A MODEL TO MEASURE THE EFFECTS OF EXCHANGE RATE VARIATIONS ON PRICES

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ABSTRACT

The paper modifies the current input-output price models to analyze exchange rate variation effects on products price indices. In so doing, a Table Adjustment Price (TAP) model was expanded to deal with different cases of the real-world economy. Among the contributions the new model makes to the literature are its ability to distinguish between the effects of imported intermediate input and imported final goods on price indices and the capability to consider imperfect exchange rate pass-through to prices of imported goods. The results of the implementation of the model for Iran's economy indicate that only in the case of an imperfect pass-through or a non-adjustment of one or more primary factors holders' endowments, the increment in the exchange rate will lead to smaller increments in the price indices of the products and other relevant indices.

Keywords: Exchange rate changes, price model, imports, table adjustment price, input-output.
JEL Classification: C67, E31.

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UN MODELO PARA MEDIR LOS EFECTOS DE LAS VARIACIONES
DEL TIPO DE CAMBIO EN LOS PRECIOS

RESUMEN

Este artículo modifica los modelos de insumo-producto para analizar los efectos de la variación del tipo de cambio en los índices de precios de los productos. Para tal propósito, expandimos un modelo de una matriz de ajuste de precio para estudiar diferentes casos de la economía mundial real. Este nuevo modelo contribuye a la literatura sobre el tema al distinguir entre los efectos de los insumos intermedios importados y los de los bienes finales importados en los índices de precios, así como al considerar el traspaso imperfecto de las variaciones del tipo de cambio a los precios de los bienes importados. Los resultados de la implementación del modelo para el caso de la economía de Irán muestran que sólo en el caso de un traspaso imperfecto o en el de un no ajuste de uno o más de los factores primarios de las dotaciones de los agentes económicos, el aumento en el tipo de cambio conducirá a incrementos más pequeños en los índices de precios de los productos y en otros índices relevantes.
Palabras clave: variaciones del tipo de cambio, modelo de precios, importaciones, matriz de ajuste de precios, insumo-producto.
Clasificación JEL: C67, E31.

1. INTRODUCTION

The exchange rates of countries change for different reasons. Irrespective of the causes, there is sufficient evidence for the variations of the exchange rate in different countries. For instance, Karunaratne (1996) refers to the effect of policy reform on the exchange rate in Australia; Li, Philippopoulos, and Tzavalis (2000) for the case of Mexico, Bahmani-Oskooee and Kara (2000) for Turkey, Zhang (2001) and McKinnon (2009) for China, Mallick and Marques (2006) for India, Chipili (2016) for Zambia, and Effiong and Bassey (2019) for Nigeria.

Exchange rate changes mainly affect the price of goods and services through imported commodities, which are imported into a country for different purposes. In a general classification, the commodities are categorised into intermediate input and final goods. Concerning the role of each group of imported commodities in the domestic economy, the changes in the value of the commodities will have different effects on price indices.

Imported commodities that are consumed in the production process comprise a part of the intermediate input. As a result, fluctuation in the exchange rate may cause a shock in the prices of supplied commodities through domestic production processes. The shock can affect some or all of the primary factors' components to strengthen the initial shock in its own turn. Yet the imported final goods and services shape the other part of the commodities which are imported into the country. Hence, the variations in exchange rates also affect the prices of supplied commodities through imported final goods.

Import classifications influence the shape of the input-output (I-O) table and, accordingly, the relevant relationships. One of these classifications is based on final goods and intermediate input. Since each group of the commodities has a different role in an economy, the classification allows the researcher to more accurately measure the effect of the change in an exchange rate through different groups of imported goods.

There are numerous studies such as Dornbusch (1987), Goldberg and Verboven (2001), Keyfitz (2004), Gagnon and Ihrig (2004), Frankel, Parsley and Wei (2005), Gagnon (2006), Campa and Goldberg (2006a), Campa and Goldberg (2006b), Goldberg and Campa (2010), Sadeghi *et al.* (2012), Fetai (2013), Musunuru (2017), Cho-Hoi, Chi-Fai and Po-Hon (2018), Alvarez *et al.* (2019), and Aixalá, Fabro, and Gadea (2020) which concern the investigation of exchange rate volatility effects on prices of goods and/or inflation, using different kinds of econometric models with aggregated imports. However, there are only a few studies that have measured the effects of the exchange rate variations on price indices of products employing input-output models. In input-output models, imported commodities are considered as intermediate inputs. According to the review performed, the first attempt was carried out by Levy (1985) employing a price model based on the Standard Leontief Price (SLP) model to analyse the effects of exogenous changes in exchange rates on relative prices and aggregate price levels. The study by Ajakaiye and Ojowu (1994) is another of this kind that developed an SLP model for imported intermediate inputs, expatriate labour and foreign financial capital for the economy of Nigeria.

