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RESEARCH ARTICLE

Exchange Rate Pass-through in China: A Cost-Push Input-Output Price Model

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Abstract

Relying on a cost-push input-output model for China, we estimate the exchange rate pass-through to both domestic prices and export prices at the industry level. Our empirical results indicate that the decline of the RMB price in the processing exports sector in response to an RMB appreciation is larger than that in the non-processing exports sector, which, in turn, is larger than the decline of the consumer price indexes. Our cross-sector analysis also suggests that exchange rate changes have the lowest impact on prices in capital- and technology-insensitive industries.

Keywords RMB appreciation · Input-output model · Export prices · Domestic prices

JEL Code F31 · F41

1 Introduction

Exchange-rate pass-through (ERPT) refers to the impact of changes in the value of the domestic currency vis-à-vis other currencies on changes in prices. The extent to which exchange rate appreciations or depreciations are reflected in import, domestic, and export prices has important implications for the international transmission of shocks and monetary policy. A high level of pass-through means that nominal exchange rate fluctuations lead to large changes in prices. It also implies that exchange rate movements can frustrate the central bank's price stability policies. For these reasons, ERPT has become especially important for China.

There is a large body of empirical research on ERPT and its drivers (discussed in section 2). However, there is limited research on ERPT differences across industries or

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across different production types even though this may be relevant, notably for China. China has, for instance, several policies in place to stimulate processing trade. For example, imported materials used for processing trade are free of tariffs, which leads to a much higher level of imported intermediate inputs in the processing exports sector than in other sectors (Yang et al. 2015; and Chen et al. 2012).[1] Several studies show that it is important to separate processing exports from other types of production, such as production for domestic use (cf. Pei et al. 2012).[2]

To illustrate: take two industries *i* and *j* where the products of industry *i* are intermediate inputs for the production of industry *j*, while industry *i* uses imported inputs. Now consider an increase in the price of intermediate imports due to an exogenous exchange rate shock, which directly increases the costs and prices of products in industry *i*, which, in turn, further increases the costs and prices of products in industry *j* (under the assumption that producers in industry *j* cannot totally absorb the higher costs). In this case, the ERPT in industry *i* originates from the use of imported intermediates, while the ERPT in industry *j* results from the domestic production network.[3]

The main contribution of our work is that we estimate ERPT for different sectors as well as different production types in China, using a newly constructed Input-Output (IO) table for China from the Organisation for Economic Co-operation and Development (OECD), which provides data on the processing exports sector. We develop our theoretical model based on Acemoglu et al. (2015). Acemoglu et al. (2015) build an input-output framework to illustrate how productivity and demand shocks propagate across sectors through the production network for a closed economy. Our model adds the import sector and especially discusses the impact of exchange rate changes for an open economy. We thus show how changes in the exchange rate influence the price of each sector through the production network. The next step is to bring theory to the data using IO analysis. As far as we know, the only study using an IO approach to analyze exchange-rate pass-through to prices is Aydoğuş et al. (2018). These authors investigate the exchange rate pass-through to consumer prices for 26 countries (including China) using IO tables.[4] However, they ignore the incomplete pass-through of exchange rate changes to the price of imported inputs. This may bias their results of ERPT

[1] Processing exports include: 1) Processing with Imported Materials (PIM): the business enterprise in China makes a foreign exchange payment for imported raw and auxiliary materials, parts and components, accessories, and then exports the finished products after processing or assembly. 2) Processing & Assembling (P&A): the business enterprise does not have to make a foreign exchange payment for the imports, but just charges the foreign party a processing fee.

[2] Pei et al. (2012) observe that the contribution of the change in exports to the change in value added in China (from 2002 to 2007) was 32% higher when ordinary IO tables are used than when the tables capturing processing trade are used. On a similar note, Craighead (2020) argues that intermediate goods trade reduces the "exchange rate disconnect" by increasing the volatility of the real exchange rate relative to output and weakening the link between the real exchange rate and output.

[3] A few previous studies have shown the importance of imported intermediate inputs for ERPT. For example, Shi and Xu (2010) find that the degree of ERPT to intermediate import prices affects the economy more than the ERPT to final import prices. However, most previous studies ignored the price transmission through imported intermediate goods and production chains at the industry level. Furthermore, previous studies neglected processing trade, which accounts for about two thirds of total Chinese trade (Johnson and Noguera 2012).

