination ER : Δe_{dt}^R	0.0774*** (14.55)	0.0782*** (14.73)		0.0419** (3.26)	0.106*** (12.32)	0.109*** (12.76)		0.0405 (1.80)	0.0951*** (6.62)	0.0949*** (6.60)		0.0309 (0.85)
Δ Exporter ER \times Imported inputs share: $\tilde{\phi}_{sc\tau} \Delta e_{ct}^R$	-0.571*** (-15.01)	-0.500*** (-13.14)	-0.349*** (-7.95)	-0.501*** (-13.24)	-0.804*** (-12.95)	-0.707*** (-11.01)	-0.686*** (-9.29)	-0.704*** (-11.04)	-0.576*** (-6.38)	-0.511*** (-5.65)	-0.383*** (-3.73)	-0.518*** (-5.79)
Δ Exporter ER \times Share in dest-n market: $\tilde{Z}_{scdt-1} \Delta e_{ct}^R$		0.831*** (12.74)	0.857*** (12.89)	0.822*** (12.74)		0.568*** (5.94)	0.590*** (6.03)	0.568*** (5.97)		0.989*** (4.20)	1.124*** (4.91)	0.935*** (3.57)
Δ Destination ER \times Imported inputs share: $\tilde{\phi}_{sc\tau} \Delta e_{dt}^R$				0.0896* (2.22)				0.195* (2.52)				0.156 (1.45)
Δ Destination ER \times Share in dest-n market: $\tilde{Z}_{scdt-1} \Delta e_{dt}^R$				0.111*** (4.28)				0.139*** (3.58)				0.637** (2.75)
Industry-specific alpha			Yes				Yes				Yes	
Industry-specific beta			Yes				Yes				Yes	
Industry-year dummy	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
N	361608	361608	361608	361608	157416	157416	157416	157416	50335	50335	50335	50335
adj. R^2	0.192	0.194	0.194	0.194	0.212	0.213	0.213	0.213	0.172	0.173	0.173	0.173

t statistics in parentheses

* $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

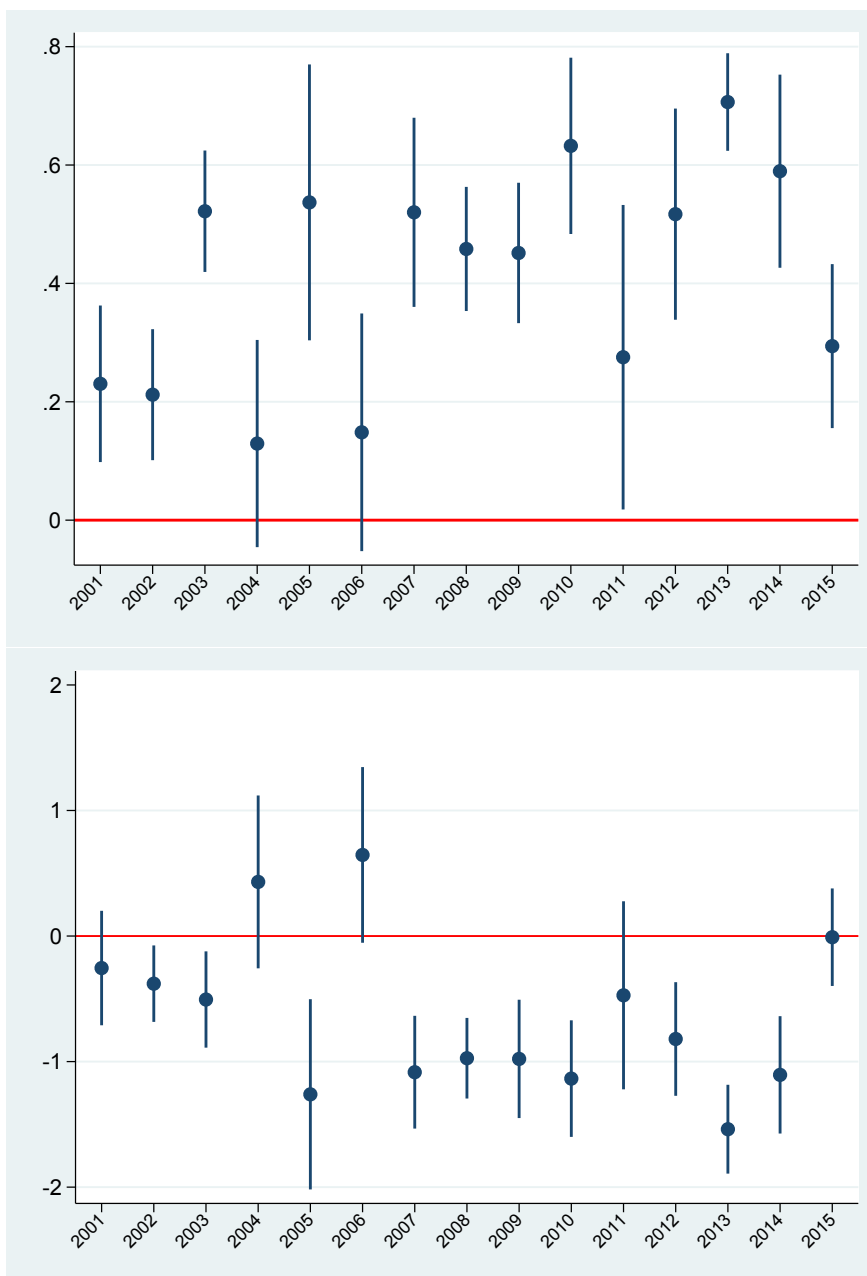
Note: CGW_{scdt} is used as a weight for each observation. Standard errors are clustered at the exporter-destination level.

Figure 1: The variance of ERPT and the imported inputs effect across industries.



Note: Figure presents the results of (30) based on trade between advanced economies (without USA). The weighted exchange rate is used, the export price index is denominated in US dollar. 90% confident intervals are shown.

Figure 2: Time variance of ERPT and the imported inputs effect.



Note: Figure presents the results of (31) based on trade between advanced economies (without USA). The weighted exchange rate is used, the export price index is denominated in US dollar. 90% confident intervals are shown.