Exchange Rate Pass-Through: A Comparative Analysis of VAR and Input-Output Model Approaches

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Abstract

This paper examines the relationship between exchange rate movements and domestic inflation across a diverse set of countries and economic sectors using both Input-Output (IO) and Vector Autoregressive (VAR) models. Drawing on data spanning from 2011 to 2018, the study delves into the intricacies of exchange rate pass-through (ERPT), exploring cross-country variation, temporal trends, and sectoral sensitivities. The analysis reveals notable differences in ERPT coefficients across countries, with developed economies displaying higher coefficients compared to developing economies. Furthermore, the sectoral analysis highlights significant disparities, with agricultural and manufacturing sectors exhibiting higher sensitivity to exchange rate fluctuations compared to the services sector. These findings underscore the nuanced nature of ERPT dynamics, influenced by country-specific characteristics, trade openness, and monetary policy frameworks.

1 Introduction

Exchange rate pass-through (ERPT) is the general term for the process by which changes in a currency's foreign exchange value are translated into changes in domestic inflation. Even though the relationship between exchange rate movements and local prices began to be examined in the 1960s, this remains a pertinent area of inquiry due to the pivotal role ERPT plays in shaping monetary policy frameworks. Since the exchange rate stands as a primary conduit through which monetary policy actions influence inflation dynamics, a comprehensive understanding of the impacts of exchange rate shocks is crucial for the formulation and implementation of effective monetary policies.

Early studies tried to test the validity of the law of one price assumption, revealing that ERPT does not exhibit complete transmission effects as suggested by prevailing open-economy monetary frameworks. The following works have delved into elucidating the underlying mechanisms driving incomplete ERPT. The main findings of the literature underscore notable cross-country and cross-sectoral differences in terms of the magnitude and the speed of the ERPT. While many factors such as structural vulnerabilities, stability in the economy, and trust in monetary policy authorities, explain the differences between countries, differences in market structure and strategic interdependence of firms' decisions are some of the reasons for the differences across industries. Moreover, a downward trend throughout time is also observed for almost all economies. This trend can be attributed to multifaceted factors including the decrease in global inflation, the proliferation of inflation-targeting policy frameworks, and the increasing popularity of multi-country production.

Various methodologies and models have been deployed to show the size and the magnitude of the ERPT. Traditional Vector Auto Regression (VAR) approaches, for instance, have been a cornerstone in understanding the multifarious impacts of exchange rate movements. This framework allows for fundamental dynamic interrelationships between prices and other variables of interest at various stages of distribution. Additionally, it allows to track the dynamic reaction of prices to external shocks.

However, while the VAR approach offers useful insights, it also comes with its own set of limitations. One such limitation is that the VAR approach often assumes that the relationships between variables are linear and that these relationships remain constant over time. This assumption, however, might not hold in real-world scenarios, particularly in emerging economies and developing countries where economic structures can change rapidly. Additionally, VAR models typically consider aggregate data, which can mask considerable sectoral heterogeneities. Given these shortcomings of traditional VAR approaches, there is a growing impetus to employ alternative methodologies that offer a more nuanced understanding of the relationship between exchange rates and different sectors.

In light of these factors, it becomes evident that the limitations of VAR models in capturing the intricacies of ERPT have prompted the exploration of alternative methodologies. This paper adopts an Input-Output (IO) model to offer a more detailed understanding of the relationship between exchange rates and various sectors. The IO model provides a detailed depiction of the interdependencies among different industries within an economy, capturing the flow of goods and services among sectors. This sector-specific approach offers deeper insights into the sensitivities of different sectors to exchange rate movements, addressing a key limitation of the VAR approach. By adopting an IO model, researchers can unravel the complexity between sectors and have a deeper understanding of how exchange rate fluctuations affect various sectors.

Despite its potential, the application of IO models in ERPT research remains limited. This paper strives to bridge this gap by introducing sectoral import prices into the IO model, enabling a more comprehensive analysis of ERPT, employing the latest available IO tables (OECD, 2018) to offer a contemporary perspective, comparing and contrasting the IO model with the traditional VAR methodology, enriching the understanding of ERPT dynamics. Recognizing the pivotal role that exchange rates play in shaping the economic trajectory of countries, we believe that understanding the sector-specific sensitivities to exchange rate fluctuations can help policymakers formulate strategies to mitigate exchange rate risks and maintain economic stability. In addition to observing the sectoral ERPT, we will show the difference in the method results by comparing it with VAR results. To our knowledge, this is the first paper that analyzes ERPT by two different methodologies for the same observation set.

The rest of the paper is organized as follows: Section 2 reviews the existing literature on ERPT to provide a theoretical and empirical foundation for our research. Section 3 describes the VAR analysis as the first analysis. Section 4 explains IO tables and the IO model. Section 5 discusses the results obtained from both models and compares the estimates derived from the two methodologies. Finally, Section 6 concludes the paper.

2 Literature

The interest in ERPT started in the 1960s when open economy monetary models used the absolute Purchasing Power Parity assumption to explain the effect of exchange rate behaviors. The main question of the early studies was whether the Purchasing Power Parity holds in the data. The results of these studies indicated that a complete pass-through hypothesis had very little evidence across countries (Ihrig, Marazzi, and Rothenberg (2006)).