[4] Some previous studies used IO models to analyze price formation (Folloni and Miglierina 1994). Some studies research the impact of changes in energy prices (Berüment and Taşçı 2002; Bazzazan and Batey 2003; Wu et al. 2013), while others focus on the effect of implicit subsidies on sectoral prices (e.g. Sharify 2013).

to domestic prices. In addition, these authors do not distinguish differences in ERPT between processing and non-processing export sectors, which, we argue, is crucial in estimating ERPT for China.

Our results suggest a heterogeneous ERPT across different production patterns as well as industries. We find that an appreciation of the Chinese currency (RMB) decreases both China's domestic and export prices in RMB. However, the RMB price in the processing exports sector declines more in response to an RMB appreciation than that in the non-processing exports sectors, which is, in turn, larger than the decline of the domestic price index. In the processing exports sector, the ERPT to the RMB price in the *Food products, beverages and tobacco* sector and *Textiles, wearing apparel, leather and related products* sector are the lowest, while that in the *Coke and refined petroleum products* sector and the *Computer, electronic and optical products* sector are the highest. In the non-processing exports sector, the ERPT to the RMB price of the *Private households with employed persons* and *Financial and insurance activities* are the lowest, while that of the *Coke, refined petroleum products and nuclear fuel* sector and *Computer, electronic and optical products* sector are the highest. Our results suggest that capital- and technology-insensitive industries which are at the high end of the global value chain are least affected by exchange rate changes.

The structure of the paper is as follows. The next section briefly reviews previous studies. Section 3 presents the input-output model to examine ERPT. Section 4 presents our empirical estimates of ERPT in China. The last section concludes.

2 Literature Review

We classify the existing literature on ERPT into three categories. The first category of studies aims to quantify the degree of ERPT. Most previous studies support partial ERPT and find that ERPT ranges from 30 to 100% (see e.g. Campa and Goldberg 2005; Bussière et al. 2020). Furthermore, developing economies seem to have a larger and more rapid ERPT than high-income economies (cf. Frankel et al. 2012), although López-Villavicencio and Mignon (2017) suggest that emerging economies have similar ERTP as advanced economies once their level of inflation is controlled for.

Some recent empirical studies estimated the ERPT in China. Using firm-level data for Chinese exporting firms during the period 2000–2006, Bouvet et al. (2017) report almost complete exchange rate pass-through, but Li and Zhang (2018) find an ERPT of 67% for Chinese export prices, while Shu and Su (2009) find that China's ERPT to import prices is 60% in the long run.

The second line of literature explores the drivers of ERPT. A prominent explanation for partial ERPT is 'pricing-to-market' (PTM) behavior (see, for instance, Froot and Klemperer 1989; Betts and Devereux 2000; and Marazzi and Sheets 2007). PTM refers to the practice of limiting the ERPT by adjusting the profit margin in response to exchange rate changes. Another explanation is the difference between local currency pricing (LCP) and producer currency pricing (PCP); LCP and PCP imply different degrees of ERPT (Choudhri et al. 2005; and Gopinath et al. 2010). Due to exchange rate risk, LCP firms calculate export prices with an additional mark-up, while PCP firms usually do not apply significant markups. Other explanations for a partial ERPT include the inflationary environment, market structure, and exchange rate elasticity

(Fisher 1989; Dixit 1989; Campa and Goldberg 2002; and Choudhri et al. 2005). Several studies find that economies with higher inflation rates as well as higher exchange rate volatility have a higher ERPT (see, e.g., Taylor 2000; Campa and Goldberg 2002; and Choudhri and Hakura 2006). As to market structure, Devereux et al. (2017) find that ERPT is dependent on the market share of both importers and exporters. Li and Zhao (2016) show that expectations of future exchange rate fluctuations pass through into import prices.