The current study proposes a new model for measuring the pass-through of exchange rate fluctuations to price indices of the products by modifying the existing I-O model. To this end, a TAP model has been developed to carry out this function. The modified model is based on an I-O table in which the imported commodities are categorised into intermediate input, household consumption, and other final goods.

The contribution of the proposed model to the literature can be seen in its advantages in comparison with previous ones. More explicitly, its main advantage is that it divides imports into two groups with different effects on prices in a domestic economy, allowing the researcher to consider the effects of exchange rate variations into final goods as well as on intermediate inputs. Taking into account the imported final goods consumed by households, he/she will be able to consider them in aggregate Consumer Price Index (CPI), which is another contribution of this model. Besides, the model is able to consider any increase in the initial shock through primary factors' components. The model's capability in considering imperfect exchange rate pass-through is still another contribution that it can make to the literature.

The paper has been organised into five sections. The following section provides an overview of the previous attempts in this area. The research model is developed in the third section. The empirical implementation of the sectoral and aggregate effects of an exogenous shock in the exchange rate is presented in the fourth section. And finally, the conclusion of the research ends the paper.

2. A GENERAL OVERVIEW OF PREVIOUS MODELS

A modified version of the SLP model was developed in Levy (1985), as shown in equation [1]:

$$\mathbf{P} = \mathbf{P}\mathrm{A} + e\mathbf{P}^{f}\mathrm{A}^{f} + \mathbf{w} + \mathbf{b} + (\mathbf{w} + \mathbf{b})\hat{a} \qquad [1]$$

where **P** denotes a row vector of per unit domestic product prices, A is the technological coefficient matrix, e is the scalar of the exchange rate (domestic currency/ foreign currency), $\mathbf{P}^f$ is a row vector of world prices for non-competitive imports expressed in the foreign currency, A^f is a non-competitive imports coefficients, in which a_{ij}^{f} is the requirement of non-competitive good i per unit of the domestically produced good j, **w** is a row vector of wage payments per unit of output, **b** is a row vector of profits per unit of output, and $\hat{a}$ is a diagonal matrix of value-added taxes.

In this model:

$$\mathbf{w} = x\mathbf{l} \qquad [2]$$

$$\mathbf{b} = [\mathbf{P}\mathrm{A} + e\mathbf{P}^f \mathrm{A}^f + x\mathbf{l}]\hat{\mathrm{m}} = \mathbf{c}\hat{\mathrm{m}} \qquad [3]$$

x is a scalar of the nominal wage rate, **l** a row vector of labour/output coefficients, **c** a row vector of unit costs, the sum of domestic and imported intermediate input costs and labor costs, and $\hat{\mathrm{m}}$ is a diagonal matrix of profit mark-up rates.

The effect of exchange rate depreciation under different pricing regimes in Nigeria was measured by Ajakaiye and Ojowu (1994). For this purpose, an extended SLP model was also developed:

$$\mathbf{P} = \mathbf{P}\mathrm{A} + (1+u)\mathbf{P}^f \mathrm{A}^f + \mathbf{w}^h + (1+u)\mathbf{w}^f + \mathbf{d} + \mathbf{r}^h + (1+u)\mathbf{r}^f + \mathbf{t} - \mathbf{s} \qquad [4]$$

where u is the rate of the exchange rate variations, $\mathbf{w}^h$ the row vector of wages per unit of output for indigenous workers, $\mathbf{w}^f$ the row vector of wages per unit of output for expatriate workers, **d** the row vector of depreciation, $\mathbf{r}^h$ the row vector of per unit profit accruing to indigenous investors, $\mathbf{r}^f$ the row vector of per unit profit accruing to foreign investors, **t** the row vector of per unit indirect taxes, and **s** the row vector of per unit subsidies.

These models seem to share a number of features. For instance, both were derived from the development of the SLP model. Another common characteristic of the two models is that the imported commodities are considered non-competitive goods in intermediate inputs. In other words, the imports of competitive goods demanded as final commodities are ignored in both of them, so that only the price indices of domestic products are measured. And finally, the use of the technical coefficient matrix of imported intermediate inputs is the last shared feature of the two models.

