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EXCHANGE RATE PASS-THROUGH INTO INDUSTRY-SPECIFIC PRICES: AN ANALYSIS WITH INDUSTRY-SPECIFIC EXCHANGE RATES

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This paper examines the heterogeneity of exchange rate pass-through into industry-specific import, producer, and consumer prices. Results show that depending on the imported input contents, price responsiveness to the aggregate and relative exchange rate changes displays significant differences. We found that direct exchange rate impacts are more significant than indirect effects. The importance of the indirect effects is largely influenced from energy, basic metal, and chemical industries that provide intermediate inputs to others. The time horizon plays a role in the transition process: exchange rate pass-through tends to get stronger and spread to different price indices over time. The short-run impacts of aggregate exchange rate changes are not significant, while relative exchange rate changes partially transmit to producer and consumer prices in low-import content industries. In the long run direct impacts of both aggregate and relative exchange rates are significant on import prices in all industries and producer prices in high-import content industries. Another interesting finding is that the relative and aggregate exchange rate changes have opposing impacts on domestic prices: asymmetric information about industry-specific exchange rates can create pricing opportunities.

Keywords: Pass-through, Industry-specific Exchange Rates, Production Structure, Panel-VAR

1. INTRODUCTION

Industry-specific factors can lead to a diverse set of exchange rate pass-through into domestic prices [Campa and Goldberg (2005, 2006), McCarthy (2007), Bhattacharya et al. (2008), Auer and Schoenle (2014)]. In other words, responses in domestic prices to the changes in exchange rate may exhibit significant variation across industries. Technological advancements, by allowing production processes to be sliced up into several stages, have been mediating the integration

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of production activities around the world [Acemoglu et al. (2015)]. Integration has not only increased the volume of trade in intermediate goods [Hummels et al. (2001)] but also amplified the effects of industry-specific factors on trade flows that lead to heterogeneity in trade linkages. Shi and Xu (2010) argue that for a small open economy characterized by intermediate goods trade, exchange rate changes affect the relative price of not only domestic consumption goods to foreign consumption goods but also the local inputs to imported intermediate goods. Auer and Schoenle (2014) imply that when relative prices are industry-specific, pass-through may work in the opposite direction if domestic and imported inputs are complementary. Thoenissen (2011) reports an anomalous relationship between real-exchange rate persistence and the elasticity of substitution between home and foreign produced goods. Heterogeneity of pass-through across the industries, thus, can complicate the way policymakers monitor, model, and execute the monetary policies.

The aim of this study is to investigate (i) the responsiveness of industry-specific prices to the changes in aggregate and industry-specific exchange rates, (ii) if there are heterogeneities in the import, producer, and consumer price responses, and (iii) if there is a systematic link between the industrial production structure and exchange rate pass-through dynamics in both the short and long run.

Our main contribution to the literature arises from the consideration of industry-specific exchange rates into the industry-specific pass-through analysis. According to Goldberg (2004), Lee and Yi (2005), Alexandre et al. (2009) and Saygılı and Yılmaz (2013) industry-specific exchange rates may diverge significantly from the aggregate index due to the heterogeneities in industrial structures, and thus they are more informative in explaining industrial activities. If aggregate and industry-specific rates display different dynamics, then the transmission of exchange rate changes into domestic prices would become more complex than what standard pass-through models suggest.

However, while there is no difficulty in accessing information about aggregate exchange rate indices, often the industry-specific exchange rates are not publicly available. This implies that at least some economic agents can be informed asymmetrically about the exchange rate dynamics that leads to an unexpected response in domestic prices. For the empirical purpose industry-specific exchange rates are included in the analyses as a ratio of the aggregate rates and called relative exchange rates. The increase in relative rates implies an appreciation in the industry-specific exchange rate with respect to the aggregate rate. Appreciation in relative exchange rate is possible even if industry-specific exchange rate depreciates less than aggregate rate. Expressing the indicator in relative terms enables the possible information asymmetries in the exchange rates to be taken into account in the analysis. To our knowledge, this study is the first in the literature introducing aggregate exchange rate, industry-specific exchange rates, and industry-specific prices altogether into a pass-through analysis.

This paper is closely related to the literature studying the exchange rate pass-through into industry-specific prices [Goldberg and Knetter (1997), Campa and

Goldberg (2005, 2006), Bhattacharya et al. (2008); Goldberg and Campa (2010); Jiang and Kim (2013)], but this study diverges from them by accounting for contemporaneous correlation among industry-specific import, producer, and consumer prices. By doing so, similar to Bhattacharya et al. (2008), this paper sheds light on the ongoing debate on the role industry-specific heterogeneities play in the response of domestic prices to the changes in exchange rates.

The studies in the literature find heterogeneity in the extent of pass-through across the industries and the variation is attributed to numerous factors including market structure, demand and supply elasticities, nature of trade (in other words, share of intermediate goods import), degree of competition, income distribution, extent of integration to a global value chain, choice of currency in trade, distribution costs, presence of non-tradable goods, and so on.[1] In this paper we focus on the roles technology and imported input contents of industries play on the transmission of exchange rate changes to domestic prices. These two characteristics are widely accepted as indicators of strong linkages with international production networks that boost international trade activities and complementarity relationship between imported and domestic goods. For the purpose of our study these are important features because they allow for implementing different pricing strategies in the domestic markets. We use disaggregated price indices and classified two-digit manufacturing industries by technology intensity, intermediate import content of exports, and intermediate import content of total input use. There are studies in the literature that point out the significance of import content in pass-through dynamics, but none of them applies cross-sectoral analysis to examine if there are systematic differences in responses based on technology and imported input content.

The econometric model used in this study, although related, is different from the VAR framework adapted by Choudhri et al. (2005), Campa and Goldberg (2005, 2006), Bhattacharya et al. (2008), and Jiang and Kim (2013). As in Choudhri et al. (2005) and Bhattacharya et al. (2008) we employ VAR techniques to build a "structural" system. We set up a panel-VAR with prices for two-digit manufacturing industries. Panel-VAR techniques are also used in Coulibaly and Kempf (2012) to investigate exchange rate pass-through to domestic prices in emerging countries. Our study focuses on disaggregate data. As in Bhattacharya et al. (2008), we carry out SUR system analysis, but differing from them we use panel data to find out the best-fitted models for each industry group. SUR system regression allows us to take contemporaneous correlations among the industry-specific prices and exchange rates into account. In addition, it allows comparison of short- and long-run pass-through coefficients across the industry groups with different technology and imported import contents.

We find that the coefficients of pass-through vary with respect to technology and imported input content, confirming the heterogeneity and complexity of pass-through into industry-specific prices. Aggregate and relative exchange rate pass-through to prices works in opposite directions, which indicates further complexity in the pass-through processes. Significance and magnitude of the pass-through coefficients differ from short to long run. The inclusion of coke and petroleum products, basic metals, and chemicals and chemical products into the analysis mainly influences the short-run pass-through and the indirect effects from import to domestic prices. Once these industries are excluded, in general, the short-run dynamics of pass-through exhibits Local-Currency-Pricing behavior. However, we also get evidence for partial pass-through into import prices in the long run. Among the industrial groups, long-run (short-run) impact on import prices is found to be larger for high (low) imported input content industries. Partial pass-through into producer prices is also evident in high-import content industries in the long run. In sum, our results are in line with the findings indicating higher pass-through in the long run, particularly for the industries with strong production linkages abroad.[2]

The rest of the paper is organized as follows: Section 2 theoretically motivates the study, while Section 3 summarizes the empirical framework. Sections 4 and 5 present the data and the estimation results. Section 6 concludes.

2. THEORETICAL MOTIVATION

In this section we build a simple model for a small open economy to examine the transmission of an exchange rate shock to various domestic price indices by using Krugman's (1987) partial equilibrium model. Details of the model can be found in Appendix A.

For a small open economy where law of one price holds, import prices in industry $i\,(P_t^{m,i})$ can be expressed in terms of exchange rates (e_t) at time t, foreign/exporter (f) markup ($MKUP^{f,i}$), and marginal cost ($MC^{f,i}$):

$$P_t^{m,i} = e_t \times MKUP_t^{f,i} \times MC_t^{f,i}. \tag{1}$$

The size of pass-through to import prices ($PT_t^{m,i}$) then depends on three factors: price elasticity of demand for imported goods in the short run, and response of markup and marginal cost to the changes in quantity demanded over time. One percent increase in exchange rates, depending on the elasticity, proportionally shifts $P_t^{m,i}$ upward at the given markup and marginal cost. Changes in import prices meanwhile realign quantity demanded, which results in adjustments in $MKUP^{f,i}$ and $MC^{f,i}$. Since $MKUP^{f,i}$ and $MC^{f,i}$ are industry-specific, the pass-through depends on both the demand and the structure of competition in industry i.[3,4]

Theoretically, if the share of substitute goods in imports of industry i is high, then pass-through is expected to be low or even nonexistent, because both price elasticity and markup and marginal cost adjustments are likely to be high in this industry. Hence, we expect low (high) exchange rate pass-through to import prices in low (high) imported input content industries.

Similarly, if domestic and imported intermediate goods are used together in domestic production, then producer prices ($P_t^{p,i}$) can be rewritten as follows:

$$P_t^{p,i} = MKUP^{p,i} \times MC^{p,i}\left(P_t^{d,i}, P_t^{m,i}\right), \tag{2}$$

where $P_t^{d,i}$ stands for price of domestic intermediate goods, $MKUP^{p,i}$ stands for markup and $MC^{p,i}$denotes marginal costs of domestic production in industry *i*. Equation (2) is constructed under the assumption that there is no direct effect of exchange rates on producer prices. But, as it is shown in Appendix A, pass-through to producer prices ($PT_t^{p,i}$) depends on five factors: elasticity of demand, response of markup to the changes in quantity, response of marginal cost to the changes in domestic and imported input prices, elasticity of domestic input prices to imported input prices, and exchange rate pass-through to import prices. The last three factors point out the indirect transmission channel from exchange rates to imported and then to producer prices.

Transmission of exchange rate changes on producer prices is expected to be quite complex.[5] Ex-ante we expect a high exchange rate pass-through to producer prices in high-imported intermediary content industries for several reasons. First, there exists a strong complementarity relationship between domestic and imported intermediate inputs. Complementarity suggests high elasticity of domestic input prices to the changes in import prices of intermediates, but low price elasticity of demand for domestically produced intermediate inputs, resulting in, *ceteris paribus*, higher pass-through to producer prices. Second, these industries have relatively stronger international production linkages, indicating scale economies and price-setting power in domestic markets. Markup and marginal costs are expected to be less sensitive to the changes in quantities increasing the pass-through effect.

In the meantime, it is also possible to use only domestic intermediate inputs in the production of certain goods. We call them purely domestic goods. Accordingly, no direct exchange rate effect is expected in pricing behavior of these goods:

$$P_t^{pd,i} = MKUP^{pd,i} \times MC^{pd,i}\left(P_t^{d,i}\right), \tag{3}$$

where $P_t^{pd,i}$, $MKUP^{pd,i}$, and $MC^{pd,i}$ stand for price, markup cost, and marginal cost for purely domestic goods in industry *i*, respectively. Changes in exchange rates may be passed on to the pure domestic goods prices indirectly through the changes in domestic input prices. The degree of substitutability between domestic and imported inputs affects the size of pass-through, $PT^{pd,i}$. As the production function in equation (3) assumes the use of domestic inputs only, by definition, imported and domestic inputs cannot be complements. Due to, perhaps, consumer preferences (using local spices instead of imported ones in ready-made food) or cost advantages, local inputs are preferred to be used in production. It is also possible to have no imported alternatives in the market, as in the case of locally produced ethnic food. Thus, according to the model, the exchange rate transmission to purely domestic goods is possible but very feeble.