Finally, scholars have started to focus on non-linearities and time-variability in the relationship between exchange rates and prices (cf. Taylor 2000; Bussière 2013; Bussière et al. 2014; and Razafindrabe 2017). Several studies explore the existence of non-linearities due to inflation, sovereign bond yield spreads, the exchange rate regime in place, and financial globalization (e.g. Barhoumi 2006; Bergin and Feenstra 2009; and Enders et al. 2018). Some studies examine the development of the ERPT over time. For example, López-Villavicencio and Mignon (2017) find that ERPT has declined over the past two decades.

In sum, previous studies have investigated the (drivers of) ERPT using different data and methods. However, how exchange rate fluctuations influence prices through the production network has received scant attention, even though some recent studies have stressed the importance of the production network in the propagation of shocks.[5] Acemoglu et al. (2015) develop a multisector framework to study how productivity and demand shocks propagate through the input-output linkage. Likewise, Bigio and La'O (2016) investigate the propagation of sectoral financial shocks through the production network and examine their influence on aggregate output and employment. Both studies document the essential role of the cost-push input-output price model in tracking the influence of shocks on economic variables. These studies provide us a new framework for studying ERPT. Thus, we focus on the propagation of exchange rate changes to (domestic and export) prices via a cost-push input-output price model.

3 Input-Output Model for China

In the online Appendix A1 we present a partial equilibrium framework to investigate the propagation effect of an exchange rate shock to export and consumer prices through the production chain. In this framework, we focus on the role of input-output linkages in the propagation of exchange rate shocks to prices in different industries in China. As indicated before, trade in China is dominated by processing trade, which implies that it is necessary to further distinguish processing exports from non-processing exports in each industry. Accordingly, an input-output table, which differentiates the production of processing exports from non-processing exports, is applied to investigate the ERPT of an RMB appreciation on export and domestic prices in China. To this end, we employ an IO model in which the production of each industry is divided into two categories: production for processing exports ("processing exports" hereafter), and non-non-processing production. The later includes two bundles of products: the production for non-processing exports ("non-processing exports" hereafter) and the production to

[5] See Carvalho (2014) for a literature review.

satisfy domestic demand ("domestic demand" hereafter). The form of the bipartite input-output table is shown in online Appendix A2.

We henceforth use the subscript O to represent non-processing production, and the subscript P to indicate processing exports. Suppose there are n industries in total. Then, in the bipartite table, the $2n \times 2n$ matrix of the domestic input coefficients is $\widetilde{\mathbf{A}} = \begin{pmatrix} \mathbf{A}^{OP} & \mathbf{A}^{OO} \\ \mathbf{0} & \mathbf{0} \end{pmatrix}$, where $\mathbf{A}^{ST}$ ($S = O;\ T = P,\ O$) indicates the cost share of products S used as intermediate input in production T. Notice that processing exports are not for domestic use by definition, and therefore the sub-matrices of their intermediate use are zeros. Similarly, the import intermediate coefficient matrix has the form of $\widetilde{\mathbf{B}} = \begin{pmatrix} \mathbf{B}^{MO} & \mathbf{B}^{MP} \end{pmatrix}$, where $\mathbf{B}^{MT}$ indicates the cost share of each imported input in the production of product T ($T = O,\ P$). Denote $\mathbf{e} = \begin{pmatrix} \mathbf{e}^{O} \\ \mathbf{e}^{P} \end{pmatrix}$ as the export vector with $\mathbf{e}^O$ and $\mathbf{e}^P$ representing the vector of non-processing exports and the vector of processing exports, respectively.

Let $\widehat{\mathbf{p}}^O$ and $\widehat{\mathbf{p}}^P$ denote the industry-wise export price change of non-processing exports and processing exports, respectively.

Then, analogue to eq. (A8) of the model in the online Appendix A1, the industry-wise price changes due to the exchange rate shock ε can be calculated by

$$\begin{pmatrix} \widehat{\mathbf{p}}^{O} \\ \widehat{\mathbf{p}}^{P} \end{pmatrix} = \left(\varepsilon\delta\widetilde{\mathbf{B}}\right)\left(\mathbf{I}-\widetilde{\mathbf{A}}\right)^{-1} \tag{1}$$

where δ is the ERPT to the price of imported products. The aggregated export price change in home currency due to an exchange rate shock is:

$$\widehat{p}_e = \sum_{i=1}^{n}\left(\widehat{p}_i^{P}\right)^{\sigma_i^P}\sum_{i=1}^{n}\left(\widehat{p}_i^{O}\right)^{\sigma_i^O} \tag{2}$$