However, the two models are not without any differences. For instance, they differ in their division of labour and capital endowment into domestic and foreign. Since payments are made in domestic currency, the exchange rate variations will not affect these components. Another important difference between the models concerns tax revenue. Irrespective of taxes on value-added or sale tax, *t* has a fixed value in the price index. Then the level of tax revenue in per unit of commodities is independent of exchange rate shocks in the model proposed by Ajakaiye and Ojowu (1994). In contrast, in the model proposed by Levy (1985), the tax revenue in per unit of commodities is adjusted with respect to the exchange rate shock through **b** (equation [3]).

3. THE MODEL

The present study starts with a case in which the imported commodities are classified into imported intermediate input and final goods consumed by households or used for other purposes. Due to the different roles of these two groups of imported goods, as shown in Table 1, the imported final goods appear to the right of the domestic final products and the imported intermediate goods are shown below the value-added components; imports of final goods are considered as other final commodities.

It is assumed that I_j^1 stands for the price index of the product *j* due to the direct effect of the exchange rate variations. It is equal to the ratio of the size of the total input value of the j^{th} products after the initial shock in the exchange rate to the corresponding value before the initial shock. When multiplying this ratio by the corresponding row of the I-O table, the change in the price index of the products is considered in the value of these products in different sectors. This change, which can be strengthened by value-added components, causes a new shock on the value of the total inputs of the product.

Table 1. The schematic I-O table

Intermediate transaction	Households consumption	Other final demand	Total output	Households imported consumption	Other imported final goods	Total supply
Value added components						
Intermediate imports						
Total outlays						

Similarly, I_j^2 is obtained by the ratio of the new value of total inputs for product *j* to the corresponding value after the initial shock. When multiplying I_j^2 by the value of the products in the corresponding row of the table, like the initial shock, the second shock is also considered in the table. This process will continue until I_j^t comes close enough to one so that the result of the shock adjustment leads to an ignorable amount.

To generalise the adjustment from one product to others, a matrix form is required. To this end, the adjustment process of the table is shown in equation [5]:

$$T^k = I^k T^{k-1} = \begin{bmatrix} I_1^k & 0 & \cdots & 0 & 0 & 0 & 0 \\ 0 & I_2^k & \cdots & 0 & 0 & 0 & 0 \\ \vdots & \vdots & & \vdots & & & \vdots \\ 0 & 0 & \cdots & I_n^k & 0 & 0 & 0 \\ 0 & 0 & & 0 & A^k & 0 & 0 \\ 0 & 0 & & 0 & 0 & B^k & 0 \\ 0 & 0 & \cdots & 0 & 0 & 0 & C_j^k \end{bmatrix} \begin{bmatrix} T_{11}^{k-1} & T_{12}^{k-1} & \cdots & T_{1n}^{k-1} & \cdots & T_{1m}^{k-1} \\ T_{21}^{k-1} & T_{22}^{k-1} & \cdots & T_{2n}^{k-1} & \cdots & T_{2m}^{k-1} \\ \vdots & \vdots & & \vdots & & \vdots \\ T_{n1}^{k-1} & T_{n2}^{k-1} & \cdots & T_{nn}^{k-1} & \cdots & T_{nm}^{k-1} \\ W_1^{k-1} & W_2^{k-1} & & W_n^{k-1} & 0 & 0 \\ S_1^{k-1} & S_2^{k-1} & & S_n^{k-1} & 0 & 0 \\ X_1^{k-1} & X_2^{k-1} & \cdots & X_n^{k-1} & 0 & 0 \end{bmatrix}$$

$$= \begin{bmatrix} T_{11}^k & T_{12}^k & \cdots & T_{1n}^k & \cdots & T_{1m}^k \\ T_{21}^k & T_{22}^k & \cdots & T_{2n}^k & \cdots & T_{2m}^k \\ \vdots & \vdots & & & & \vdots \\ T_{n1}^k & T_{n2}^k & \cdots & T_{nn}^k & \cdots & T_{nm}^k \\ W_1^k & W_2^k & & W_n^k & 0 & 0 \\ S_1^k & S_2^k & & S_n^k & 0 & 0 \\ X_1^k & X_2^k & \cdots & X_n^k & 0 & 0 \end{bmatrix} \quad [5]$$