Eventually, we can express the consumer prices ($P_t^{c,i}$) as a weighted average of imported, producer, and purely domestic goods prices. With some modifications the exchange rate pass-through into consumer prices ($PT_t^{c,i}$) can be summarized as follows:

$$PT_t^{c,i} = w_t^{m,i} \times PT_t^{m,i} + w_t^{p,i} \times PT_t^{p,i} + \left(1 - w_t^{m,i} - w_t^{p,i}\right) \times PT_t^{pd,i}. \qquad (4)$$

Parameters $0 < w_t^{m,i} < 1$ and $0 < w_t^{p,i} < 1$ are the weights given to the imported and domestically produced final goods prices in the computation of consumer price index, respectively. Therefore, exchange rate pass-through to consumer prices is also a weighted average of pass-through to imported ($PT_t^{m,i}$), producer ($PT_t^{p,i}$), and purely domestic goods prices ($PT_t^{pd,i}$).

Accordingly, consumer price index has both direct and indirect exchange rate effects. The initial direct impact of a shock on exchange rates (e_t) at time t would be observed on industry i's import prices ($P_t^{m,i}$) and then pass-through into consumer prices ($P_t^{c,i}$) via two channels. The first channel is from $P_t^{m,i}$ to $P_t^{c,i}$ through imported final consumption goods, which mostly consists of substitutes of similar domestic final goods in industry i. Here, we expect depreciation of domestic currency to increase $P_t^{m,i}$, which in turn eventually raises $P_t^{c,i}$ depending on the weight import prices take in the computation of the consumer price index for industry i.

The second channel works indirectly through imported intermediate inputs used in the production of domestic goods in industry i. Depreciation would increase the cost of imported intermediate goods in domestic currency, which leads to a rise in producer prices ($P_t^{p,i}$). In addition to these two channels, a third-round indirect effect kicks in as higher $P_t^{p,i}$ further pumps the $P_t^{c,i}$ up. Consumers may change the composition of their consumption in favor of the goods that are not directly affected by the exchange rate changes.[6] The rate of increase would depend on both the share of imported intermediate goods in the cost of domestic production and the share of imported final goods in the household consumption bundle.

In the introduction we have argued that the extent of the exchange rate impact depends, *inter alia*, on the imported input use characteristics of industries. Accordingly, within the framework of the model described earlier we expect high exchange rate pass-through to import prices in industries using high volume of imported intermediary inputs. Since domestic and foreign inputs are more likely to be complements, producer prices go up further due to the indirect effects. The exchange rate pass-through to producer and consumer prices is expected to be lower than the pass-through to import prices, because of the fact that part of the shock is absorbed by import prices. The consumer price index is composed of the weighted average of the three sub-indices, and depending on the share of purely domestic goods, the transmission of exchange rate changes is expected to be lower than that of producer and imported prices.

2.1. Relative Exchange Rate Pass-Through

One of the main contributions of this study is the introduction of industry-specific exchange rates into a pass-through analysis. Aggregate exchange rates are publicly available in many countries. However, often the industry-specific rates are not freely available to the public. Even if economic agents may have some information about the exchange rates specific to their own industries, they may not be fully informed about the others. When the rates are not directly observable, then profits are maximized based on the expected exchange rates while relying on publicly available information. Hence, optimization problem can be solved by using expected industry-specific exchange rates. In this case equation (1) can be modified as follows:

$$P_t^{m,i} = E_t e_t^i \times P_t^{f,i}, \quad (5)$$

where e_t^i stands for industry-specific exchange rates and E_t denotes expectation operator. If we assume that expectations on the industry-specific exchange rate are related to the aggregate/average exchange rate due to informational problems, then $E_t e_t^i = f(e_t)$. If $E_t e_t^i = e_t$, then equations (5) and (1) will be identical. In a more general case exchange rate pass-through to import prices can be expressed as a fraction of industry-specific exchange rate pass-through:

$$PT_t^{p,i} = f' \frac{e_0}{e_0^i} \widetilde{PT}^{m,i}, \quad (6)$$

where f' is partial derivative of the function $f(e_t)$ and measures the increase in expected industry-specific exchange rate as a result of a change in average exchange rate. Ratio $\frac{e_0}{e_0^i}$ represents initial conditions. If there is a belief that industry-specific exchange rate is lower than the average exchange rate, then one percent change in average exchange rate, *ceteris paribus*, will lead to greater than one percent change in expected industry-specific exchange rate. Therefore, a change in average exchange rate will lead to a higher rate of expected exchange rate change in those industries whose past industry-specific exchange rates are currently below the average rate than the others whose rates are higher.

It is also possible to express pass-through equations in terms of relative exchange rates, in other words, industry-specific rates relative to the aggregate rate, to evaluate the behavior of the pass-through when industry-specific and aggregate rates exhibit different dynamics that are not fully observable. As it is shown in Appendix A, relative exchange rate pass-through to import prices $\left(\widetilde{PT}_t^{m,i*}\right)$ in industry i can be expressed as a proportion of the pass-through to industry-specific exchange rates $\left(\widetilde{PT}_t^{m,i}\right)$:

$$\widetilde{PT}_t^{m,i*} = f' \left(\frac{e_0}{e_0^i}\right)^2 \left(\frac{e}{f'e - e^i}\right) \widetilde{PT}_t^{m,i}. \quad (7)$$

$\widetilde{PT}_t^{m,i*}$ and $\widetilde{PT}_t^{m,i}$ may have opposite signs. $\widetilde{PT}_t^{m,i*}$ is positive if rate of expected industry-specific exchange rate change is less than the (observed) rate of aggregate exchange rate change ($f'e - e^i < 0$). For example, if there is a belief that the industry-specific exchange rate is depreciating less than the aggregate rate, then prices will be revised upward, even when in reality relative exchange rates are increasing.

3. EMPIRICAL FRAMEWORK

In Section 2 we developed a partial equilibrium model to examine how differences in technology and import content of industries affect transmission of one-time shock to exchange rates to domestic prices. The conclusions, nevertheless, are driven from a static model while in reality the transmission process takes some time. If the transmission process takes a sufficiently long period, then the process itself may impact the final long-term outcome. In fact, Baldwin (1988) and Dixit (1989) argue that exchange rate changes may generate hysteresis effects that may have permanent impacts on prices.[7] In order to take these effects into account, the empirical analysis uses the dynamic version of the theoretical model. After making necessary adjustments a dynamic form of the empirical model can be summarized as follows:

$$z_{it} = \sum_{k=1}^{n} \Phi_k z_{it-k} + \alpha_i + \gamma_t + \boldsymbol{u}_{it}, \tag{8}$$

where $\boldsymbol{\Phi_k}$ is a (4×4) parameter matrix and β_j is a (4×1) parameter vector. According to our setup, slope parameters are not unit-specific, but there exists a heterogeneity in intercept. $\boldsymbol{u}_{it}$ is a vector of idiosyncratic errors and $\boldsymbol{z_{it}} = \left(e_t,\ P_t^{m,i},\ P_t^{p,i},\ P_t^{c,i}\right)'$ includes the vector of stationary endogenous variables composed of percentage change in exchange rate, percentage change in import prices in domestic currency, producer price inflation, and consumer price inflation in industry i at time t.

Equation (8) contains three characteristic elements that are important for the purpose of our study. First, dynamic interdependencies are accounted for by including lags of endogenous variables of all panel members i. Second, static interdependencies are allowed by letting $\boldsymbol{u}_{it}$ correlate across i. Third, time and cross-sectional heterogeneity is ensured by allowing intercept to vary over time and across panel members.

The vector of time dummies γ_t in equation (8) captures aggregate time-specific shocks that may affect all industries the same way, such as having an inflation targeting regime or an aggregate productivity shock. We eliminate these dummies by subtracting the aggregate index of each variable from the industry-specific series.[8] For instance, we subtract aggregate P_t^c inflation from industry i's $P_t^{c,i}$ inflation. The demeaned series are denoted as $\boldsymbol{\bar{y}_{it}}$.

The vector of industry dummies α_i captures cross-sectional heterogeneity. Since the cross-sectional fixed effects are correlated with the lagged dependent variables, Arellano and Bover (1995) suggest using "forward mean-differencing" procedure to eliminate cross-sectional heterogeneity. This procedure removes only the forward mean of all the future observations available to the panel members. Let $\tilde{y}_{it} = \sum_{s=t+1}^{T} \bar{y}_{is}/(T-t)$ denote the means obtained from the future values of $\bar{y}_{it}$. Hence, the transformed variables can be computed as $y_{it}^{*} = \mu_{it}\ (\bar{y}_{it} - \tilde{y}_{it}\ )$ where $\mu_{it} = \sqrt{(T-t)/(T-t+1)}$.[9] After these transformations, the final form of our model is:

$$z_{it}^{*} = \sum_{k=1}^{n} \Pi_k \, z_{it-k}^{*} + u_{it}^{*}. \tag{9}$$

This procedure allows us to preserve the orthogonality between the transformed and lagged variables [Arellano and Bover (1995)].

We conduct a panel-VAR regression to obtain our initial parameter estimates of equation (9). Panel-VAR models have advantages over alternative approaches by dealing with dynamic interdependencies in the data.[10] By removing time and cross-sectional fixed effects, equation (9) assumes that underlying structure is similar for each cross-sectional unit. Then, we use SUR method to estimate the parameters of the system to account for contemporaneous correlation in the errors across the equations. By using SUR method we perform a series of hypothesis tests, including the hypothesis of "the lack of feedback from $P_t^{c,i}$ to $P_t^{p,i}$; from $P_t^{c,i}$ and $P_t^{p,i}$ to $P_t^{m,i}$; from $P_t^{c,i}$, $P_t^{p,i}$ and $P_t^{m,i}$ to e_t" to find out the best-performing model for panel members.

Ordering of endogenous variables in a VAR analysis plays a critical role in the identification of pass-through process of exchange rate shocks on domestic prices, in particular, in measuring the indirect effects. Considering the channels discussed in Section 2, we are interested in the transmission of an exchange rate shock on domestic prices. Hence, e_t is placed ahead of all other prices. We follow Ito and Sato (2008) and Coulibaly and Kempf (2012) in ordering the other endogenous variables in z_{it}^{*}, such that $P_t^{m,i}$ is placed ahead of $P_t^{p,i}$ and $P_t^{c,i}$, and $P_t^{c,i}$ is placed last. The ordering is also consistent with the model described in Section 2.