Many studies analyze the reasons behind the incompleteness of ERPT. Krugman (1986) and Dornbusch (1987) try to explain this phenomenon by suggesting market pricing behavior in the case of an exchange rate shock. These papers indicate that the firms may choose to adjust their profit margins instead of reflecting the shock on prices to maintain market share. Hahn (2003) presents some reasons to change desired markups, such as the variations in demand elasticity, the threat of new firms' entrance, and the intertemporal profit maximization considerations. This approach can also be supported by Gust, Leduc, and Vigfusson (2010) since this study shows that lower trade costs, which are a result of international globalization, cause a decline in exchange-rate pass-through by increasing firms' profits and providing an opportunity for companies to adjust their profits.

The local currency pricing argument is another tool that was presented by Devereux and Engel (2001) and Bacchetta and van Wincoop (2003) as an explanation. These articles argue that if trade between two countries is denominated in domestic (importing) currency, changes in the exchange rate will not be reflected in import prices and other related prices.

Hegji (2003) puts forward a different argument and mentions the role of cross-border production to explain incomplete pass-through. This approach indicates that if several currencies take place throughout the production phase, the appreciation of some currencies against the domestic currency would not lead to a complete pass-through.

The studies in the literature also try to understand the differences between the size and degree of ERPT for different sets of countries. However, there exist many conflicting results to make a general assessment. For instance, Kreinin (1977) indicates that the pass-through coefficient is negatively associated with the size of the country, whereas the findings of Khosla and Teranishi (1989) point out an opposite result. Similarly, an interest in a comparison between advanced and emerging economies arose. While some studies such as Devereux and Engel (2001) find that ERPT in emerging economies is higher than in developed economies, this is not the case always, according to Devereux and Engel (2001). Other contradicting results are about the relationship between the level of inflation and the size of ERPT. Taylor (2000) focuses on the importance of inflation and finds that a low inflation level leads to lower ERPT. It is also stated that this is valid not only between countries but also over time. Nevertheless, Campa and Goldberg (2002) analyzes 25 OECD economies and finds that ERPT is largely uncorrelated with inflation.

The stability of the pass-through relationship has also been studied for a long time. Even though some early studies such as Lattimore (1988) and chandra Athukorala and Menon (1992) find that the ERPT is stable throughout the period, many papers present evidence about the decline in pass-through for almost all economies. Taylor (2000) explains this tendency as a product of a low-inflation environment. Gagnon and Ihrig

(2001) observes the decrease in ERPT in 18 out of 20 countries from 1971 to 2003. It is also shown that the decline in the level or standard deviation of inflation brings about a larger fall in ERPT. Frankel, Parsley, and Wei (2005) uses data for 76 countries for the period from 1990 to 2001 and shows that developing countries have experienced a rapid downward trend. Ihrig et al. (2006) conducted a similar analysis for G-7 countries from late 70s to early 00s. The results signify a downturn in the pass-through coefficient in all countries except one during the specified period. The importance of this downward trend all over the world for monetary policy was discussed in Taylor (2000). This fall affects the forecasts of inflation and the impacts of changes in monetary policy on inflation. Moreover, the role of the inflation-targeting policy framework was also highlighted.

The most widely employed approach for assessing ERPT is the VAR model pioneered by McCarthy (2000) and developed by Hahn (2003). This model encompasses various key variables, including the nominal exchange rate, industrial production, import prices, oil prices, producer prices, interest rate and consumer prices. These models allow for the straightforward monitoring of the transmission of exchange rate fluctuations to every level of the distribution chain within a unified framework. This methodology also brought some criticism since the VAR specification consists of linear equations with constant parameters, and its appropriateness may be compromised in the presence of nonlinearity or structural breaks in the series. For example, Gagnon and Ihrig (2001) argued that VAR models might be unsuitable for economies that have experienced significant macroeconomic instability, which could potentially disrupt the stability of relationships estimated within VAR models. Moreover, Towbin and Weber (2013) highlighted that VAR models might fail to adequately capture structural breaks and non-linearities that are characteristic of certain economies, thus leading to biased or inconsistent estimates of pass-through rates. In response to these limitations, an emerging body of literature is exploring alternative approaches to the VAR methodology. These include the use of detailed micro-level data Gopinath and Itskhoki (2008), non-linear models Bussiere (2013), and Input-Output (IO) tables.

This paper explores the effectiveness of utilizing an IO approach to analyze price formation and the impact of exchange rate fluctuations on prices. While price dynamics and exchange rate interactions have been extensively studied, the application of IO analysis in this context remains a relatively unexplored area. We aim to address this gap by employing IO models to provide a novel perspective on ERPT.

The seminal work of Leontief (1937) and Leontief (1946) established the foundation for IO analysis. While its application to ERPT research has been limited (Campa and Goldberg (2005); Hara, Hiraki, and Ichise (2015)), Aydoğuş, Değer, Çalışkan, and Günal (2018) offers a notable exception. Their study examined ERPT on consumer prices using IO tables, but their assumption of constant import prices neglects the documented high responsiveness of these prices to exchange rate changes.

Our research addresses this limitation by incorporating dynamic import prices into the IO model. We leverage the UN COMTRADE database to compute sectoral import prices based on trade values and quantities. This innovation allows us to analyze the transmission of exchange rate changes from import prices to consumer prices through the latest available IO tables from the OECD (2018). This approach captures both direct and indirect impacts of exchange rate shifts on sectoral equilibrium prices, considering production interdependencies and the utilization of imported inputs.