where $\widehat{p}_i^P$ and $\widehat{p}_i^O$ are one of the elements in $\widehat{\mathbf{p}}^P$ and $\widehat{\mathbf{p}}^O$, respectively; σ_i^P and σ_i^O are the export share of industry i's processing exports and non-processing exports in total exports. Since the exports are sold in the foreign market, we also calculate the export price change in US Dollars, that is:

$$\widehat{p}_{fe} = \widehat{p}_e + \varepsilon = \sum_{i=1}^{n}\left(\widehat{p}_i^{P}\right)^{\sigma_i^P}\sum_{i=1}^{n}\left(\widehat{p}_i^{O}\right)^{\sigma_i^O} + \varepsilon \tag{3}$$

The aggregate domestic price, i.e., the price of domestic products to satisfy the domestic demand, is:

$$\widehat{p}_d = \sum_{i=1}^{n}\left(\widehat{p}_i^{O}\right)^{\sigma_i^D} \tag{4}$$

where σ_i^D is the output share of industry i in the total output of domestic demand. The output of domestic demand is calculated by deducting non-processing exports from the output of non-processing production. Similarly, the aggregated consumer prices change due to an exchange rate shock is:

$$\widehat{p}_c=\sum_{i=1}^{n}\left(\widehat{p}_i^O\right)^{\theta_i^d}\sum_{i=1}^{n}\left(\widehat{p}_i^m\right)^{\theta_i^m}=\sum_{i=1}^{n}\left(\widehat{p}_i^O\right)^{\theta_i^d}\sum_{i=1}^{n}(\delta_i\varepsilon)^{\theta_i^m} \tag{5}$$

We use eqs. (1)–(5) to investigate the exchange rate pass-through to the Chinese consumption price, processing export price, and non-processing export price.

4 Data and Results

4.1 Data

To calculate the ERPT for domestic and export prices, we need the domestic input coefficients ($\widetilde{\mathbf{A}}$), import intermediate coefficients ($\widetilde{\mathbf{B}}$), the industry-wise export share for processing exports and non-processing exports (σ_i^P and σ_i^O), the expenditure shares of domestic goods and imported goods (θ_i^O and θ_i^m), and ERPT to the import price (δ). Except for δ, all variables come from the international input-output tables from 2005 to 2015 released by the OECD in 2018.[6] We then obtain the Chinese national bipartite tables by aggregating the production activities of other countries together. The online Appendix A2 shows the framework of the bipartite IO tables and explains how we obtain these variables based on the bipartite IO tables. Although there are several IO databases for China, such as those from the Chinese Statistics Bureau and the World Input-Output Database, the OECD IO database clearly distinguishes processing exports from other productions. In the OECD IO tables, 36 industries in China are included, where the 20 tradable sectors (see Table 2 below for a list of all sectors) are further disaggregated into two categories by usage, i.e., non-processing production and processing exports. We calculate the ERPT for all years at industry level from 2005 to 2015, but only list the results for 2015 in Tables 1 and 2, since the ERPT figures for different years across industries and across production types are quite similar.

For the ERPT to the price of imported products (δ), existing literature provides different values for different countries and different time periods. Table A 2 in the online Appendix A3 lists these estimates, which range from 39% to 80%, while most of them are around 50%. Specially, Shu and Su (2009) provide the estimation of δ for China by using data from 1997 to 2007. Their estimates are around 60%, Therefore, we impose 60% as the value of δ. As a robustness check, we re-calculate the results by using the δ value of 39% and 80%. Our findings are quite robust to using different values of δ. Specially, the value of δ will not change the rankings of ERPT among different industries.

[6] The data are available at http://www.oecd.org.