The study focuses on how a percentage change in exchange rate affects domestic prices in the short and long run. After choosing the best-fitted model, we compute the short- and long-run coefficients of the system in the following way. Let's rewrite equation (9) by using lag operator notation as[11]:

$$(1 - \Pi(L))z_{it}^{*} = \varphi(L)x_{it}^{*} + u_{it}^{*}, \tag{10}$$

where $\Pi(L) = \pi_1 L + \pi_2 L^2 + \ldots \pi_n L^n$ and $\phi\,(L) = \phi_1 L + \phi_2 L^2 + \ldots \phi_q L^n$. Percentage changes in exchange rate are included in x_{it}^{*}. Estimated short-run pass-through coefficients $\phi_{i1's}$ are in the parameter matrix φ_{ij}.

Division of both side of the equation (10) by the autoregressive polynomial gives

$$z_{it}^{*} = \frac{\varphi(L)}{1-\Pi(L)} x_{it}^{*} + \frac{1}{1-\Pi(L)} u_{it}^{*}. \tag{11}$$

When the system is in the long-run equilibrium, the variables approach their steady-state values; therefore they are not expected to deviate significantly from some fixed values, say $E(z_{it}^{*}) = z_{it}^{*\prime}$, $E(x_{it}^{*}) = x_{it}^{*\prime}$, and $u_{it}^{*\prime} = E[u_{it}^{*}] = 0$. Therefore, the long-run representation of the model can be written as

$$z_{it}^{*\prime} = \frac{\varphi_1 + \varphi_2 + \ldots \varphi_q}{1-(\pi_1 + \pi_2 + \ldots \pi_n)} x_{it}^{*\prime}. \tag{12}$$

Using equation (12), the long-run effect of exchange rate growth on domestic prices can be computed by dividing sum of the estimated $\phi_j' s$ by $\Pi_k' s$. Since estimated parameters do not vary across the industries, estimated impacts can be interpreted as the average impacts of the shock in exchange rates on industry-specific prices. Standard errors for the long-run effects can be obtained by using the Delta method.

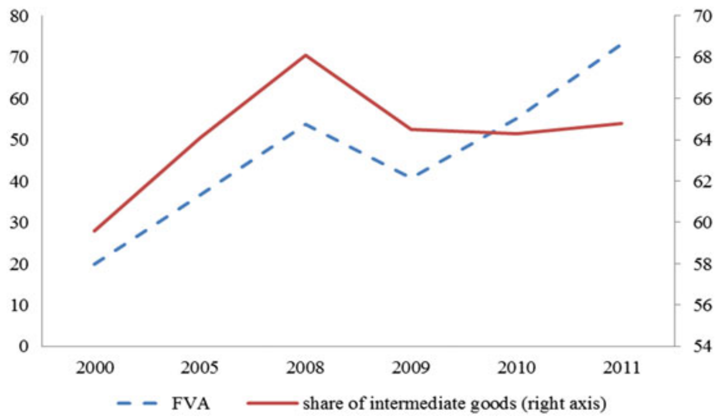
We use nominal effective exchange rates in the regression analysis where increase implies appreciation in domestic currency.[12] Thus, when the hypothesis $\phi_1 = -1$ is not rejected, we can conclude that the fluctuations in exchange rates are fully reflected in domestic prices and data favors producer currency pricing (PCP) in the short run. Likewise, we reach the same conclusion for the long run if the hypothesis of $(1 - \Pi(L))^{-1}\ \phi(L) = -1$ is not rejected. Conversely, local currency pricing (LCP) prevails when $\varphi_1 = 0$ in the short run and $(1 - \Pi(L))^{-1}\ \phi(L) = 0$ in the long run. If both hypotheses are rejected, then there is evidence of partial exchange rate pass-through into import and domestic prices.

In the case of relative exchange rates, hypothesis tests for LCP in the short and long run are similar to the earlier case. If coefficients of pass-through are different from zero, then they could be positive or negative depending on the rate of expected exchange rate change vis-à-vis rate of aggregate exchange rate. If the rate of expected exchange rate change is less (more) than the observed rate of aggregate exchange rate change, then pass-through coefficient will be positive (negative). Nevertheless, we cannot test the PCP model in this transformed model without estimating the other coefficients of the model mentioned in Section 2.

4. DATA

We use Turkish data since it is possible to find two-digit industry-specific effective exchange rate indices that can be roughly matched by domestic price indices. Furthermore, Turkish case is a good example for a small open developing economy with strong global production linkages. As seen in Figure 1, foreign value added (FVA) embodied in domestic demand, one of the key indicators for integration to global production networks, went up continuously, except in 2009, and increased more than 3.5 times from 2000 to 2011. The share of intermediate goods in manufacturing goods imports also exhibited a parallel trend during the same period highlighting the linkage between integration and intermediate goods imports. Meanwhile, the share of medium- and high-technology (medium- and low-technology) intensive industries in total merchandise trade increased from 34 (20)% in 2000 to around 40 (30)% in 2011.

Domestic and import prices in Turkish Lira are collected from the Turkish Statistics Institution's database. We use the industry-specific effective (trade weighted) exchange rates developed by Saygılı and Yılmaz (2013) and cover 10 Turkish manufacturing industries classified under ISIC codes, for the 2003q1–2011q4 period. Aggregate nominal effective exchange rates are taken from the



Source: Organization for Economic Co-operation and Development OECD.

FIGURE 1. Foreign value added embodied in domestic final demand (USD Billion) and share of intermediate goods (%), 2000–2011.

Bank for International Settlements. Note that an increase in effective exchange rates implies appreciation in domestic currency. Table 1 shows that while price indices and exchange rates are easily available for some industries, for others we need to match them with their closest possible product group.

The novelty of our study is linking the exchange rate pass-through with technology intensity and import content. According to the OECD industrial classification, wearing apparel, textiles, basic metals, food, and coke and petroleum products are grouped under low- and medium-technology (LMT) intensive industries, while chemicals, radio-TV, machinery, motor vehicles, and electrical machineries are grouped under medium- and high-technology (MHT) intensive industries.[13]

Table 2 ranks industries with respect to the share of imported intermediate goods in exports and in total intermediate goods use. We classified a sector as high-import-content (HIC) if it has higher than average import content of exports and import content of total input use at the same time. Radio-TV, chemicals, motor vehicles, basic metals, and machinery and equipment industries tend to import above the average intermediate goods per unit of input use. That is to say, they trade more complementary goods than the industry average. Therefore, four out of five industries are classified as HIC-intensive industries as radio-TV, motor vehicles, basic metals, electrical machinery, and machinery and equipment industries import above the average intermediate goods per unit of exports. Note that those industries classified under MHT at the same time import above the average intermediate goods. In chemicals, despite its high-imported input content, production for the domestic market is high.

Figure 2 plots the industry-specific exchange rate indices, the one on the left for the HIC and the one on the right for the low-import-content (LIT) industries. Average exchange rate index is also shown as a benchmark to compare the relative

TABLE 1. Matching industry-level price data

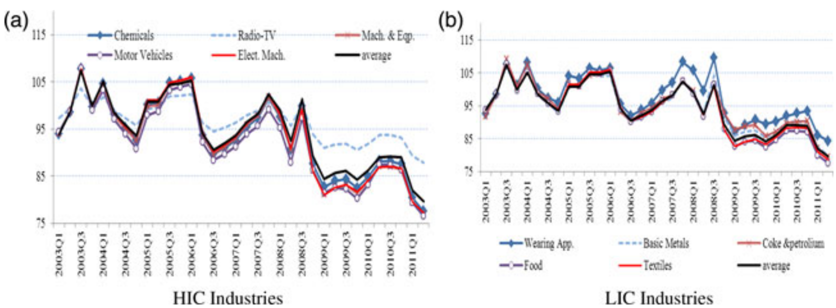
Import price (SITC)[a]	Producer price (ISIC)[a]	Consumer price (CPO)[a]	REER (ISIC)[b]
55-volatile oil, perfumes, cosmetics, toilet preparations	245-soaps and detergents, cleaning and polishing preparations, perfumes and toilet preparations	121-personel care	24-chemicals
55-volatile oil, perfumes, cosmetics, toilet preparations	245-soaps and detergents, cleaning and polishing preparations, perfumes and toilet preparations	56-goods and services for routine household maintenance	24-chemicals
65-textiles (textile fibers, wearing, floor coverings, made-up textile articles except apparels)	17-textile products	52-household textiles	17-textiles
76-communication	32-radio-TV, communication equipment	91-audio-visual, photography and information processing equipment	32-radio-TV
77-electrical machinery, apparatus and appliances	297-domestic appliances	53-household appliances	31-electrical machinery
78- motor vehicles	341-motor Vehicles	71-purchases of vehicles	34-motor vehicles
69-metal products, except machinery	286-cutlery, tools, and general hardware + 287-other fabricated metal products	54- only steel kitchen utensils	27-basic metals
0-food	15-food	11-food	15-food
84-clothing	18-wearing apparel	31-clothing	18-wearing apparel
33-petroleum and petroleum products	232-refined petroleum products	452-gas + 453-liquid fuels + solid fuels	232-refined petroleum products

[a]Taken from Turkish Statistics Institute.
[b]Taken from Saygılı and Yılmaz (2013).

TABLE 2. Share of intermediate goods imports in total exports and total domestic input use (%), 2005

Sector codes	Import content of exports	Sector codes	Import content of total input use
32	0.45	32	0.66
34	0.30	24	0.44
27	0.30	27	0.41
31	0.27	34	0.41
29	0.25	29	0.34
Average	0.24	Average	0.33
24	0.23	31	0.27
17–19	0.21	23	0.26
15–16	0.08	17–19	0.11
23	0.06	15–16	0.10

Source: OECD 2005 input/output tables.
Notes: 15–16: food; 17–19: textiles; 23: coke and petroleum products; 24: chemicals; 27: basic metals; 29: machinery and equipment; 31: electrical machinery and apparatus; 32: radio-TV; 34: motor vehicles.



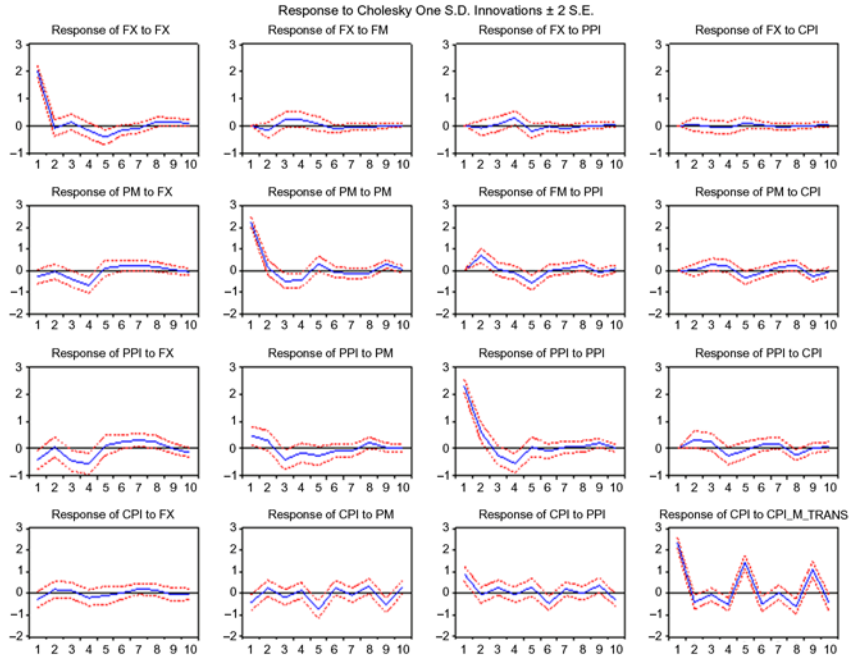
Source: Saygılı and Yılmaz (2013).