3 VAR Model

3.1 The Data

To be compatible with IO table analysis, the VAR analysis covers the period from the first quarter of 2011 to the last quarter of 2018, except that the analysis starts from 2013:Q1 for Turkey and ends in 2018:Q1 for Indonesia and in 2018:Q2 for Argentina due to lack of data availability. While 14 of these countries have developing economies, the remaining have developed economies. We prefer to work on quarterly data series since monthly data are not available for some countries and yearly data have limitations to capture the fluctuations within a year.

The crude oil price, which is a quarterly average of monthly prices in nominal US dollars of Brent, Dubai, and WTI, is obtained from World Bank Commodity Price Data. As the interest rate variable, we use the central bank policy rate from the BIS Data Portal. The reel GDP data, which is not seasonally adjusted, come from the IMF IFS database. Since the unadjusted version of reel GDP data of Canada does not exist, we use seasonally unadjusted industrial production data from IMF IFS. We use nominal effective exchange rates from the BIS Data Portal to capture the fluctuations in exchange rates. As the import price index, which is gathered by weighting commodities by the ratio of imports to total commodity imports, we used the commodity import price index from IMF Access to Macroeconomic & Financial Data. Federal Reserve Economic Data was preferred for

Mexico to access import price data. Because of the lack of this index, we use the unit value of import as a proxy for Costa Rica, Iceland, India, Russia, Thailand, and Turkey. These values were obtained from the data sources of national statistical institutions or central banks. Producer and consumer price indices were collected from IMF IFS.

3.2 VAR Analysis

We applied the models of McCarthy (2000) and Hahn (2003), the most popular VAR models in the literature, to observe and compare the ERPT effect across countries. The VAR model consists of seven variables. The first one is the oil price index (Oil_t) to capture supply shocks in the economy. The order is followed by the short-term interest rate (i_t) to observe the effects of changes in monetary policy on the degree of ERPT. The next variable is the reel GDP ($RGDP_t$), which identifies the demand shocks. The fluctuations in the nominal effective exchange rate ($NEER_t$) reflect the external shocks. The last three variables in our specification are the import price index (IPI_t), producer price index (PPI_t), and consumer price index (CPI_t), which were listed according to the pricing chain.

We use Cholesky decomposition, which imposes n(n-1)/2 zero restrictions to the variance-covariance matrix of the reduced form residuals. By using this methodology and order, we ensure that while the variables listed in the first stages can contemporaneously affect the variables later in the list, they begin to affect the variables before them with one period lag. This is the reason why we include the oil price shocks as the most exogenous variable in the first order. Thus, the changes in the oil price index have the potential to affect all variables contemporaneously, whereas the same argument does not hold for the opposite direction of the relation. According to the order of our model, the short-term interest rate should be placed in the second order since the monetary policy authorities would observe the supply shock and use interest rates as instruments to reduce its impact on production and price levels. Then, we observe the contemporaneous impact of demand shock, which was contemporaneously affected by supply and policy shocks, on the value of the domestic currency against a weighted average of several foreign currencies and on the price levels. By placing the nominal effective exchange rate next, we allow exchange rate dynamics to influence all prices in the economy contemporaneously. Lastly, we order the price variables according to the pricing chain. Equation (1) gives the relationship between the reduced form residuals, e_t, and the structural shocks, ϵ_t, as a result of the Cholesky decomposition.

$$\begin{bmatrix} e_t^{oil} \\ e_t^{i} \\ e_t^{RGDP} \\ e_t^{NEER} \\ e_t^{IPI} \\ e_t^{PPI} \\ e_t^{CPI} \end{bmatrix} = \begin{bmatrix} S_{11} & 0 & 0 & 0 & 0 & 0 & 0 \\ S_{21} & S_{22} & 0 & 0 & 0 & 0 & 0 \\ S_{31} & S_{32} & S_{33} & 0 & 0 & 0 & 0 \\ S_{41} & S_{42} & S_{43} & S_{44} & 0 & 0 & 0 \\ S_{51} & S_{52} & S_{53} & S_{54} & S_{55} & 0 & 0 \\ S_{61} & S_{62} & S_{63} & S_{64} & S_{65} & S_{66} & 0 \\ S_{71} & S_{72} & S_{73} & S_{74} & S_{75} & S_{76} & S_{77} \end{bmatrix} \begin{bmatrix} \epsilon_t^{oil} \\ \epsilon_t^{i} \\ \epsilon_t^{RGDP} \\ \epsilon_t^{NEER} \\ \epsilon_t^{IPI} \\ \epsilon_t^{PPI} \\ \epsilon_t^{CPI} \end{bmatrix} \tag{1}$$

This structural setup makes the order of the variables in the VAR model crucial.

Although we do not have a clear theoretical rule as to how this ranking should be, we know that various rankings are appropriate. Hahn (2003) and Ca' Zorzi, Hahn, and Sánchez (2007) tested whether different rankings significantly changed the outcome and observed that there were no critical differences for the set of observations they examined. We followed the order of Hahn (2003) as the baseline model. However, as a robustness check, we used an alternative order as suggested by McCarthy (2000): the interest rate policy changes might be listed last since the monetary policy authorities may choose to intervene after observing the changes in inflation as a result of the inflation-targeting framework. The findings of this alternative approach indicate that the results were not affected much except for some economies. The results of the new method applied are given in Appendix A.