where I^k indicates a diagonal matrix of the k^{th} iteration of the adjustment coefficient and I_j^k is associated with the j^{th} product intermediate input adjustment. A^k, B^k, and C^k are three additional adjustment coefficients relevant to *W*, wages, *S*, operating surplus, and *X,* taxes, *i.e.*, the value-added items of the products. As Table 1 indicates, T^{k-1} and T^k refer to partitioned matrices of I-O tables in the $k-1^{th}$ and k^{th} iteration of the adjustment process, respectively. The schematic forms of these tables, as shown in equation [6], include the intermediate demand, final demand from the domestic products, and the value-added items as follows:

$T^{k-1} or\ T^k =$ [6]

$$\begin{bmatrix} \text{Intermediate input} & \text{Households consumption} & \text{Other final demand} \\ \text{Value added items} & 0 & 0 \end{bmatrix}$$

For instance, in cases when the wages are adjusted with respect to *CPI*, A^k, the adjustment coefficients for the k^{th} iteration of adjustment is calculated using the Laspeyres price index:

$$g = \frac{\sum_{i=1}^{n} Q_i^c P_i^0}{\sum_{i=1}^{n} Q_i^c P_i^0 + \sum_{i=1}^{n} M_i^c P_i^f}$$

$$CPI = g\frac{\sum_{i=1}^{n} Q_i^c P_i^1}{\sum_{i=1}^{n} Q_i^c P_i^0} + (1-g)\frac{\sum_{i=1}^{n} M_i^c P_i^f e^1}{\sum_{i=1}^{n} M_i^c P_i^f e^0} = \quad [7]$$

$$g\frac{\sum_{i=1}^{n} C_i^1}{\sum_{i=1}^{n} C_i^0} + (1-g)\frac{\sum_{i=1}^{n} C_i^{m^1}}{\sum_{i=1}^{n} C_i^{m^0}} = g\frac{\sum_{i=1}^{n} C_i^1}{\sum_{i=1}^{n} C_i^0} + \left(1-g\right)(1+r)$$

g and $(1 - g)$ denote the share of household consumption expenditure in domestic and imported goods before an exchange rate shock, respectively. Q_i^c refers to the quantity of the domestic product i in household consumption. Since it is assumed that there is no change in the volume of consumption, imports, etc., the sizes of these items are constant before and after any shock. P_i^0 and P_i^1 indicate the price indices of the product i before and after any shock including exchange rate shocks or any other shocks during the iteration of the adjustment process, respectively. P_i^f shows the world price index for the i^{th} imported final goods expressed in the foreign currency. M_i^c denotes the quantity of imported goods i in the household consumption. As explained in equation [1], e^0 and e^1 are a scalar of exchange rate (domestic and foreign currencies) before and after an exchange rate shock, respectively; r is the increment rate in the size of e, hence $e^1/e^0 = (1+r)$. C_i^0 and C_i^1 refer to the household expenditures on the domestic products i before and after any shock, respectively. $C_i^{m^0}$ and $C_i^{m^1}$ indicate the household expenditures on imported goods i before and after any shock, respectively.

It is notable that in cases in which the pass-through of exchange rate volatilities is imperfect, $e^1/e^0 = (1+r)$ would be replaced by $e^1/e^0 = (1+rv)$. v indicates the pass-through rate of exchange rate volatilities on imported goods. A similar relationship can be used to consider the imperfect effect of initial shock in the exchange rate on the imported final goods as well as on the intermediate inputs.

B^k, the adjustment coefficients of the operating surplus, can be replaced by an index. For instance, it can be assumed that the capital holders attempt to adjust their endowments with respect to the Producer Price Index (PPI). To this end, the Laspeyres price index is used to measure PPI as follows:

$$PPI = \frac{\sum_{i=1}^{n} Q_i^0 P_i^1}{\sum_{i=1}^{n} Q_i^0 P_i^0} = \frac{\sum_{i=1}^{n} Z_i^1}{\sum_{i=1}^{n} Z_i^0} \qquad [8]$$

Q_i^0 and Z_i^0 refer to the quantity and the value of the total products for the i^{th} products before any exchange rate shocks, respectively. Z_i^1 denotes the total value of the i^{th} products after each shock.