FIGURE 2. Industry-specific nominal effective exchange rates (2003q1–2011q4).

position of sub-industry indices. Note that exchange rates for LIC industries tend to remain below, while HIC industries stand above the average.

5. RESULTS

We would like to analyze how different the responses of industry-specific prices are to the aggregate and relative exchange rate changes, and if there is a systematic link between the industrial production structure and pass-through behavior. To do that, we perform the regression analysis by first using only the aggregate exchange rate and then by taking into account the industry-specific exchange rates in the panel-VAR estimates.[14] As in Choudhri et al. (2005), models are estimated with



Note: Response to generalized one SD innovation ±2 S.E. FX, PM, PP, and PC stand for percentage change in exchange rate, percentage change in import prices, percentage change in producer prices, and percentage change in consumer prices, respectively.

FIGURE 3. Impulse response analysis for sample of all industries excluding CokeBasiChem.

four lags to generate a sufficiently flexible model with the possibility of partial adjustment for each industry group.[15]

Figure 3 presents impulse response analysis involving the endogenous variables in our systems. The analyses by industry groups are given in Appendix C. Figures provide a prior check for the presence of lagged feedback in the system. Our results report no-feedback as there are no significant contemporaneous linkages from domestic prices to exchange rates, from consumer prices to producer and import prices. Innovation in producer prices generates responses in import prices. A similar result is observed in low-technology-intensive and low-import content industries (see Appendix C).

Alternative hypothesis tests are conducted using SUR system estimations to find out the best-fitted model for each industrial group. Results suggest the rejection of feedback effects from $P_t^{c,i}$ to $P_t^{p,i}$; from $P_t^{c,i}$ and $P_t^{p,i}$ to $P_t^{m,i}$; from $P_t^{c,i}$, $P_t^{p,i}$, and $P_t^{m,i}$ to exchange rates and the hypothesis of ‘insignificant coefficients are different from zero’ as it is also evident in the impulse response analyses. Hence, we chose the unrestricted models to estimate the underlying dynamics in each panel-VAR system.

5.1. Aggregate Exchange Rates

Table 3 reports the results of the estimated unrestricted models. The first three columns show the direct effect of the rate of change in exchange rates on $P_t^{m,i}$, $P_t^{p,i}$, and $P_t^{c,i}$, respectively. The fourth and the fifth columns present the indirect effects from $P_t^{m,i}$ to $P_t^{p,i}$ and $P_t^{c,i}$, while the last column shows the indirect effects from $P_t^{p,i}$ to $P_t^{c,i}$. The upper panel reports the estimated short-run coefficients, while the lower panel includes the long-run effects. Table 3 also shows how the estimated coefficients change with respect to the import content.

According to Campa and Goldberg (2006) as the relationship between exchange rates and import prices of energy, raw materials, and non-manufactured goods are noisy and unstable, estimates of exchange rate pass-through excluding these industries would be more informative. Therefore, Table 3 reports the results from the regression analysis including all industries, coke and petroleum, basic metals, and chemicals (cokebasichem here after) and all industries excluding cokebasichem. First three rows of each panel in Table 3 confirm Campa and Goldberg (2006) and conclude that the inclusion of cokebasichem affects the results for the other industries in both the short and long runs. Therefore, results for the sub-industries do not include cokebasichem.

In Table 3 exchange rate pass-through displays dissimilarity not only from short to long run but also across industrial groups as it is also found by Campa and Goldberg (2005), Bhattacharya et al. (2008), and Goldberg and Campa (2010).[16] When cokebasichem are excluded, all estimated short-run direct effects become insignificant demonstrating lack of significant pass-through from exchange rates to domestic prices in the short run. The inclusion of these industries mainly affects indirect transmissions.

The finding of the lack of direct channel in the short run contradicts the ex-ante prediction of the model. Despite that $P_t^{m,i}$ adjusts gradually as a response to the changes in exchange rates in the long run. The pattern of long-run transmission of exchange rate changes on $P_t^{m,i}$ displays a similarity across the industries, but consistent with the model expectations, HIC industries have larger coefficient estimates. The results suggest that in the short run, importers apply LCP, but they can transmit part of the increase in exchange rates in $P_t^{m,i}$ in the long run, and importers in HIC industries are able to reflect a greater portion of exchange rate increases to $P_t^{m,i}$.

In line with the model predictions, the short-run direct estimates are insignificant for $P_t^{p,i}$ indicating LCP in producer goods pricing. In the long run $P_t^{p,i}$ gradually but partially adjusts to the changes in exchange rates in HIC industries but coefficients are only significant at 10% level. Table 3 also reports, at best, a weak positive indirect impact from $P_t^{m,i}$ to $P_t^{p,i}$ in HIC industries in the short run. The impact disappears over time.

There is no evidence on the short- or long-run direct impacts from exchange rates to $P_t^{c,i}$ (except cokebasichem). The indirect impact of $P_t^{m,i}$ on $P_t^{c,i}$ is positive (less than one) and significant in LIC industries in the short run. Even though

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TABLE 3. Pass-through by industry groups: Aggregate exchange rates (excluding cokebasicchem)

Short run

	Direct Fx-effect			Indirect Fx-effect		
	P^m_*fx*	P^p_*fx*	P^c_*fx*	P^p_*pm*	P^c_*pm*	P^c_*pp*
All industries	−0.047	−0.012	−0.072**	0.125***	−0.015	−0.002
	0.069	0.054	0.033	0.049	0.030	0.038
cokebasichem	−0.127	−0.112	−0.195***	0.243**	−0.109***	0.032
	0.112	*0.112*	*0.042*	*0.104*	*0.039*	*0.039*
All industries excluding cokebasichem	0.041	0.052	0.036	0.057	0.031	0.034
	0.081	*0.043*	*0.046*	*0.039*	*0.042*	*0.078*
HIC	−0.026	0.042	0.058	0.109**	−0.015	0.052
	0.129	*0.062*	*0.065*	*0.053*	*0.056*	*0.113*
interimp_H	0.033	0.056	0.007	0.107	−0.034	0.082
	0.203	*0.096*	*0.098*	*0.066*	*0.067*	*0.139*
impcont_H	−0.026	0.042	0.058	0.109	−0.015	0.052
	0.129	*0.062*	*0.065*	*0.053*	*0.056*	*0.113*
LIC	0.093	0.035	−0.002	0.021	0.121**	0.126
	0.086	*0.055*	*0.045*	*0.064*	*0.052*	*0.091*
interimp_L	0.056	0.014	0.050	−0.002	0.041	0.086
	0.076	*0.045*	*0.047*	*0.051*	*0.054*	*0.100*
impcont_L	0.093	0.035	−0.002	0.021	0.121**	0.126
	0.086	*0.055*	*0.045*	*0.064*	*0.052*	*0.091*

Long run

	P^m_*fxl*	P^p_*fxl*	P^c_*fxl*	P^p_*pml*	P^c_*pml*	P^c_*ppl*
All industries	−0.376***	−0.086	−0.141*	0.078	−0.199***	0.058
	0.135	*0.087*	*0.077*	*0.076*	*0.073*	*0.089*
cokebasichem	−0.339	−0.008	−0.227**	0.211*	−0.231**	−0.009
	0.261	*0.161*	*0.113*	*0.121*	*0.101*	*0.110*
All industries excluding cokebasichem	−0.350***	−0.170**	0.029	−0.083	−0.134	0.137
	0.142	*0.089*	*0.102*	*0.089*	*0.096*	*0.158*
HIC	−0.547***	−0.237*	0.121	−0.128	−0.048	0.173
	0.223	*0.128*	*0.148*	*0.112*	*0.111*	*0.188*
interimp_H	−0.551**	−0.311*	0.046	−0.117	−0.007	0.147
	0.249	*0.166*	*0.211*	*0.132*	*0.155*	*0.253*
impcont_H	−0.547**	−0.237*	0.121	−0.128	−0.048	0.173
	0.223	*0.128*	*0.148*	*0.112*	*0.111*	*0.188*

TABLE 3. Continued

	Long run					
	P^m_fxl	P^p_fxl	P^c_fxl	P^p_pml	P^c_pml	P^c_ppl
LIC	−0.278*	−0.093	0.024	0.038	−0.012	0.343
	0.150	*0.120*	*0.109*	*0.148*	*0.144*	*0.221*
interimp_L	−0.342**	−0.126	0.063	−0.097	−0.197*	0.296
	0.173	*0.106*	*0.099*	*0.127*	*0.117*	*0.188*
impcont_L	−0.278*	−0.093	0.024	0.038	−0.012	0.343
	0.150	*0.120*	*0.109*	*0.148*	*0.144*	*0.221*

Notes: ***,**, and * indicate the 1%, 5%, and 10% significance levels, respectively; standard errors are reported under each estimated coefficient; P^m_fx, P^p_fx, and P^c_fx denote the estimated short-run coefficients of import, producer, and consumer price inflation equations, respectively; P^m_fxl, P^p_fxl, and P^c_fxl denote the estimated long-run coefficients of the import, producer, and consumer price inflation equations, respectively; P^p_pm and P^c_pm denote short-run indirect impact of import prices on the producer and consumer price inflation, respectively; P^c_pp denotes short-run indirect impact of a change in producer price inflation in the consumer price inflation; respective long-run impacts are denoted with P^p_pml, P^c_pml, and P^c_ppl. "All industries" includes all of the 10 industries; interimp_H (L) stands for the industries having above (below) the average intermediate input imports over total intermediate input used in production and impcont_H (L) stands for the industries having above (below) the average intermediate input imports over total exports.

not formally tested, lack of indirect pass-through in $P_t^{c,i}$ can be explained by the distribution costs that weaken the transmission of exchange rate changes into $P_t^{c,i}$ [see Campa and Goldberg (2006); Burstein et al. (2005); Boug et al. (2013)].

Our findings on high vis-à-vis low intermediate-import content industries are in contrast with Amiti et al. (2014)'s results. While we estimate higher pass-through coefficients for high-imported input using industries, Amiti et al. (2014) found low pass-through for high-import-intensive exporters. Nonetheless, there are major differences between our dataset and definition of import intensive industries. Amiti et al. (2014) used firm-level data, thus low pass-through is due to the big import companies that are also major exporters in the same markets. Our study, however, uses industry-specific data, and import intensity essentially depends on imports of intermediate inputs. Our findings are in line with Gopinath and Itskhoki (2010b) who found strategic complementarities, which operate through variable markups on the intermediate (producer) goods prices rather than on the consumer prices, which is very important. The results also support Campa and Goldberg (2005) and Goldberg and Campa (2010) who point out the significance of imported input use in goods production on the extent of exchange rate pass-through to consumer prices.

5.2. Relative Appreciation

In this section, we would like to analyze how our estimation results may change when we introduce industry-specific exchange rate dynamics into the panel-VAR system. First, we eliminate the time-fixed effects by subtracting the percentage change in the industry-specific rates from the percentage change in aggregate rate.