All variables were used in natural logarithmic form except for interest rate. As a result of limited observation for each country, the results of different unit root tests are not compatible with each other. Thus, to increase the robustness of the stationary decision, we used four different tests and considered a variable to be stationary if it was found to be stationary in at least 3 out of 4 tests. These tests are ADF, PP, DF-GLS, and KPSS. We used dummies to capture seasonalities. The AIC was used to decide the optimal lag in the model specifications. In addition, the LM test results indicate that no residual auto-correlation problem exists for any country. Lastly, we checked model stability for each VAR analysis and found that all the eigenvalues lie inside the unit circle.

The size of the impact of a standard deviation shock on a variable on other variables is measured by the impulse response function (IRF). Even though the effect of exchange rate changes on consumer price indexes lasts for a longer period in some economies, we use 4-quarters changes for all to have a better comparison with IO table results. By using the outcomes of the IRFs, we can calculate the cumulative elasticity of the consumer price index with respect to the shocks in the exchange rate as follows:

$$ERPT_s = \frac{\Delta\%CPI_{t,t+s}}{\Delta\%NEER_{t,t+s}} \tag{2}$$

where the nominator of the right-hand side of the equation gives the cumulative change in CPI s periods after the shock, and the denominator is the cumulative change in NEER for the same period after the shock. The results of the VAR analysis are given in Section 5.

4 IO Table Model

The model described is a cost-push Input-Output (IO) price model utilized to determine the pass-through effect within an economy. In this economy, there are 'n' producing sectors and two fundamental inputs: labor (L) and capital (K), which encompasses all other factors of production. Labor is compensated through wages and salaries (W), while capital earns the operational surplus (V).

In the context of a multi-sector economy, the equilibrium price system can be described by the equation:

$$p_j = \sum_{i=1}^{n} a_{ij} \cdot p_i + e \cdot \sum_{i=1}^{n} m_{ij} \cdot p_i^* + v_j \quad \text{for} \quad j = 1, \ldots, n \tag{3}$$

where each p_j represents the price of output j. The coefficient a_{ij} captures the direct domestic input, determined by the ratio of the price and quantity of output i to that of output j. The nominal exchange rate e reflects the conversion rate between domestic and foreign currency. Import prices, denoted as p_i^*, are transformed into domestic currency using $p_i^f = e \cdot p_i^*$. Additionally, m_{ij} represents the direct imported input coefficient, calculated based on the price and quantity of imported intermediate use M_{ij} relative to output j. Unit labor costs (w_j) and unit operational surpluses (v_j) are determined by the total labor costs (W_j) and total operational surplus (V_j) for sector j, respectively, relative to the output quantity.

This equation can also be written in matrix format as below:

$$\mathbf{p} = \mathbf{A}^T\mathbf{p} + \mathbf{M}^T\mathbf{p}^f + \mathbf{w} + \mathbf{v}. \tag{4}$$

Here, $\mathbf{p}$ denotes the array of commodity prices, $\mathbf{p}^f$ signifies the array of import prices in domestic currency, where $\mathbf{p}^f$ is determined as $e\mathbf{p}^*$, with $\mathbf{p}^*$ representing the array of import prices in foreign currency. The scalar $\mathbf{e}$ represents the nominal exchange rate. Moreover, $\mathbf{v}$ stands for the array of unit operational surpluses (unit capital costs), while $\mathbf{w}$ represents the array of unit labor costs. Additionally, $\mathbf{A}^T$ denotes the transpose of the matrix of direct domestic input coefficients, represented as $\mathbf{A}$, and $\mathbf{M}^T$ signifies the transpose of the matrix of direct imported input coefficients, denoted as $\mathbf{M}$.

We reduce the model to the below form for calculation purposes:

$$\mathbf{p} = (\mathbf{I} - \mathbf{A}^T)^{-1}(\mathbf{M}^T\mathbf{p}^f + \mathbf{w} + \mathbf{v}) \tag{5}$$

Then we take total differentials:

$$\Delta \mathbf{p} = (\mathbf{I} - \mathbf{A}^T)^{-1}(\mathbf{M}^T \Delta \mathbf{p}^f + \Delta \mathbf{w} + \Delta \mathbf{v}) \tag{6}$$

Here, we rewrite the equation under the assumption of constant domestic and direct imported input coefficients and basic input costs. However, note that we don't assume import prices are constant, so the impact of a small exchange rate change on prices is shown as

$$\Delta \mathbf{p} = (\mathbf{I} - \mathbf{A}^T)^{-1}(\mathbf{M}^T \mathbf{p}^* d\mathbf{e}) \tag{7}$$

Therefore, the effect of the exchange rate on sectoral equilibrium prices is expressed as:

$$\frac{\partial \mathbf{p}}{\partial \mathbf{e}} = (\mathbf{I} - \mathbf{A}^T)^{-1}(\mathbf{M}^T \mathbf{p}^*) \tag{8}$$

After computing changes in sectoral equilibrium prices, the change in the general price level, π, is computed as a weighted average of sectoral price changes:

$$\pi = \sum_{i=1}^{n} \alpha_i \left(\frac{\partial p_i}{\partial e} \right) \tag{9}$$

where α_i indicates the share of commodity i in aggregate consumption expenditures.