Table 1 The exchange rate pass-through rate in China, aggregate results (in %)

Industry	In Chinese RMB	In US dollars
Aggregate exports price	−0.067	+0.933
Processing exports price	−0.155	+0.845
Non-processing exports price	−0.060	+0.940
Domestic production	−0.058	
CPI	−0.041	

We assume that the Chinese RMB appreciates by 1%. The signs indicate an increase or decrease of prices in response to the appreciation

4.2 Empirical Analysis

In this section, we use the framework provided in section 3 to estimate the degree of RMB appreciation pass-through to China's prices through the cost-push input-output price model.[7] We consider a scenario under which the RMB has appreciated by 1%, that is, $\varepsilon=1\%$. Then, based on eq. (1), we calculate the impact of this appreciation on the prices of non-processing products and processing exports. The results at the industry level are aggregated to the national level by using the corresponding industry outputs as weights. We use eqs. (1)–(5) to calculate the impact of an exchange rate change on the aggregate export price as well as the Consumer Price Index (CPI) in China. Except for exports, all prices are expressed in RMB.

4.2.1 Overall Results

Recall that we have distinguished three production types in our model, namely processing exports, non-processing exports, and domestic production. Table 1 provides an overview of the ERPT for these three aggregated production types by aggregating the industry-level results with the use of industrial exports or output as weights.[8] The results indicate that an appreciation of the RMB decreases both China's domestic and export prices via the cost-push input-output price model. This is quite intuitive. An RMB appreciation decreases the prices of imports of both final goods and intermediate goods in RMB, which, in turn, lower the production costs for domestic products as well as exports. Therefore, a larger share of imported intermediate inputs in production leads to a more significant decline in the RMB price. As the production of exports in China normally uses more imported intermediate inputs than the production of domestic sales, the export price decreases more than the price of domestic sales as shown in the Table 1. In other words, China's export sectors show a higher ERPT than its domestic sectors.

[7] It is worth stressing that except for the production network, an exchange rate appreciation can also influence domestic and export prices through other channels, such as firms' markups or product quality. However, these other channels are not focused upon in our analysis.

[8] More specifically, the processing exports of each industry are used as weights to calculate the ERPT for total processing exports, while the non-processing exports are used for that of non-processing exports, and the outputs for domestic demand are used for that of domestic demand.

Table 2 Price changes due to an exchange rate appreciation of 1% (in %)

Industry	Domestic demand (Non-processing exports)	Processing exports
Agriculture, forestry and fishing	−0.038	
Mining and extraction of energy producing products	−0.053	
Mining and quarrying of non-energy producing products	−0.069	
Mining support service activities	−0.070	
Food products, beverages and tobacco	−0.046	−0.062
Textiles, wearing apparel, leather and related products	−0.062	−0.070
Wood and products of wood and cork	−0.083	−0.093
Paper products and printing	−0.071	−0.085
Coke and refined petroleum products	−0.170	−0.226
Chemicals and pharmaceutical products	−0.092	−0.104
Rubber and plastic products	−0.094	−0.106
Other non-metallic mineral products	−0.070	−0.082
Basic metals	−0.105	−0.127
Fabricated metal products	−0.089	−0.099
Computer, electronic and optical products	−0.161	−0.197
Electrical equipment	−0.109	−0.123
Machinery and equipment, nec	−0.094	−0.108
Motor vehicles, trailers and semi-trailers	−0.100	−0.105
Other transport equipment	−0.113	−0.103
Other manufacturing; repair and installation of machinery and equipment	−0.074	−0.094
Electricity, gas, water supply, sewerage, waste and remediation services	−0.071	
Construction	−0.072	
Wholesale and retail trade; repair of motor vehicles	−0.025	
Transportation and storage	−0.053	
Accommodation and food services	−0.033	
Publishing, audiovisual and broadcasting activities	−0.039	
Telecommunications	−0.028	
IT and other information services	−0.061	
Financial and insurance activities	−0.009	
Real estate activities	−0.011	
Other business sector services	−0.041	
Public admin. and defence; compulsory social security	−0.035	
Education	−0.026	
Human health and social work	−0.046	
Arts, entertainment, recreation and other service activities	−0.028	
Private households with employed persons	0.000	

The exporting products have to compete with other countries' products in the international market. To test how exchange rate changes affect China's competitiveness, we express the export price change in US dollars. It equals the RMB price change plus the appreciation of the RMB. Since the decrease in RMB price of exports is always smaller than the degree of RMB appreciation, the RMB appreciation increases the dollar price of exports. Table 1 shows that this increase is large. A 1% RMB appreciation causes the aggregate export price in US dollars to increase by 0.933%. Our results are in line with those of Li et al. (2015) who also find a relatively high ERPT to foreign-currency denominated prices. Since most Chinese exporters are positioned in the low end of the value chain, high ERPT may reveal low profit margins so that exporters do not have room to pricing to market.