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This procedure not only eliminates time-specific effects but also generates a relative exchange rate series. Next, the cross-sectional fixed effects are eliminated by forward demeaning the relative rates. These are rather standard procedures that are used in the literature to eliminate time and cross-sectional fixed effects in variables in a panel-VAR.

We follow the same estimation strategy as we did in the previous section by performing the regression analysis with and without cokebasichem industries. As it can be seen in Table 4 the inclusion of these industries influences both the short- and long-run effects of relative exchange rate changes on domestic prices. Comparison of Tables 3 and 4 reveals that while the exclusion of these industries lowers the significance of the short-run pass-through, it also increases the number of significant coefficients for $P_t^{m,i}$ and $P_t^{p,i}$ prices, even though the coefficients of aggregate and relative appreciations do not have any systematic pattern in the long run. Nevertheless, these findings are in conformity with the results of Bhattacharya et al. (2008) and Gopinath and Itskhoki (2010b) who also find partial pass-through into $P_t^{m,i}$in the long run.

The increase in the relative exchange rates implies that the domestic currency is becoming more valuable in industry *i* relative to the aggregate economy. Import prices, though unresponsive in the short run, tend to react positively to the increase in relative exchange rates over time in all industries. As the model predicts, the result is more pronounced in HIP industries, since the estimated coefficients are significant at 5% level.

Relative appreciation increases $P_t^{p,i}$ significantly in the short run in the LIC industries, but it does not have a persistent impact. On the other hand, producer prices adjust over time in line with the increase in relative exchange rates in the HIC industries. In these industries, due to the terms of contracts with global production networks, it may take some time to reflect the changes in the relative valuation on $P_t^{p,i}$. PCP may explain pricing in these industries better as the significant amount of semi-finished products is imported for the purpose of further processing and re-exporting. In sum, markup opportunities may arise in the short run in the LIC industries, which involves the exchange of substitute consumption goods; but this prospect lasts longer in HIC industries.

Finally, we found that even though consumers have to pay more than they expect for the LIC products in the short run, the impact becomes insignificant in the long run.

6. CONCLUSION

This paper focuses on the transmission of both aggregate and relative exchange rate changes into industry-specific prices. The role of technology intensity and imported input content is explored to explain the heterogeneity in the exchange rate pass-through across the industries. Different pass-through channels involving import, producer, and consumer prices are examined in both short and long runs.

TABLE 4. Pass-through rates by industry groups: Relative exchange rates (excluding cokebasicchem)

Short run						
	Direct Fx-effect			Indirect Fx-effect		
	P^m_fx	P^p_fx	P^c_fx	P^p_pm	P^c_pm	P^c_pp
All industries	−0.133	−0.065	0.114	0.124***	−0.013	0.011
	0.280	0.217	0.134	0.049	0.030	0.039
Cokebasichem	−0.800	−0.158	−0.037	0.242**	−0.126***	0.054
	0.531	0.527	0.213	0.107	0.043	0.043
All industries	0.231	0.141	0.199	0.064	0.040	0.027
excluding cokebasichem	0.310	0.170	0.172	0.041	0.042	0.077
HIC	0.063	0.078	0.368*	0.063	−0.069	−0.032
	0.408	0.217	0.209	0.058	0.056	0.112
interimp_H	0.085	0.167	0.291	0.075	−0.070	−0.012
	0.493	0.253	0.244	0.069	0.067	0.139
impcont_H	0.063	0.078	0.368*	0.063	−0.069	−0.032
	0.408	0.217	0.209	0.058	0.056	0.112
LIC	0.319	0.616**	0.415*	0.044	0.123**	0.117
	0.458	0.285	0.225	0.065	0.051	0.090
interimp_L	0.153	0.568**	0.659**	0.004	0.053	0.114
	0.431	0.247	0.247	0.052	0.052	0.096
impcont_L	0.319	0.616***	0.415*	0.044	0.123**	0.117
	0.458	0.285	0.225	0.065	0.051	0.090

Long Run						
	P^m_fxl	P^p_fxl	P^c_fxl	P^p_pml	P^c_pml	P^c_ppl
All industries	1.760***	0.121	0.222	0.108	−0.189***	0.055
	0.655	0.328	0.301	0.076	0.077	0.092
Cokebasichem	1.231	−0.443	0.163	0.169	−0.264***	0.035
	1.192	0.705	0.480	0.136	0.107	0.107
All industries	1.787***	0.579*	−0.025	−0.022	−0.113	0.149
excluding cokebasichem	0.672	0.322	0.364	0.087	0.094	0.156
HIC	1.586**	0.844**	0.634	−0.089	−0.078	−0.093
	0.841	0.408	0.500	0.117	0.115	0.236
interimp_H	1.983**	0.898***	0.704	0.010	−0.027	−0.170
	0.979	0.339	0.680	0.103	0.167	0.363
	0.841	0.408	0.500	0.117	0.115	0.236

TABLE 4. Continued

	Long Run					
	P^m_fxl	P^p_fxl	P^c_fxl	P^p_pml	P^c_pml	P^c_ppl
LIC	2.063*	0.644	0.166	0.074	0.024	0.281
	1.116	0.593	0.546	0.135	0.141	0.217
interimp_L	1.923*	0.507	0.432	−0.088	−0.153	0.293*
	1.135	0.610	0.501	0.128	0.108	0.177
impcont_L	2.063*	0.644	0.166	0.074	0.024	0.281
	1.116	0.593	0.546	0.135	0.141	0.217

*Notes:****,**, and * indicate the 1%, 5%, and 10% significance levels, respectively; standard errors are reported under each estimated coefficient; P^m_fx, P^p_fx, and P^c_fx denote the estimated short-run coefficients of import, producer, and consumer price inflation equations, respectively; P^m_fxl, P^p_fxl, and P^c_fxl denote the estimated long-run coefficients of the import, producer, and consumer price inflation equations, respectively; P^p_pm and P^c_pm denote short-run indirect impact of import prices on the producer and consumer price inflation, respectively; P^c_pp denotes short-run indirect impact of a change in producer price inflation in the consumer price inflation; respective long-run impacts are denoted with P^p_pml, P^c_pml, and P^c_ppl. "All industries" includes all of the 10 industries; interimp_H (L) stands for the industries having above (below) the average intermediate input imports over total intermediate input used in production and impcont_H (L) stands for the industries having above (below) the average intermediate input imports over total exports.

The paper chiefly has five conclusions. First, energy, basic metal, and chemical industries are influential mainly on the indirect effect from import to consumer and producer prices. Second, pass-through into domestic prices is heterogeneous across industries owing to the differences in the technology intensity and imported input content of the sectors. There is correlation between the technology intensity and input content of the sectors and the differential exchange rate pass-through between high- and low technology-intensive industries which is mainly because of their differences in imported input uses. Third, aggregate and relative appreciations have opposite impacts on domestic prices partly due to the imperfect information. In the latter case, prices tend to increase since it creates profit opportunities for the producers in the market. This is possible if the market is exposed to weak competition, participation in global production networks is extensive, and economic agents are not able to distinguish industry-specific exchange rate changes from the overall index fluctuations. Fourth, pass-through is essentially evident in the long-run import prices in both high- and low-imported input content industries and in the long-run producer prices in high-imported input using industries. Fifth, the short run is characterized by LCP, but long-run pricing behavior changes depending on the segment of the distribution chain investigated. While high-imported input using industries can partially pass-through exchange rate changes into domestic prices, the pass-through in low-imported input using industries remains limited.

The results indicate the significance of industry-specific features such as market structures, rate of imported input use, international trade linkages, and different definitions of exchange rates on differential exchange rate pass-through into prices. This study further underlines the complexity and difficulty of monitoring, modeling, and executing the monetary policies when pass-through processes are heterogeneous across industries. As a corollary, we found improving competitiveness in domestic markets at different levels from importers to domestic producers to retailers having potentially positive effect in enhancing the efficacy of monetary policy in stabilizing domestic prices.

NOTES

1. See for instance Baldwin (1988), Dixit (1989), Froot and Klemperer (1989), Goldberg and Knetter (1997), Taylor (2000), Campa and Goldberg (2006), Campa et al. (2006), Goldberg and Campa (2010), Gust et al. (2010), Shi and Xu (2010), Boug et al. (2013), Li (2014), Auer and Schoenle (2016), Auer et al. (2018), Amiti et al. (2014), Cravino et al. (2018), Villarreal (2016).
2. See Goldberg and Knetter (1997), Campa and Goldberg (2005), Goldberg and Campa (2010), Maria-Dolores (2010), and Amiti et al. (2014).
3. See Krugman (1987), Campa and Goldberg (2005), Goldberg and Knetter (1997), and Obstfeld (2002) for a detailed explanation.
4. See Melitz and Ottaviano (2008) for variable markup strategy as a result of exchange rate changes. Also see Epifani and Gancia (2011), Dhingra and Morrow (2012), Mrazova and Neary (2017), de Blas and Russ (2015) and Holmes et al. (2014), Edmond et al. (2015), and Arkolakis et al. (2018) for alternative models analyzing variable markup strategies. For instance in Arkolakis et al. (2018) firm-level heterogeneity and monopolistic competition allow firms to follow market segmentation across countries.
5. See for instance Gopinath and Itskhoki, (2010a, 2010b), Gopinath et al. (2010), Goldberg and Campa (2010), Boug et al. (2013), Burstein and Gopinath (2014), Bacchetta and van Wincoop (2005), Goldberg and Tille (2008), and Pennings (2017).
6. Theoretically the weights can change over time as consumers reshuffle their consumption basket in response to differential changes in product prices. Price indices by construction, however, take consumer basket constant while allowing for prices to change. Hence, the empirical section treats the weights of the model constant.
7. See also Borgersen and Göche (2007).
8. This process is slightly different from the literature, where the mean of each variable calculated for each industry year is subtracted from each variable, but in line with the computation of relative exchange rates. Also, since we do not include all industries in our analysis, the use of aggregate index in transformation process allows us to account for linkage across all industries.
9. This transformation cannot be performed for the last observation.
10. A GMM approach requires differencing the specification, thus throws away sample information and may make inferences less accurate. In our case variables are already in percentage change form. Also, Canova and Ciccarelli (2013) summaries the weaknesses of Generalized Method of Moments (GMM) strategy when dynamic heterogeneity is important in a panel model. Byrne et al. (2013) further emphasize the problems related to GMM estimators with panel of disaggregate data, noting that in such cases instrumentation affects the properties of the heterogeneous panel estimators. Instead, SUR techniques that account for all cross-sectional interdependencies have become one of the popular approaches in panel data analysis with disaggregate data.
11. See Canova and Ciccarelli (2013) for detailed explanation of Panel VARX models and Djigbenou-Kre and Park (2016) and Cavallari and D'Addona (2015) for application of these models.
12. Effective exchange rates are computed as a weighted average of exchange rates of *home* versus *foreign* currencies, with the weight for each *foreign* country equals to its share in manufacturing trade. In computation of industry-specific effective exchange rates weights for each foreign country vary with respect to their share in sub-industrial trade.
13. http://www.oecd.org/sti/ind/48350231.pdf.

14. Table B1 that none of the variables include unit root.

15. Lag structure of the adjustment path of prices may vary from industry to industry. However, in this paper the optimal lag adjustment process for each industry is not analyzed as we are not interested in the differences in speed of adjustment across industries but rather in capturing a measure of pass-through behavior.