Now, we present the results of an Input-Output (IO) model analysis to understand the relationship between exchange rates and domestic inflation across diverse countries. The IO model provides a unique view through which to explore ERPT. It allows for a detailed examination of sectoral interdependencies within each economy and their implications for the pass-through effect. By leveraging data spanning from 2011 to 2018, we delve into the intricacies of ERPT, examining cross-country variation, temporal trends, and sectoral sensitivities.

Table 1: The Input-Out table results for all countries, 2011-2018

Country	**2011**	**2012**	**2013**	**2014**	**2015**	**2016**	**2017**	**2018**
Argentina	0.080	0.066	0.075	0.079	0.052	0.071	0.062	0.094
Austria	0.168	0.165	0.161	0.154	0.143	0.143	0.157	0.157
Bulgaria	0.219	0.227	0.210	0.217	0.208	0.191	0.221	0.216
Canada	0.122	0.119	0.120	0.126	0.126	0.121	0.125	0.128
Costa Rica	0.146	0.131	0.126	0.130	0.106	0.109	0.119	0.119
Finland	0.156	0.155	0.146	0.141	0.138	0.140	0.148	0.155
France	0.129	0.124	0.119	0.116	0.113	0.113	0.123	0.124
Germany	0.137	0.130	0.124	0.119	0.112	0.111	0.120	0.122
Hungary	0.245	0.234	0.226	0.223	0.217	0.212	0.228	0.230
Iceland	0.164	0.168	0.154	0.152	0.146	0.127	0.132	0.149
India	0.136	0.134	0.128	0.105	0.083	0.087	0.094	0.108
Indonesia	0.116	0.118	0.117	0.114	0.087	0.077	0.088	0.106
Ireland	0.229	0.247	0.232	0.236	0.232	0.245	0.240	0.233
Italy	0.133	0.126	0.114	0.109	0.105	0.101	0.118	0.124
Korea	0.202	0.194	0.173	0.164	0.136	0.133	0.153	0.159
Mexico	0.120	0.122	0.107	0.110	0.124	0.132	0.133	0.138
Poland	0.190	0.182	0.170	0.172	0.165	0.174	0.183	0.190
Romania	0.168	0.164	0.140	0.146	0.145	0.138	0.162	0.166
Russia	0.086	0.087	0.085	0.094	0.111	0.093	0.083	0.094
Saudi Arabia	0.144	0.139	0.145	0.138	0.111	0.085	0.090	0.091
South Africa	0.124	0.134	0.139	0.133	0.118	0.131	0.121	0.130
Sweden	0.132	0.130	0.124	0.129	0.127	0.124	0.131	0.135
Thailand	0.254	0.244	0.229	0.232	0.191	0.188	0.196	0.204
Turkey	0.154	0.123	0.120	0.127	0.111	0.105	0.156	0.166
UK	0.132	0.122	0.121	0.109	0.100	0.109	0.119	0.123
USA	0.083	0.069	0.066	0.065	0.050	0.050	0.057	0.060

The IO results display notable differences in ERPT coefficients across various countries. For example, countries such as Hungary, Bulgaria, and Thailand demonstrate consistently higher ERPT coefficients. For instance, Hungary's ERPT coefficients range from 0.217 to 0.245, indicating a substantial transmission of exchange rate movements into domestic inflation. Similarly, Bulgaria exhibits relatively elevated ERPT coefficients ranging from 0.191 to 0.227, suggesting a notable impact of exchange rate fluctuations on domestic prices. These higher ERPT coefficients may signify economies with more significant import dependencies or heightened sensitivity to external economic shocks. Countries reliant on imported goods and services are more susceptible to experiencing pass-through effects of exchange rate movements on domestic price levels.

Conversely, countries such as the USA, Canada, and Russia display consistently lower ERPT coefficients throughout the observation period. For instance, the USA's ERPT coefficients range from 0.050 to 0.083, indicating a comparatively weaker transmission of exchange rate movements into domestic inflation compared to countries like Hungary and Bulgaria. Lower ERPT coefficients in these economies may reflect greater insulation from international price pressures, potentially attributable to diversified production bases, robust domestic supply chains, or effective monetary policy measures aimed at price stabilization. Temporal dynamics in ERPT coefficients reveal interesting patterns across countries over the years. For example, while the USA consistently exhibits lower ERPT coefficients, a gradual decline is observed from 2011 to 2018. In contrast, countries like Hungary and Bulgaria maintain relatively stable or even increasing ERPT coefficients over the same period. These temporal dynamics suggest that the impact of exchange rate movements on domestic prices may evolve differently across countries over time, influenced by a myriad of factors, including changes in trade patterns, shifts in global economic conditions, and adjustments in monetary policy strategies.

Analyzing sectoral heterogeneities across countries provides valuable insights into the diverse industrial landscapes and economic structures worldwide. The table presents the sectoral composition of value-added in various countries, highlighting significant disparities and patterns across different economic activities.