Table 1 also shows that the ERPT differs across processing and non-processing exports. An RMB appreciation results in a lower increase in the dollar price of processing exports (and therefore a smaller decline of international competitiveness) than in the dollar price of non-processing exports. Our results suggest that a 1% RMB appreciation results in a 0.845% increase in the dollar price of processing exports and a 0.94% increase in the dollar price of non-processing exports. This is because the processing exports sector uses much more imported intermediate inputs than the non-processing exports sector. China's IO table in 2015 shows that a production of one unit in the processing exports sector requires 0.152 unit of imported input, while this is only 0.062 for the production of one unit in the non-processing exports sector. An import-intensive exporter benefits from a larger decrease in production costs due to a currency appreciation via the production network, and therefore has a lower ERPT in foreign-currency denominated export prices.

Table 1 also shows that a 1% of RMB appreciation leads to a decrease of 0.041% in the CPI. CPI reflects the overall price of consumption by households of both domestic products and imports. Most of the consumption is sourced from domestic productions (the first production type); only 3% of domestic consumption is satisfied via imported products. In addition, domestic consumption has a high proportion of products from the food and service industries. As we show later, the prices of these industries are usually less influenced by an RMB appreciation. Therefore, an RMB appreciation has only a small impact on domestic inflation.

4.2.2 Industry-Level Results

Table 2 lists the ERPT at the industry level for both domestic and export prices. We find a heterogeneous ERPT across industries. The RMB prices of all industries decrease in response to an RMB appreciation. As mentioned above, the ERPT to prices of manufacturing industries is larger than that of service industries, which, in turn, is larger than that of agriculture. This can be explained by the use of imported inputs in the production process. Based on the Chinese IO table in 2015, the production of one unit in the manufacturing industry requires, on average, 7.518% imported units, while these numbers are 3.855% and 2.476% in the service and agriculture industries, respectively. Since import-intensive products benefit more from a larger decrease in production costs due to the RMB appreciation, the price of the manufacturing industry also declines more than that of other industries.

For non-processing production, we find that *Coke, refined petroleum products and nuclear fuel* has the highest price decrease with 0.17%, which is followed by

Computer, Electronic and optical equipment and *Other transport equipment* with price decrease of 0.161% and 0.113%, respectively. In 2015, the unit imported input requirements of these three industries are 21.523%, 15.121% and 9.128%, respectively. In contrast, the price of *Private households with employed persons* is barely influenced by the appreciation. The prices of the *Financial intermediation,* and *Real estate activities* also suffer little from an RMB appreciation with price decrease of 0.009% and 0.011%, respectively. Previous studies suggest that the product homogeneity and substitutability or market shares of foreign firms lead to a heterogeneous ERPT to domestic prices across industries. Our results show that the production chain is another reason for the different levels of ERPT among industries.

For export prices, the RMB price of processing exports also decreases more than that of non-processing exports (domestic prices) at the industry level. For processing exports, the price changes range from −0.226% for *Coke and refined petroleum products* to −0.062% for *Food products, beverages and tobacco*. By contrast, for non-processing exports, the price changes range from −0.17% for *Coke, refined petroleum products and nuclear fuel* to 0% for *Private households with employed persons*. These differences are quite intuitive, since unit imported input requirements range from 4.400% to 30.017% for processing exports while they are from 2.934% to 21.523% for non-processing exports. The larger decrease in RMB price of processing exports also indicates a lower ERPT to its dollar prices. Accordingly, an RMB appreciation tends to weaken the competitiveness of non-processing exports more seriously than that of processing exports.