16. Note that after excluding cokebasichem, industries included in MHT/impcont_H and LMT/impcont_L significantly overlaps, resulting in coefficients estimates to be the same for these coupled groups.

17.

$$\frac{dP^{m,i}/P^{m,i}}{de/e} = 1 + \frac{dMKUP^{f,i}/MKUP^{f,i}}{dQ^{m,i}/Q^{m,i}} \times \frac{dQ^{m,i}/Q^{m,i}}{dP^{m,i}/P^{m,i}} \times \frac{dP^{m,i}/P^{m,i}}{de/e} + \frac{dMC^{f,i}/MC^{f,i}}{dQ^{m,i}/Q^{m,i}} \times \frac{dQ^{m,i}/Q^{m,i}}{dP^{m,i}/P^{m,i}} \times \frac{dP^{m,i}/P^{m,i}}{de/e}$$

18. Theoretically, $PT^{m,i}$ can be greater than one when $\left(\theta_{Q^{f,i}}^{MKUP^{f,i}} + \theta_{Q^{f,i}}^{MC^{f,i}}\right)\epsilon^{m,i} > 0$. The demand curve is negatively sloped ($\epsilon^{m,i} < 0$) and the $MC^{f,i}$ function is upward sloping in the area where $\theta_{Q^{f,i}}^{mc^{f,i}} > 0$. Thus, $PT^{m,i}$ can be greater than one only when $\theta_{Q^{f,i}}^{MKUP^{f,i}}$ has a sufficiently big negative value. This is possible only when the demand curve becomes increasingly elastic as quantity increases. Therefore, the exporter is forced to reduce its markup significantly when demand for its products falls as a result of higher $P_t^{m,i}$.

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APPENDIX A: A PARTIAL EQUILIBRIUM MODEL ON EXCHANGE RATE PASS-THROUGH INTO DOMESTIC PRICES

This section formally derives the linkages among exchange rates, import prices, producer prices, and consumer prices using a partial equilibrium framework adopted from Krugman (1987).

(i) Pass-through into import prices

Law of one price states that the domestic price of a tradable good i is equal to its price abroad when expressed in a common currency term. If industry i goods are traded freely, then import prices can be expressed as a transformation of foreign (export) prices:

$$P_t^{m,i} = e_t \times P_t^{f,i}, \tag{A1}$$

where $P_t^{m,i}$ is the import price in domestic currency, $P_t^{f,i}$ is the foreign price in foreign currency, and e_t is the bilateral nominal exchange rate (domestic currency per unit of foreign currency) at time t.

According to the profit maximization condition [Varian (2010)]: $P_t^{f,i}\frac{1}{1-\epsilon^{m,i}} = MC_t^{f,i}$. By substituting $P_t^{f,i}$ in equation (A1) and rearranging the terms, import prices can be rewritten as a function of markup ($MKUP_t^{f,i}$) and marginal cost:

$$P_t^{m,i} = e_t \times MKUP_t^{f,i} \times MC_t^{f,i}, \tag{A2}$$

where $MKUP_t^{f,i} = \frac{1}{1+\frac{1}{\epsilon^{m,i}}}$, $\epsilon^{m,i} = \frac{dQ^{m,i}/Q^{m,i}}{dP^{m,i}/P^{m,i}} < 0$ is demand elasticity of price for imported goods and $Q^{m,i}$ denotes the quantity demanded for imported goods in industry i. Then, the expression for exchange rate pass-through to import prices ($PT^{m,i}$):

$$PT^{m,i} = \frac{dP^{m,i}/P^{m,i}}{de/e} = 1 + \frac{dMKUP^{f,i}/MKUP^{f,i}}{de/e} + \frac{dMC^{f,i}/MC^{f,i}}{de/e}. \tag{A3}$$

In order to analyze the different channels that exchange rate changes influence $PT^{m,i}$ we divide and multiply the second and the third terms on the RHS by $\frac{dQ^{m,i}}{dP^{m,i}}$, so that:

$$\frac{dP^{m,i}/P^{m,i}}{de/e} = 1 + \frac{e}{MKUP^{f,i}}\frac{dMKUP^{f,i}}{dQ^{m,i}} \times \frac{dQ^{m,i}}{dP^{m,i}} \times \frac{dP^{m,i}}{de} + \frac{e}{MC^{f,i}}\frac{dMC^{f,i}}{dQ^{m,i}} \times \frac{dQ^{m,i}}{dP^{m,i}} \times \frac{dP^{m,i}}{de}. \tag{A4}$$

Consequently, changes in exchange rates affect $P_t^{m,i}$ via three channels. (1) An increase in e_t proportionally shifts $P_t^{m,i}$ upward at the given $MKUP^{f,i}$ and $MC^{f,i}$ (the first term on the RHS). (2) As quantity demanded responds to the changes in prices, there would be an adjustment in markup (the second component on the RHS). (3) A change in equilibrium quantity demanded, at the same time, results in alignments in $MC^{f,i}$ (the third component at the RHS).

Multiplication of the second and third terms on RHS by $\frac{Q^{m,i}}{Q^{m,i}}\frac{P^{m,i}}{P^{m,i}}$ gives an expression in terms of elasticities,[17] which makes it possible to have the following expression:

$$\frac{dP^{m,i}/P^{m,i}}{de/e} = 1 + \left(\theta_{Q^{mi}}^{MKUPfi} + \theta_{Q^{mi}}^{MCfi}\right)\epsilon^{m,i}\frac{dP^{m,i}/P^{m,i}}{de/e}, \tag{A5}$$

where $\theta_{Q^{mi}}^{MKUPf,i} = \frac{dMKUP^{f,i}/MKUP^{f,i}}{dQ^{mi}/Q^{mi}}$ and $\theta_{Q^{mi}}^{MCfi} = \frac{dMC^{f,i}/MC^{f,i}}{dQ^{mi}/Q^{mi}}$ are percentage changes in $MKUP^{f,i}$ and $MC^{f,i}$ in response to one percent increase in quantity demanded, respectively, and $\epsilon^{m,i} = \frac{dQ^{mi}/Q^{mi}}{dP^{m,i}/P^{m,i}}$ is the price elasticity of demand for imported goods. The equation can be simplified further as follows:

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$$PT^{m,i} = \frac{dP^{m,i}/P^{m,i}}{de/e} = \frac{1}{1-\left(\theta_{Q^{mi}}^{MKUPfi} + \theta_{Q^{mi}}^{MCfi}\right)\epsilon^{m,i}}. \quad \textbf{(A6)}$$

The sign and the size of the pass-through depend on both sign and size of $\epsilon^{m,i}$, $\theta_{Q^{mi}}^{MC^{f,i}}$ and $\theta_{Q^{mi}}^{MKUP^{f,i}}$. Since demand function is negatively sloped, price elasticity is always negative ($\epsilon^{m,i} < 0$). $\theta_{Q^{mi}}^{MC^{f,i}}$ is positive as the industry i operates at the upward sloping part of MC curve. The sign of $\theta_{Q^{mi}}^{MKUP^{f,i}}$ depends price elasticity of demand. For a very broad set of demand functions as we move up along the demand curve, price elasticity of demand increases and thus markup falls.[18] In brief, equation (A6) states that:

(a) Since $\epsilon^{m,i} < 0$, $PT^{m,i}$ is negatively associated with the demand elasticity, as well as the quantity elasticity of markup and MC.
(b) $PT^{m,i}$ is partial as denominator is greater than one. Exchange rate pass-through is negative, partial and its size depends on the magnitude of the price and quantity elasticities.

(ii) Pass-through into producer prices

Analogous to equation (A2), in the domestic production sector, producer price ($P_t^{p,i}$) can be expressed as a function of $MKUP_t^{p,i}$ and $MC_t^{p,i}$. When both domestic and foreign inputs are used in production, $MC_t^{p,i}$ can be expressed as a function of domestic ($P_t^{d,i}$) and imported input prices ($P_t^{m,i}$).

$$P_t^{p,i} = MKUP_t^{p,i} \times MC_t^{p,i}\left(P_t^{d,i}, P_t^{m,i}\right). \quad \textbf{(A7)}$$

In equation (A2) imported input prices are affected directly by exchange rate changes. Once we use imported intermediate goods in domestic production, a shock to exchange rates will be transmitted to $P_t^{p,i}$ through $P_t^{m,i}$. Equation (A7) shows the indirect effect of exchange rate changes by including $P_t^{m,i}$ in the marginal cost function. Then, exchange rate pass-through to producer prices is $PT^{p,i} = \frac{dP^{p,i}/P^{p,i}}{de/e} = \frac{dMKUP^{p,i}/MKUP^{p,i}}{de/e} + \frac{dMC^{p,i}/MC^{p,i}}{de/e}$.

Following the steps used to obtain equation (A5), it is possible to write the preceding expression as

$$PT^{p,i} = \frac{dP^{p,i}/P^{p,i}}{de/e} = \theta_{Q^{pi}}^{MKUPfi}\epsilon^{p,i}\frac{dP^{p,i}/P^{p,i}}{de/e} + \frac{dMC^{p,i}/MC^{p,i}}{de/e},$$

where $\theta_{Q^{p,i}}^{MKUP^{p,i}} = \frac{dMKUP^{f,i}/MKUP^{f,i}}{dQ^{pi}/Q^{pi}}$ is the percentage changes in $MKUP^{p,i}$ in response to one percent increase in quantity demand for input (Q^{pi}) and $\epsilon^{p,i} = \frac{dQ^{pi}/Q^{pi}}{dP^{p,i}/P^{p,i}}$ denotes the price elasticity of demand for inputs. By rearranging the terms we may further reduce the equation as follows:

$$PT^{p,i} = \frac{dP^{p,i}/P^{p,i}}{de/e} = \frac{1}{1-\theta_{Q^{p,i}}^{MKUP^{p,i}} \times \epsilon^{p,i}} \times \frac{dMC^{p,i}/MC^{p,i}}{de/e}. \quad \textbf{(A8)}$$

Equation (A8) is analogous to equation (A6). The second term can be expanded further as follows so as to show the link between the pass-through to import prices and the pass-through to producer prices:

$$\frac{dMC^{p,i}/MC^{p,i}}{de/e} = \left(\frac{dMC^{p,i}/MC^{p,i}}{dP^{d,i}/P^{d,i}} \times \frac{dP^{d,i}/P^{d,i}}{dP^{m,i}/P^{m,i}} + \frac{dMC^{p,i}/MC^{p,i}}{dP^{m,i}/P^{m,i}}\right) \times \frac{dP^{m,i}/P^{m,i}}{de/e}. \quad \textbf{(A9)}$$

Let $MC_d^{p,i}$ and $MC_m^{p,i}$ be partial derivatives of $MC^{p,i}$ with respect to $P_t^{d,i}$ and $P_t^{m,i}$ and homogeneous of degree one in input prices. They show how marginal cost reacts to the changes in domestic and imported input prices, respectively. Also, let $\in_{pm}^{pdi}$ represent the elasticity of $P_t^{d,i}$ to the changes in $P_t^{m,i}$ and measure the responsiveness of domestic input prices to the changes in imported input prices. Then, equation (A9) can be rewritten as:

$$\frac{dMC^{p,i}/MC^{p,i}}{de/e} = \left(MC_d^{p,i} \times \in_{pmi}^{pdi} + MC_m^{p,i}\right) \times PT^{m,i}. \tag{A10}$$

Here, the relationship between domestic and imported inputs (complement/substitute) and the input market structure play important roles in the determination of the sensitivities. Hence, the extent of the exchange rate pass-through to import prices depends on these factors. Equations (A8) and (A10) together state that

(a) If $\in_{pm}^{pdi} = 1$, that is to say domestic and imported inputs are perfect substitutes, then an incremental change in imported input price leads domestic producers to switch to domestic inputs resulting in an equal amount of increase in domestic input prices. Decrease in marginal costs due to the reduction in demand for imported inputs will then be offset completely by the increase arising from the surge in demand for domestic inputs. Therefore, $\frac{dMC^{p,i}/MC^{p,i}}{de/e} = PT^{m,i}$. Then

1. $PT^{m,i} = PT^{p,i}$ if $\epsilon^{p,i} = 0$ or $\theta_{Q^{p,i}}^{MKUP^{p,i}} = 0$.