Table 2: The IO Model results by sector

Country	**Agriculture**	**Manufacturing**	**Service**
Argentina	0.067	0.148	0.059
Austria	0.239	0.384	0.119
Bulgaria	0.272	0.413	0.164
Canada	0.208	0.316	0.089
Costa Rica	0.188	0.265	0.078
Finland	0.179	0.328	0.124
France	0.200	0.301	0.090
Germany	0.195	0.289	0.085
Hungary	0.277	0.470	0.185
Iceland	0.255	0.273	0.139
India	0.044	0.206	0.090
Indonesia	0.046	0.160	0.086
Ireland	0.433	0.426	0.208
Italy	0.130	0.282	0.082
Korea	0.183	0.338	0.135
Mexico	0.113	0.254	0.064
Poland	0.232	0.349	0.133
Romania	0.164	0.216	0.137
Russia	0.105	0.184	0.066
Saudi Arabia	0.078	0.185	0.107
South Africa	0.242	0.272	0.091
Sweden	0.217	0.305	0.105
Thailand	0.177	0.346	0.177
Türkiye	0.140	0.249	0.100
UK	0.204	0.267	0.096
USA	0.100	0.172	0.045

The ERPT values for agriculture exhibit notable variability across countries, ranging from a minimum of 0.044 for India to a maximum of 0.433 for Ireland. Countries such as Ireland, Bulgaria, Hungary and Iceland demonstrate relatively high ERPT values in agriculture, indicative of a more robust transmission of exchange rate fluctuations to agricultural prices. Conversely, economies like Argentina, Indonesia, and India exhibit considerably lower ERPT values. However, the agricultural sector typically exhibits lower sensitivity to exchange rate fluctuations than manufacturing. This characteristic stems from the inherent nature of agricultural commodities, which often have inelastic demand and are influenced by various non-currency-related factors such as weather conditions, government policies, and global demand dynamics. Consequently, while exchange rate movements may impact export revenues for agricultural products, their effects on domestic prices and inflation tend to be restrained.

ERPT values for manufacturing display wide-ranging disparities among countries, with values spanning from 0.148 for Argentina to 0.467 for Hungary. Hungary, Ireland and Bulgaria show higher ERPT values in manufacturing, implying a significant influence of exchange rate fluctuations on manufacturing prices. These nations display sophisticated manufacturing bases heavily reliant on imported raw materials and intermediate goods. Consequently, they are more susceptible to exchange rate fluctuations, affecting their export competitiveness and domestic price levels. Domestic currency depreciation may enhance export competitiveness internationally but simultaneously elevate import costs and induce inflationary pressures nationally. Thus, these countries are prone to experiencing more evident exchange rate pass-through effects than counterparts like the USA, Indonesia, and Russia, which have less dependent manufacturing structures.

ERPT values for the services sector also manifest considerable heterogeneity, ranging from 0.045 for the USA to 0.208 for Ireland. Ireland, Bulgaria, and Thailand display higher ERPT values in the services sector, suggesting a significant impact of exchange rate movements on service prices. Conversely, countries like the USA, Mexico, and Argentina exhibit lower ERPT values. Unlike goods-producing sectors, services are generally less susceptible to exchange rate movements, particularly in economies where services represent a substantial portion of GDP. This resilience is attributed to the non-tradable nature of many services or their limited exposure to international competition, mitigating their sensitivity to exchange rate fluctuations.

These results underline the nuanced relationship between sectoral ERPT dynamics and various economic factors, providing valuable insights into the mechanisms governing the transmission of exchange rate fluctuations to domestic prices across agriculture, manufacturing, and services sectors.

5 Results

In this section, we give the results of both analyses and compare them according to some criteria. Table 3 shows the findings of the models with respect to the country's development level. The developed economies were listed on the left side, while the right side is reserved for developing countries. The results of the models show striking differences for countries in different classes. The estimations of ERPT by the VAR analysis for developed countries are lower than the IO table results. Moreover, the differences between the findings are remarkably enormous except for the USA. Another interesting result is the negative ERPT for some countries (Finland, France, Korea) by VAR. These findings indicate that a depreciation of the domestic currency leads to a decrease in CPI. The other side of the table has a different story. The results imply that in 10 of the 14 countries observed (Hungary, Mexico, Turkey, and South Africa are the exceptions), VAR results are higher than IO results. While the gap between the outcomes is negligible for some, such as Indonesia and Thailand, it is large enough for several economies, such as Costa Rica and Bulgaria.

The results of the two models can be considered together with other variables thought to be determinants of ERPT. Firstly, the degree of a country's openness to the outside world should impact the pass-through coefficient. As suggested by McCarthy (2000) and Goldfajn and Werlang (2000), in a more open economy characterized by a substantial volume of imports and exports, a depreciation would exert a more pronounced influence on prices. Figure 1 displays the visual comparison of the relationship between countries' openness levels and ERPT estimations by VAR and IO analyses. As we can see, IO results

Country	VAR	IO	Country	VAR	IO
Austria	0.032	0.156	Costa Rica	0.438	0.123
Canada	0.029	0.123	Hungary	0.146	0.227
Finland	-0.040	0.147	Mexico	0.031	0.123
France	-0.031	0.120	Poland	0.235	0.178
Germany	0.018	0.122	Turkey	0.086	0.133
Iceland	0.050	0.149	Argentina	0.244	0.072
Ireland	0.052	0.237	Bulgaria	0.585	0.214
Italy	0.070	0.116	India	0.174	0.109
Korea	-0.076	0.164	Indonesia	0.110	0.103
Sweden	0.050	0.129	Romania	0.253	0.154
UK	0.000	0.117	Russia	0.137	0.092
USA	0.058	0.062	Saudi	0.152	0.118
			South Africa	0.046	0.129
			Thailand	0.224	0.217

Table 3: ERPT coefficients by two approaches

show the effect of openness more clearly than VAR results.