C_j^k, the adjustment coefficient for indirect tax, has been calculated to meet the ad valorem tax policy. It is worth noting that due to differences in the size of the tax rate of commodities, the adjustment coefficients for the indirect tax of the products are different. Hence, equation [9] calculates different coefficients to adjust the tax on commodities.

$$C_j^k = \frac{\sum_{i=1}^{n} T_{ij}^k + W_j^k + S_j^k + Tf_j^k + M_j^k - Su_j^k}{\sum_{i=1}^{n} T_{ij}^{k-1} + W_j^{k-1} + S_j^{k-1} + Tf_j^{k-1} + M_j^{k-1} - Su_j^{k-1}} \qquad [9]$$

Hence,

$$Ta_j^k = C_j^k Ta_j^{k-1} \qquad [10]$$

here, $\sum_{i=1}^{n} T_{ij}^k, W_j^k, S_j^k, Tf_j^k, M_j^k, Su_j^k$ and Ta_j^k denote the total domestic intermediate input, wages, operating surplus, tariffs, imported intermediate input, subsidy, and indirect taxes for the products *j* in the k^{th} iteration of the table adjustment process, respectively. $\sum_{i=1}^{n} T_{ij}^{k-1}, W_j^{k-1}, S_j^{k-1}, Tf_j^{k-1}, M_j^{k-1}, Su_j^{k-1}$ and Ta_j^{k-1} refer to the same items for the product *j* in the $(k-1)^{th}$ iteration of the table adjustment process.

However, in the cases where one or more value-added items are not adjusted based on price shocks, the relevant adjustment coefficients will be equal to one. It is notable that if we assume C_j^k to be one, it renders the model fit for a unitary tax policy.

The result of the adjustment process of the table leads to T^t, the adjusted I-O table, according to price exchange rate shocks in equation [11]:

$$\mathrm{T}^t = \mathrm{I}^1\mathrm{I}^2\mathrm{I}^3 \ldots \mathrm{I}^t\mathrm{T}^0 = \mathrm{I}\mathrm{T}^0 \qquad [11]$$

T^0 refers to the initial I-O table, and I is the diagonal matrix of price indices for the products and value-added components, where T^1 refers to the 1st and I^t to the t^{th} iteration of the adjustment.

Hence, the values of the price indices of the products, *CPI* and *PPI*, which change as a result of any variation in the exchange rate, are calculated by multiplying the size of the components by corresponding coefficients in different iterations of adjustment. For instance, the price index for the j^{th} product, I_j, is given by equation [12]:

$$\mathrm{I}_j = \prod_{k=1}^{t} \mathrm{I}_j^k = \mathrm{I}_j^1\mathrm{I}_j^2\mathrm{I}_j^3 \cdots \mathrm{I}_j^t \qquad [12]$$

In addition, in a method similar to *CPI* calculation, the domestic supply price index (*DSPI*) of those commodities consisting of the domestic products and imported final goods is measured using equation [13]:

$$DSPI = y\frac{\sum_{i=1}^{n} Q_i^f P_i^1}{\sum_{i=1}^{n} Q_i^f P_i^0} + (1-y)\frac{\sum_{i=1}^{n} M_i^f P_i^f e^1}{\sum_{i=1}^{n} M_i^f P_i^f e^0} = \qquad [13]$$

$$y\frac{\sum_{i=1}^{n} F_i^{d^1}}{\sum_{i=1}^{n} F_i^{d^0}} + (1-y)\frac{\sum_{i=1}^{n} F_i^{m^1}}{\sum_{i=1}^{n} F_i^{m^0}} = y\frac{\sum_{i=1}^{n} F_i^{d^1}}{\sum_{i=1}^{n} F_i^{d^0}} + (1-y)(1+r)$$

y and $(1 - y)$ indicate the weight of the outputs and the value of the imported final goods in the total supply of goods before the exchange rate variations, respectively. Q_i^f and M_i^f denote the quantity of the domestic products and the foreign final goods, respectively. $F_i^{d^0}$ and $F_i^{d^1}$ are the nominal value of domestic outputs before and after any shock, respectively. $F_i^{m^0}$ and $F_i^{m^1}$ are the nominal value of the imported final goods before and after any shock, respectively.

Finally, the model *i* can also be utilized in cases where all the imported commodities are used as intermediate input only, of course, if M_i^c and M_i^f are equal to zero in equations [7] and [13], respectively.