This case is not plausible as it suggests no change in demand for domestic input no matter how great its price increases.

2. $PT^{p,i} < PT^{m,i}$ if $\epsilon^{p,i} < 0$ or $\theta_{Q^{p,i}}^{MKUP^{p,i}} > 0$.

This case is plausible as it indicates that if inputs are substitute, a part of the exchange rate change transmits to producer prices because decrease in domestic input prices encourages producers to use domestic inputs. That in turn increases the markup.

(b) If $\in_{pm}^{pdi} > 0$, that is to say imported and domestic inputs are complements, then the domestic input prices increase in a proportion to the increase in imported input prices. This means the first term on the RHS of equation (A8) is positive, which implies $\frac{dMC^{p,i}/MC^{p,i}}{de/e} < PT^{m,i}$. In turn equation (A7) argues that $PT^{p,i} < PT^{m,i}$, even smaller than the case in a.2 above.

Assume that some producers export a portion of their products to the foreign market at price $P_t^{f,i}$. Then, domestic producer prices at the export market ($P_{t,x}^{p,i}$) can be linked to $P_t^{f,i}$ as follows:

$$P_{t,x}^{p,i} = e_t \times P_t^{f,i}. \tag{A11}$$

Under the small-country assumption, domestic producers take $P_t^{f,i}$ as given ($\bar{P}_t^{f,i}$) and fully adjust their markup to counter-balance exchange rate changes as in the PCP model. Then, $P_t^{p,i}$ is a weighted average of the exported and domestically consumed goods prices. If α^i, which takes a value between 0 and 1, is the weight attached to foreign prices:

$$P_t^{p,i} = \alpha^i \times \left(e_t \times \bar{P}_t^{f,i}\right) + \left(1-\alpha^i\right) \times P_t^{p,i}. \tag{A12}$$

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The first term on the RHS is the direct effect, and the second term is the indirect effect of the exchange rates on prices. Since PCP prevails in pricing exported goods, $PT^{p,i}$ converges to the PCP model as α^i approaches one.

(iii) Pass-through into consumer prices

As the consumers' basket of consumption goods consists of both imported and domestically produced final goods, the consumer price index $\left(P_t^{c,i}\right)$ can be written as a weighted average of $P_t^{m,i}$ and $P_t^{p,i}$:

$$P_t^{c,i} = \left(P_t^{m,i}\right)^{w_t^{m,i}} \left(P_t^{p,i}\right)^{w_t^{p,i}} \left(P_t^{pd,i}\right)^{\left(1-w_t^{m,i}-w_t^{p,i}\right)}, \tag{A13}$$

where $0 < w_t^{m,i} < 1$ and $0 < w_t^{p,i} < 1$ are time-varying weights of imported and domestically produced goods' prices in the computation of consumer goods price index in industry i, respectively. We also introduce a purely domestic goods' price $\left(P_t^{pd,i}\right)$, which is simply the price index of domestic products that are produced by only using domestic inputs. The first and the second terms on the RHS represent the indirect effects of $P_t^{m,i}$ and $P_t^{p,i}$ into $P_t^{c,i}$, respectively. Exchange rate changes may directly affect $P_t^{c,i}$ if they are indexed to exchange rate changes.

Exchange rate pass-through to consumer prices $\left(PT^{c,i} = \frac{dP^{c,i}/P^{c,i}}{de/e}\right)$ can be computed by totally differentiating equation (A13) with respect to exchange rate. The result is:

$$PT_t^{c,i} = w_t^{m,i} \times PT_t^{m,i} + w_t^{p,i} \times PT_t^{p,i} + \left(1-w_t^{m,i} - w_t^{p,i}\right) \times PT_t^{pd,i}. \tag{A14}$$

In the absence of a purely domestic goods' price, $PT^{c,i}$ would be measured as a weighted average of $PT^{m,i}$ and $PT^{p,i}$, which implies $PT^{p,i} < PT^{c,i} < PT^{m,i}$. This is due to the conclusions in ii.a.2 and ii.b.

When the price index of purely domestic goods is introduced, the size of $PT^{c,i}$ depends on how much domestic input prices would react to the changes in $P_t^{m,i}$. Appreciation of domestic currency would increase $P_t^{m,i}$, which in turn would increase the demand for domestic inputs and equilibrium prices if they are substitutes. The latter, in turn, would increase the marginal cost of production and thus, the purely domestic goods' price. Theoretically, $PT^{pd,i}$ can take any value, greater or less than $PT^{p,i}$. $PT^{c,i}$ can fall below $PT^{p,i}$ when the domestic inputs used in producing purely domestic goods are insensitive to the changes in $P_t^{m,i}$. At the other extreme, $PT^{c,i}$ may exceed $PT^{p,i}$ if imported and domestic inputs are close substitutes.

(iv) Pass-through into prices when exchange rates are not fully observable

When changes in industry-specific exchange rates are not fully observable, then optimization problems can be solved by first estimating the industry-specific exchange rates. Accordingly, equation (A1) can be modified as follows:

$$P_t^{m,i} = E_t e_t^i \times P_t^{f,i}, \tag{A15}$$

where e_t^i stands for industry-specific exchange rates and E_t denotes expectation operator. Equation (A15) states that import prices in industry i is equal to expected industry-specific rates multiplied by foreign prices. Differentiating the expression with respect to the industry-specific exchange rates gives us an expression for pass-through similar to equation (A6):

$$\frac{\frac{dP^{m,i}}{P^{m,i}}}{\frac{de^i}{e^i}} = \widetilde{PT}^{m,i} = \frac{1}{1-\left(\theta_{Q^{m,i}}^{MKUPf,i} + \theta_{Q^{m,i}}^{MCf,i}\right)\epsilon^{m,i\prime}}. \tag{A16}$$

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Assume that expectations are formed based on observed changes in the aggregate/average exchange rates (e_t). If $E_t e_t^i = e_t$ then $\widetilde{PT}^{m,i} = PT^{m,i}$. If $E_t e_t^i = f(e_t)$, then:

$$\frac{de^i}{e^i} = f' \times \frac{e_0}{e_0^i} \times \frac{de}{e}, \tag{A17}$$

where f' is partial derivative of the function $f(e_t)$ and measures the increase in expected industry-specific exchange rate in response to the change in average exchange rate. Ratio $\frac{e_0}{e_0^i}$ represents initial conditions and if agents believe that industry-specific exchange rate is lower than the average exchange rate, then one percent change in average exchange rate, *ceteris paribus*, leads to a greater than one percent change in the expected industry-specific exchange rate. Therefore, a change in average exchange rate will lead to higher rate of expected exchange rate changes in those industries whose past industry-specific exchange rates are below the average exchange rate than the others and vice versa. By inserting A17 into A16 we get:

$$\frac{\frac{dP^{m,i}}{P^{m,i}}}{\frac{de}{e}} = f' \frac{e_0}{e_0^i} \widetilde{PT}^{m,i}, \tag{A18}$$

In this case pass-through is a scale of the pass-through under full information ($\widetilde{PT}^{m,i}$). The scale depends on f' and $\frac{e_0}{e_0^i}$. Thus, we expect higher pass-through coefficients for the industries whose industry-specific rates are below the average rate.

In order to link pass-through to relative exchange rates equation (A15) is divided by its average values as:

$$P_t^{m,i} = \tilde{e}_t^i \times P_t^{f,i} \times \bar{P}_t^i, \tag{A19}$$

where $\tilde{e}_t^i = \frac{e_t^i}{e_t}$ and $\bar{P}_t^i = \frac{\overline{P^{m,i}}}{\overline{P^{f,i}}}$. At the given $\bar{P}_t^i$, profits are maximized under incomplete information (cannot distinguish average exchange rate from industry-specific exchange rate). Note that if $E_t e_t^i = f(e_t)$, then by totally differentiating $\tilde{e}_t^i = \frac{e_t^i}{e_t}$ we have $d\tilde{e}^i = \frac{(f'e - e^i)}{e} \frac{de}{e}$. Therefore, equation (A18) becomes:

$$\frac{\frac{dP^m}{P^m}}{\frac{de}{e}} = \frac{(f'\mathrm{e} - e^i)}{e} \times \frac{e_0^i}{e_0} \times \widetilde{PT}^{m,i*}, \tag{A20}$$

where $\widetilde{PT}^{mi*} = \frac{\frac{dP^m}{P^m}}{\frac{d\,\tilde{e}^i}{\tilde{e}^i}}$ is the relative exchange rate pass-through. Substituting equation (A18) into the LHS of equation (A20) and rearranging provides an expression for PT^{mi*}:

$$\widetilde{PT}^{mi*} = \frac{e}{(f'\mathrm{e} - e^i)} \times \left(\frac{e_0}{e_0^i}\right)^2 \times f' \times \widetilde{PT}^{m,i}, \tag{A21}$$

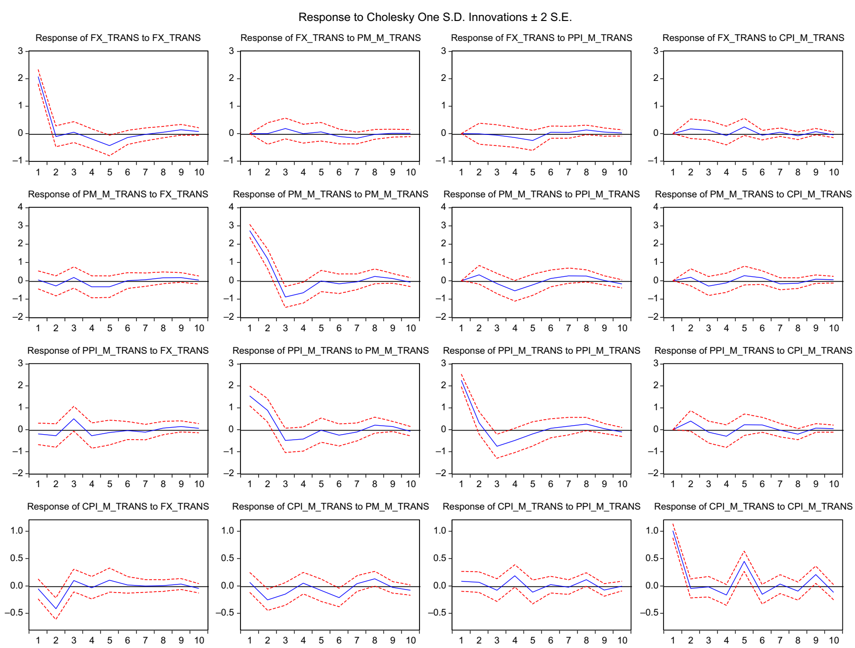
$\widetilde{PT}^{mi*}$ is as a scale of pass-through under full information ($\widetilde{PT}^{m,i}$). An interesting point about this expression is that $\widetilde{PT}^{mi*}$ and $\widetilde{PT}^{m,i}$ may have opposite signs depending on the expected industry-specific rate and aggregate exchange rate changes. The second and third terms in RHS of equation (A21) normally take positive values. The first term, however, may take both positive and negative values. If $\left(f'e - e^i\right) < 0$ then $\widetilde{PT}^{mi*}$ becomes positive. This would be the case if $f' = \frac{de^i}{de}$, and $\frac{de^i}{e^i} < \frac{de}{e}$. In other words, if expected percentage change in the industry-specific exchange rate is less than that of the average exchange rate, then $\widetilde{PT}^{mi*} > 0$.