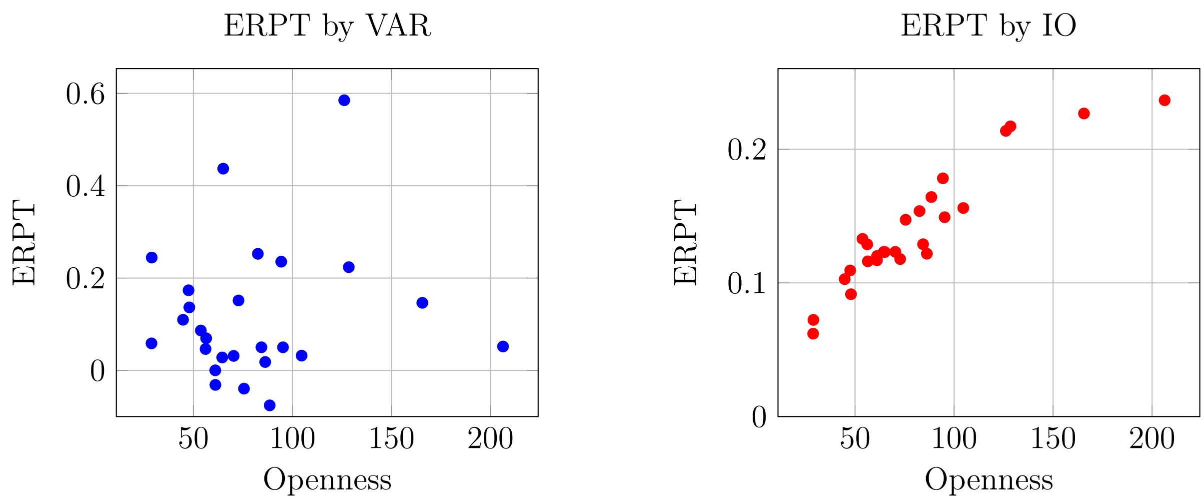

Figure 1: Openness

The share of intermediate imports is also an important determinant of ERPT. María-Dolores (2008) underlines the importance of intermediate import dependency empirically. Thus, a substantial reliance on imported intermediates makes us suspect higher ERPT. In Figure 2, where the x-axis is the ratio of imported intermediate goods to total imports,

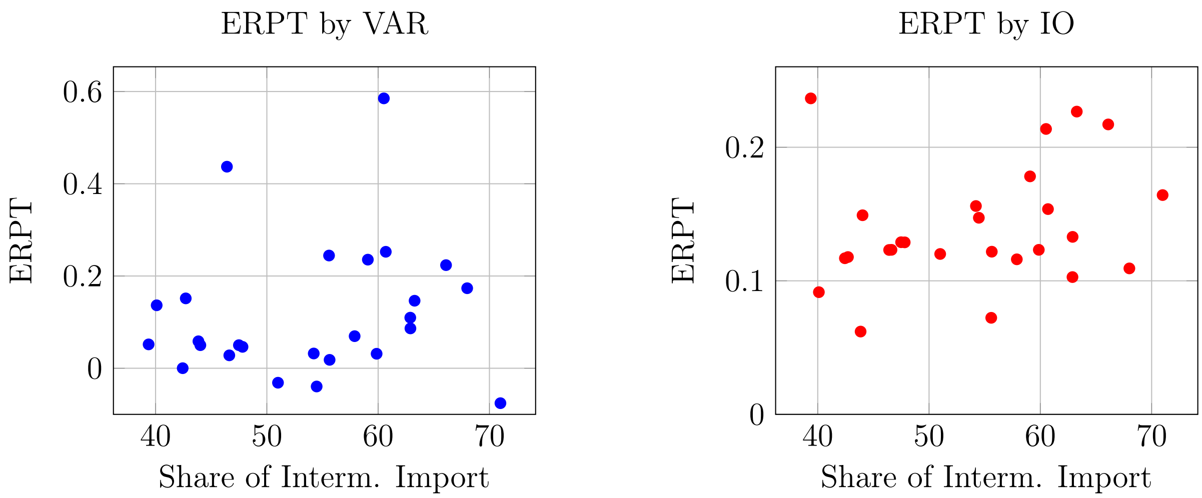

Figure 2: Relation between share of intermediate import and ERPT

the positive relationship between the rate of imported intermediate goods and the level of ERPT can be observed better for the results of IO analysis.

The import content of exports is the last comparison subject we will examine in this section. Similar to the share of imported intermediate goods in total imports, the ratio of imported products in the export structure of an economy is among the factors that determine the level of ERPT. If an economy's exports, and therefore its foreign trade balance, include imported products to a high degree, fluctuations in the exchange rate will effectively affect domestic prices. Therefore, Figure 3 shows the ERPT estimates of both models with the import content percentages of exports. The figure on the right indicates that the positive impact of import content of export on ERPT can be supported by the findings of IO results. This hypothesis contradicts the results of the VAR analysis.