4. IMPLEMENTATION OF THE MODEL

The model is applied to different cases utilizing the latest I-O table of Iran that seems to be quite suitable for the above purpose. Next, an integrated version of the symmetric interindustry table of Iran for the year 2016-2017 with 12 products was prepared. Finally, the effect of a 20% increment in the price of the exchange rate is examined for different cases.

Table 2 below demonstrates the effect of a 20% increment in the exchange rate on the price indices of the products, *PPI*, *CPI,* and *DSPI* in a unitary tax policy. The middle column of the table, O_j represents the share of imported intermediate inputs for the products. In this table of calculation, the values of A^k, B^k, and C_j^k in equation [5] were all assumed to be one, and then the effects of the exchange rate increment in a unitary tax policy on the price indices of the products were displayed.

As expected, the products with greater proportions of imported input have higher price indices, the correlation coefficient between O_j and price indices being about 0.98. In other words, when no value-added components are adjusted with respect to the increments of price indices, the price indices of the products with more dependency on imported input will be more dependent on exchange rate variations. However, due to the differences in the share of value added in total inputs of products, which are not adjusted, the correlation coefficient is not equal to one. In addition, exchange rate variations influence *PPI*, *CPI,* and *DSPI*. Compared with *CPI* and *DSPI*, since the imported final goods were not considered in *PPI*, the exchange rate variations have a less noticeable effect on this index. However, due to the significance of the direct effect

Table 2. The effect of a 20% increment in the exchange rate on the price indices of the products, PPI, CPI, and DSPI in Unitary Tax Policy (all numbers in O_j column in percent)

Products	O_j	Price indices	Products	O_j	Price indices
Agricultural products	5.22	101.52	Education services	0	100.18
Crude petroleum & Natural gas	2.06	100.45	Health services	0	100.23
Other minerals	2.31	100.71	Public services	0	100.14
Electricity, Water & Gas distribution	6.59	101.66	Private services	0	100.16
Industrial products	9.53	102.74	*PPI*	-	101.29
Buildings	7.44	102.64	*CPI*	-	103.08
Banking & insurance services	0	100.13	*DSPI*	-	103.81
Transport services	0	100.47	Correlation coefficient	-	0.98

of exchange rate variations, the effect on *CPI* and *DSPI* is to some extent dependent upon the share of imported intermediate goods, $1-g$, and upon the imported final goods, $1-y$, in household consumption and supply, respectively. Hence, it can be concluded that in cases where the exchange rate increment is not strengthened by the value-added components, the exchange rate variations have small effects on the price indices of the products and other related indices.

In the second case, in contrast to the first one, all value-added components have been adjusted in accordance with the price index increment. More specifically, using equation [5], wages and operating surplus have been adjusted in the ad valorem tax policy. For this purpose, A^k, B^k, and C_j^k were calculated by equations [7], [8], and [9], respectively. Table 3 displays the price indices of the products, *PPI*, *CPI,* and *DSPI* stemming from a 20% increase in the exchange rate.

The correlation coefficients between the price indices of the products with the share of imported intermediate inputs in total inputs and those of the imported final demand in the total supply of the products were

Table 3. The effect of a 20% increment in exchange rate on the price indices of the products, PPI, CPI and DSPI in an ad valorem tax policy with wage and operating surplus adjustment

Products	Price indices	Products	Price indices
Agricultural products	120.58	Health services	120.67
Crude petroleum & Natural gas	120.60	Public services	120.71
Other minerals	120.60	Private services	120.62
Electricity, Water & Gas distribution	120.58	*PPI*	120.60
Industrial products	120.55	*CPI*	120.53
Buildings	120.58	*DSPI*	120.52
Banking & insurance services	120.71	Correlation coefficient1/	–0.79
Transport services	120.61	Correlation coefficient2/	–0.43
Education services	120.70		

Notes: 1/ Correlation coefficient between price indices of the products and the share of imported intermediate inputs in total inputs. 2/ Correlation coefficient between price indices of the products and the share of imported final demand in total supply of the products.

calculated. Due to the influence of different factors on the size of the product indices, there were negative correlations with these factors. Yet, since the share of the imported final goods in total supply was greater than that of imported intermediate inputs in total inputs (7.03% against 4.02%), the total input was less dependent on the imported goods compared with the total supply. Hence, the effects of other factors on the price indices of the total products were greater than their effects on the total supply of goods (–0.79 compared with –0.43). Besides, since all components were adjusted with respect to the price indices, the sizes of the price indices of all products as well as *PPI*, *CPI* and *DSPI* were greater than those in the previous case and those of the exchange rate increment. Thus, in a perfect pass-through, where all value-added components are adjusted based on price indices, the exchange rate volatilities lead to greater changes in the price indices.