Next, we express all export prices in US dollars to better assess the influence of exchange rate changes on the competitiveness of exports. For processing exports, the industry *Coke, refined petroleum products* has the lowest ERPT to its dollar price (77.419%), which is followed by *Computer, Electronic and optical equipment and Basic metals* with an ERPT of 80.337% and 87.318%, respectively. As for non-processing exports, the ERPT to dollar prices for *Coke, refined petroleum products and nuclear fuel* is the lowest with a level of 83.039% which is followed by *Computer, Electronic and optical equipment* and *Other transport equipment* with an ERPT of 83.893% and 88.747%, respectively. In contrast, exports of traditional labor-intensive industries, such as, *Food products, beverages and tobacco, Textiles, textile products,*

Table 3 The exchange rate pass-through rate in China by using different value of δ, aggregate results (in %)

Industry	δ = 39%		δ = 80%	
	In Chinese RMB	In US dollars	In Chinese RMB	In US dollars
Aggregate exports price	−0.044	+0.956	−0.089	+0.911
Processing exports price	−0.101	+0.899	−0.207	+0.793
Non-processing exports price	−0.039	+0.961	−0.080	+0.920
Domestic production	−0.038		−0.077	
CPI	−0.027		−0.055	

We assume that the Chinese RMB appreciates by 1%. The signs indicate an increase or decrease of prices in response to the appreciation

Table 4 Price changes due to an exchange rate appreciation of 1% by using different values of δ (in %)

Industry	δ = 39%		δ = 0.8	
	Domestic demand (Non-processing exports)	Processing exports	Domestic demand (Non-processing exports)	Processing exports
Agriculture, forestry and fishing	−0.025		−0.051	
Mining and extraction of energy producing products	−0.034		−0.070	
Mining and quarrying of non-energy producing products	−0.045		−0.092	
Mining support service activities	−0.046		−0.093	
Food products, beverages and tobacco	−0.030	−0.040	−0.061	−0.083
Textiles, wearing apparel, leather and related products	−0.040	−0.045	−0.082	−0.093
Wood and products of wood and cork	−0.054	−0.061	−0.111	−0.125
Paper products and printing	−0.046	−0.056	−0.095	−0.114
Coke and refined petroleum products	−0.110	−0.147	−0.226	−0.301
Chemicals and pharmaceutical products	−0.060	−0.068	−0.122	−0.138
Rubber and plastic products	−0.061	−0.069	−0.125	−0.142
Other non-metallic mineral products	−0.045	−0.053	−0.093	−0.109
Basic metals	−0.068	−0.082	−0.140	−0.169
Fabricated metal products	−0.058	−0.065	−0.119	−0.132
Computer, electronic and optical products	−0.105	−0.128	−0.215	−0.262
Electrical equipment	−0.071	−0.080	−0.145	−0.163
Machinery and equipment, nec	−0.061	−0.070	−0.126	−0.144
Motor vehicles, trailers and semi-trailers	−0.065	−0.068	−0.133	−0.140
Other transport equipment	−0.073	−0.067	−0.150	−0.137
Other manufacturing; repair and installation of machinery and equipment	−0.048	−0.061	−0.098	−0.125
Electricity, gas, water supply, sewerage, waste and remediation services	−0.046		−0.095	
Construction	−0.047		−0.096	
Wholesale and retail trade; repair of motor vehicles	−0.017		−0.034	
Transportation and storage	−0.035		−0.071	
Accommodation and food services	−0.022		−0.045	
Publishing, audiovisual and broadcasting activities	−0.026		−0.052	
Telecommunications	−0.018		−0.038	

Table 4 (continued)

Industry	δ = 39%		δ = 0.8	
	Domestic demand (Non-processing exports)	Processing exports	Domestic demand (Non-processing exports)	Processing exports
IT and other information services	−0.039		−0.081	
Financial and insurance activities	−0.006		−0.012	
Real estate activities	−0.007		−0.015	
Other business sector services	−0.027		−0.055	
Public admin. and defence; compulsory social security	−0.023		−0.047	
Education	−0.017		−0.034	
Human health and social work	−0.030		−0.061	
Arts, entertainment, recreation and other service activities	−0.018		−0.037	
Private households with employed persons	0.000		0.000	

leather and footwear tend to have higher ERPT to their dollar prices, and are therefore are more sensitive to an exchange rate shock.