In summary, there are notable differences between the ERPTs of the countries in our observation set estimated through two different models. These differences are similar depending on the development levels of the countries. The IO model used in this article

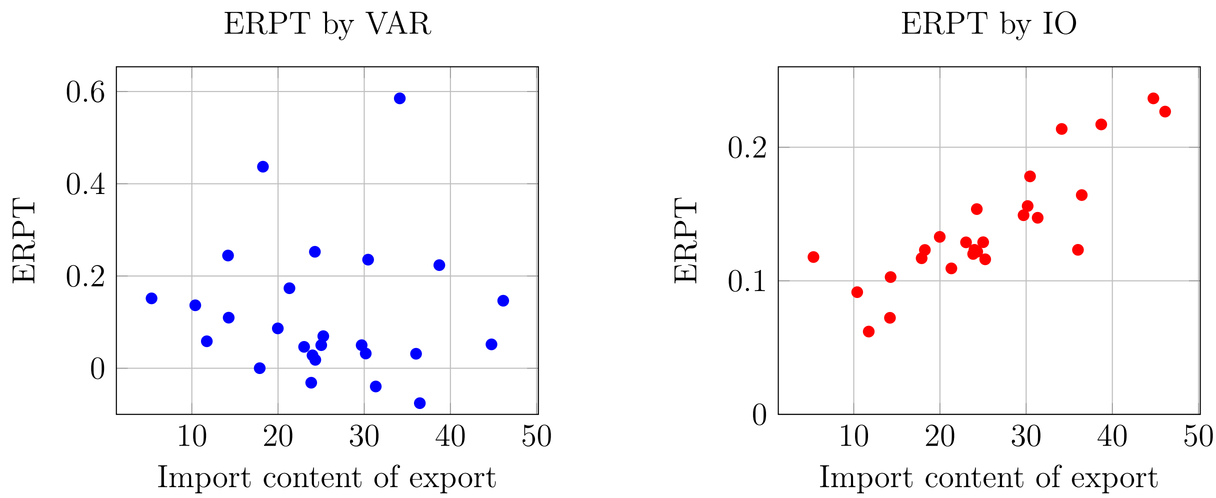

Figure 3: Import content of export and ERPT

suggests that the ERPT coefficient in developed economies is higher than the results of the VAR model, which is the most widely used in the literature, while it shows that there are overestimated results by VAR for developing economies. Considering the role of some variables shown in the literature as determinants of the ERPT effect and evaluating them with the results of the models may allow us to compare the model results better. As explained above, the findings show us that while the relationship between ERPT and some variables is revealed more strikingly by the IO table results, VAR results are not compatible with these theories.

6 Conclusion

The examination of exchange rate pass-through (ERPT) dynamics across diverse countries and economic sectors, utilizing both Input-Output (IO) and Vector Autoregressive (VAR) models, has yielded insightful findings that contribute to our understanding of the complex interactions between exchange rate movements and domestic inflation.

The analysis of ERPT using the VAR model revealed notable differences in ERPT coefficients across countries, with developed economies exhibiting higher coefficients compared to developing economies. This observation challenges the conventional wisdom in the literature and suggests the potential overestimation of ERPT effects by the VAR model for developing economies. Additionally, the VAR results underscored the importance of considering the role of determinants such as trade openness, monetary policy credibility, and exchange rate regimes in shaping ERPT dynamics.

Complementing the VAR analysis, the IO model provided a unique perspective by examining sectoral interdependencies within each economy and their implications for ERPT. The IO results demonstrated significant variability in ERPT coefficients across countries and economic sectors. Countries with greater import dependencies or heightened sensitivity to external economic shocks exhibited higher ERPT coefficients, indicating a substantial transmission of exchange rate movements into domestic inflation. Conversely, countries with diversified production bases or effective monetary policy measures displayed lower ERPT coefficients, reflecting greater insulation from international price pressures.

Furthermore, the sectoral analysis highlighted significant disparities and patterns across different economic activities. While the agricultural sector generally exhibited lower sensitivity to exchange rate fluctuations compared to manufacturing and services, there were notable exceptions, particularly in countries with sophisticated manufacturing bases heavily reliant on imported raw materials and intermediate goods.

In conclusion, the findings from both the VAR and IO models underscore the nuanced nature of ERPT dynamics, shaped by a myriad of economic factors and country-specific characteristics. Understanding these dynamics is crucial for policymakers to devise targeted strategies to manage inflationary pressures effectively and promote macroeconomic stability. Moving forward, further research exploring the interactions between exchange rate movements, domestic inflation, and sectoral dynamics will be essential for enhancing our understanding of ERPT and its implications for economic policy.

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Appendix A

Country	VAR	Alternative VAR	Country	VAR	Alternative VAR
Austria	0.032	0.060	Costa Rica	0.438	0.408
Canada	0.029	0.038	Hungary	0.146	0.201
Finland	-0.040	-0.028	Mexico	0.031	0.036
France	-0.031	-0.049	Poland	0.235	0.237
Germany	0.018	0.013	Turkey	0.086	0.081
Iceland	0.050	0.046	Argentina	0.244	0.188
Ireland	0.052	-0.015	Bulgaria	0.585	0.634
Italy	0.070	0.038	India	0.174	0.188
Korea	-0.076	-0.034	Indonesia	0.110	0.126
Sweden	0.050	0.009	Romania	0.253	0.253
UK	0.000	0.006	Russia	0.137	0.218
USA	0.058	0.076	Saudi	0.152	0.161
			South Africa	0.046	0.071
			Thailand	0.224	0.230

Table 4: Results of VAR models with different orders