The third case concerns an imperfect exchange rate pass-through. Although there are no reasons for an exchange rate variation to have the same effect on the different imported commodities, and the model allows the researcher to consider different pass-through levels for different goods, avoiding the complexity of calculation, it is assumed that 90% of exchange rate variations influence the prices of all imported goods. Table 4 displays the results of the second case in Table 3 for a 90% pass-through.

It is notable that due to the imperfect pass-through of the exchange rate, increments in the price indices of the products and other relevant indices are less than those of the exchange rate. Thus, in an imperfect pass-through, an increment in the exchange rate may lead to less increment on the relevant price indices. In addition, like in the second case, the correlation coefficient between price indices of the products with the share of imported intermediate inputs in total inputs and that of imported final demand in the total supply of the products is equal to the perfect pass-through case.

Table 4. The effect of a 20% increment in exchange rate on the price indices of the products, PPI, CPI and DSPI in an ad valorem tax policy with wage and operating surplus adjustment when a 90% pass-through occurs

Products	Price indices	Products	Price indices
Agricultural products	118.46	Health services	118.54
Crude petroleum & Natural gas	118.48	Public services	118.57
Other minerals	118.49	Private services	118.50
Electricity, Water & Gas distribution	118.47	*PPI*	118.48
Industrial products	118.44	*CPI*	118.43
Buildings	118.46	*DSPI*	118.42
Banking & insurance services	118.57	Correlation coefficient[1/]	–0.79
Transport services	118.49	Correlation coefficient[2/]	–0.43
Education services	118.56		

Notes: [1, 2/] Are the same as those of Table 3.

Finally, the model was applied to the case in which all imported commodities are used as intermediate inputs only, and where there are no imported final goods (Table 5). In other words, although the conditions of imported intermediate inputs of the two cases are the same, there are no imported final goods in this case. To this end, M_i^c and M_i^f in equations [7] and [13], respectively, are considered equal to zero.

As shown in Table 5, the price indices of all products and other relevant price indices are exactly equal to the exchange rate indices. In other words, in the case where just intermediate imported input commodities are considered and all the primary factor holders adjust their endowments based on relevant price indices, this policy leads to an exactly equal increment in all the relevant price indices. Moreover, as in the first case, the price indices of the products have a strong relationship with the share of imported intermediate inputs in total inputs. So their correlation coefficient is 0.98.

Table 5. The effect of an increment in exchange rate on the price indices of the products, PPI, CPI and DSPI in different cases where just intermediate imported inputs commodities are considered

Products	Price indices	Products	Price indices
Agricultural products	120	Education services	120
Crude petroleum & Natural gas	120	Health services	120
Other minerals	120	Public services	120
Electricity, Water & Gas distribution	120	Private services	120
Industrial products	120	*PPI*	120
Buildings	120	*CPI*	120
Banking & insurance services	120	*DSPI*	120
Transport services	120	Correlation coefficient	0.98

5. CONCLUSION

The exchange rate variations seem to affect price indices through imported intermediate inputs and imported final goods, which can be strengthened by value-added components. In this study, it was demonstrated that the classification of imported commodities influences the size of price indices due to exchange rate variations, a point neglected in previous studies.

Hence a modified version of the TAP model for the case in which the imported commodities are classified as intermediate input and final goods is proposed to deal with this shortcoming. The model enables researchers to measure the effect of exchange rate variations on the price indices of the products, *PPI*, *CPI,* and *DSPI* for different cases. It was also shown that the model can be adapted to meet the requirements of the case in which there are no final goods for different reasons. Finally, the proposed model was implemented for an imperfect exchange rate pass-through case as well.

The results of implementation of the model for the case of Iran indicate that when exchange rate volatilities pass-through affect the price of imported commodities perfectly, and all primary factors holders adjust their endowments according to the relevant price indices, an increment in the exchange rate can at least lead to an equal increment in the price indices of the products and other relevant indices. However, when there is an imperfect pass-through or a non-adjustment of one or more primary factor holders' endowments, the increment in the exchange rate may lead to a lower increment in the price indices of the products and other relevant indices. It is also worth noting that in the latter case, the price indices of the products with more dependency on imported input are more dependent upon exchange rate variations. ◄

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