Our results indicate that capital- and technology-insensitive industries which are at the high end of the global value chain are least affected by exchange rate changes. Our results thus suggest an explanation for two stylized facts from the perspective of production chain. The first one is that developing economies have different levels of ERPT than high-income economies. High-income economies are more specialized in production of capital- and technology-insensitive industries, the ERPT of which are generally lower. The second one is the declining

Table 5 The results of panel fixed effects model

	(1) δ = 0.39	(2) δ = 0.6	(3) δ = 0.8
Production Type	−0.000141***	−0.000217***	−0.000290***
	(−17.869)	(−17.869)	(−17.869)
Constant	−0.000345***	−0.000531***	−0.000708***
	(−14.128)	(−14.128)	(−14.128)
Year Dummies	YES	YES	YES
Industry Dummies	YES	YES	YES
Observations	561	561	561
R-squared	0.958	0.958	0.958

The model estimated is eq. (6). Results for different values of δ. The first row shows whether ERPT of processing export and non-processing export sectors differ. The dummy for production type is 1 for processing export and 0 for non-processing export sectors.

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

trend of ERPT over time. This may originate from the development of production technology as well as the increasing degree of production specialization. As we indicated, an industry which heavily relies on imported inputs for its production would have undergone a lower ERPT.

Our empirical results have important implications for China. Given the fact that a large proportion of Chinese exports relies on the price advantage in international markets, ERPT to dollar prices of exports is important. If the RMB appreciates moderately, exports will hardly be affected. However, a large RMB appreciation may affect China's market share in international markets seriously. The situation is even more severe for the labor-intensive industry, since it faces a greater increase of its dollar price in response to an RMB appreciation. Our results have also implications for monetary policy. Our findings suggest that even though the RMB appreciation can lower the CPI, its magnitude is small. In other words, an exchange rate appreciation can only play a limited role in stabilizing China's domestic prices.

4.2.3 Robustness Check

So far, we have used δ = 60% to estimate the ERPT in China. In this sub-section, we adopt different values of δ (i.e. 39% and 80%) to re-calculate China's ERPT to different products as a robustness check. The aggregate results are shown in Table 3, and the industry-level results are listed in Table 4.

The results show that our main empirical conclusions still hold under different values of δ. Under a 1% RMB appreciation, both the export price and domestic price in RMB decrease more with a larger value of δ. However, the rankings of ERPT among different industries and among different types of products are always constant, that is, our main findings are quite robust for using different values for δ.

We further use a panel fixed effects model to test whether the estimates are significantly different by regressing the ERPT coefficients on dummies for processing export and non-processing export. To this end, we calculate the ERPT at industry level for different production types in the case of a 1% RMB appreciation from 2005 to 2015. Based on the above panel data, we run industry and year fixed effect regressions of ERPT on a dummy of production type as follows:

$$y_{i,t} = \lambda_i + \gamma_t + \beta\chi_{it} + \mu_{it} \tag{6}$$

where i is industry, t is year, χ is the dummy of Production Type (1 for processing export, 0 for non-processing export). Our results in Table 5 suggest that the ERPT of processing exports is significantly lower than that of non-processing exports at the 1% significance level.

5 Conclusions

We study the exchange rate pass-through (ERPT) to both domestic and export prices via the production network by relying on a cost-push input-output model of China. The IO model takes the different production structure of domestic products, processing exports, and non-processing exports into account, and allows us to investigate ERPT to different prices, such as CPI, prices of processing exports, and prices of non-processing exports.

We find that an RMB appreciation decreases both China's domestic price and the RMB price of exports via the production network. The decline of the RMB price of processing exports is larger than that of non-processing exports, which in turn is larger than the decline of CPI. Our results also document a lower ERPT to dollar prices of processing exports. In other words, processing exports are less vulnerable to exchange rate shocks than non-processing exports. Our results further imply that a high share of processing exports made China to suffer less from exchange rate shocks.

At the industry level, capital-insensitive industries with higher technological complexity and that are at the high end of the global value chain usually have the lowest ERPT and are therefore least affected by exchange rate changes. In contrast, exports of traditional labor-intensive industries tend to have higher ERPT to their dollar prices, and therefore are more affected by exchange rate shocks. Thus, our results indicate that exporting firms in China should upgrade technology and product quality to cope with exchange rate risks and to gain more bargaining power in the international market. This may also help reducing China's current account imbalances (Cheung et al. 2020).

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