APPENDIX B: PANEL UNIT ROOT TEST RESULTS

TABLE B1. Panel unit root tests

	Test statistics				
	LLC	B	IPS	ADF—Fisher	PP—Fisher
P^m	9.88	−8.63	−9.65	116.71	158.83
	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)
P^p	−10.10	−9.31	−8.96	108.06	252.76
	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)
P^c	−13.14	−8.50	−13.87	235.07	544.28
	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)
rfx	−19.22	−15.36	−16.42	207.96	209.41
	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)
fx	−17.75	−15.31	−15.19	189.61	189.58
	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)

APPENDIX C: IMPULSE RESPONSE ANALYSIS



Note: Response to generalized one SD innovation ±2 S.E. FX, PM, PP, and percentage change in consumer prices stand for percentage change in exchange rates, percentage change in import prices, percentage change in producer prices, and percentage change in consumer prices, respectively.

FIGURE C1. Impulse response for CokeBasicChem.

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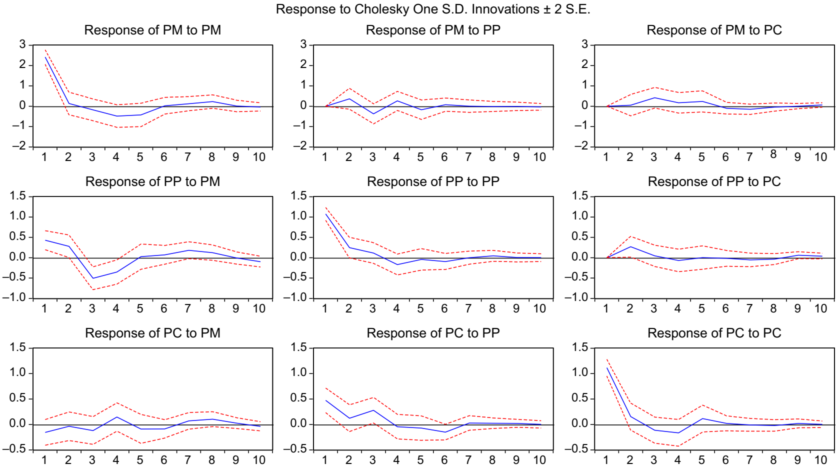
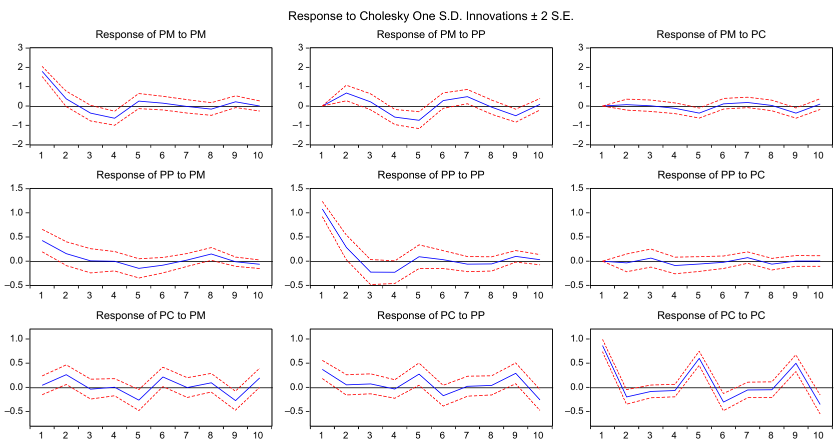


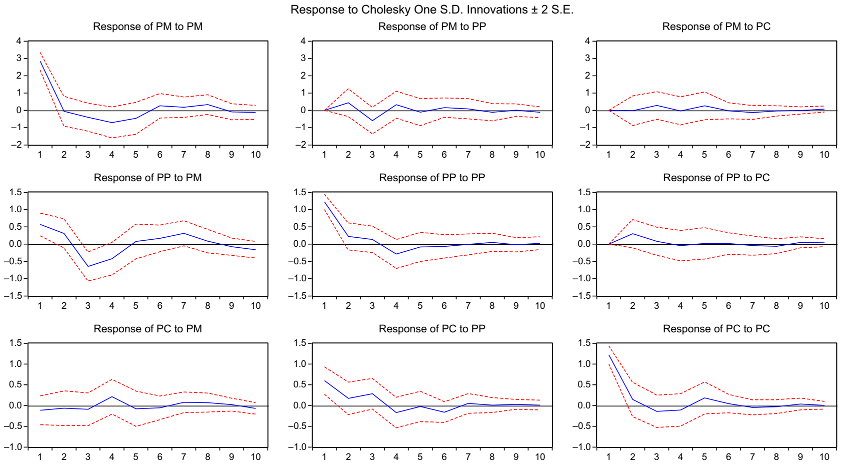
Note: Response to generalized one SD innovation ±2 S.E. PM, PP, and percentage change in consumer prices stand for percentage change in import prices, percentage change in producer prices, and percentage change in import prices, respectively.

FIGURE C2. High-technology-intensive industries.



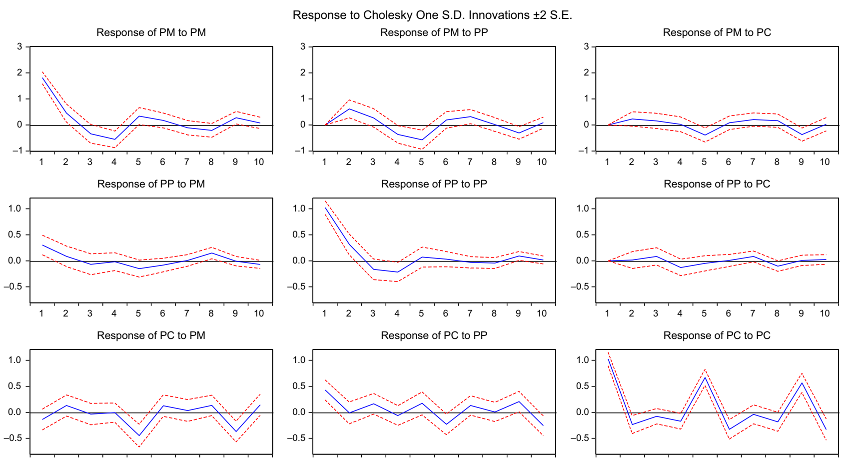
Note: Response to generalized one SD innovation ±2 S.E. PM, PP, and percentage change in consumer prices stand for percentage change in import prices, percentage change in producer prices, and percentage change in import prices, respectively.

FIGURE C3. Low-technology-intensive industries.



Note: Response to generalized one SD innovation ±2 S.E. PM, PP, and percentage change in consumer prices stand for percentage change in import prices, percentage change in producer prices, and percentage change in import prices, respectively.

FIGURE C4. Industries with high-import content in total intermediate input use.



Note: Response to generalized one SD innovation ±2 S.E. PM, PP, and percentage change in consumer prices stand for percentage change in import prices, percentage change in producer prices, and percentage change in import prices, respectively.

FIGURE C5. Industries with low-import content in total intermediate input use.

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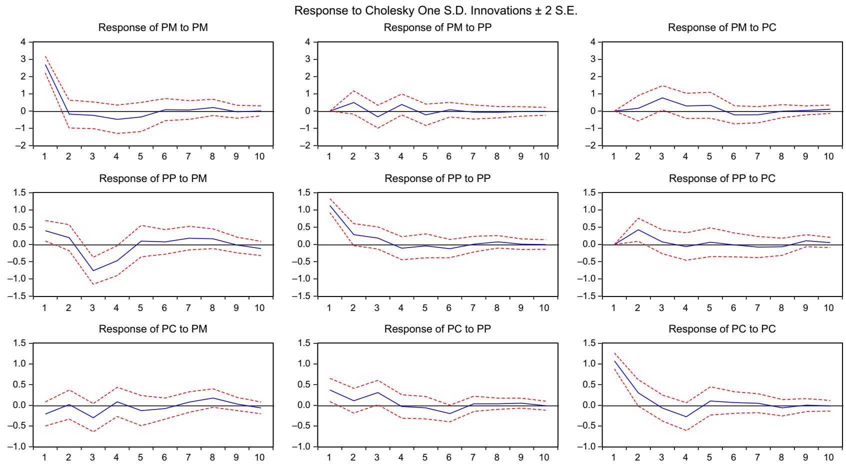
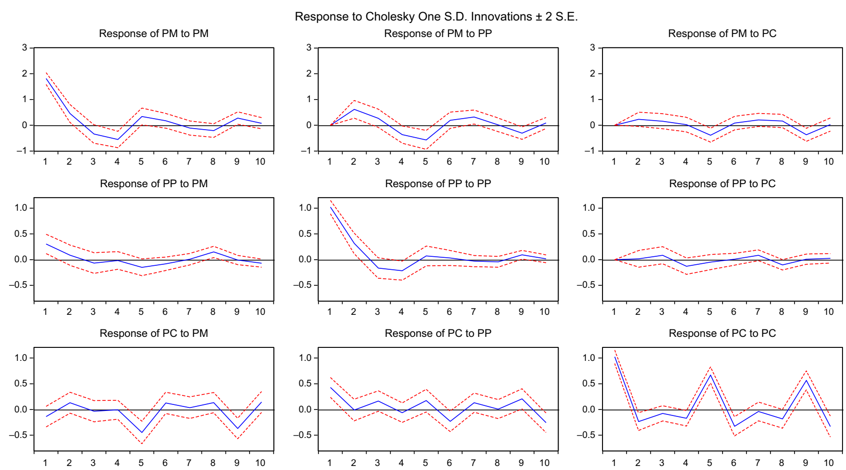


Note: Response to generalized one SD innovation ±2 S.E. PM, PP, and percentage change in consumer prices stand for percentage change in import prices, percentage change in producer prices, and percentage change in import prices, respectively.

FIGURE C6. Export industries with high intermediate-import content.



Note: Response to generalized one SD innovation ±2 S.E. PM, PP, and percentage change in consumer prices stand for percentage change in import prices, percentage change in producer prices, and percentage change in import prices, respectively.

FIGURE C7. Export industries with low intermediate-import content.

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