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A Global Multi-Sectoral Model in Local Currencies

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Abstract

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Keywords: global multi-country model; exchange rate; local currency

JEL classification: C54; D57; D58; F47

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A Global Multi-Sectoral Model in Local Currencies

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Abstract

Economic agents make their decisions by focusing on the economic performance of their economies in their currencies rather than in a foreign currency. This shows that a multi-country economic model in local currencies is suitable to analyze global economic issues. However, international input-output tables are denominated in a specific currency such as the US dollar. Employing the OECD Intercountry Input-Output Tables, this paper presents a method to convert the international input-output tables in U.S. dollars and current prices to those in local currencies and constant prices. In addition, the structure of a global model with economies of scale and imperfect competition is illustrated. A numerical example is also demonstrated in order to show the applicability of the model.

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1. Introduction

This paper aims at developing a new approach for global economic modeling; specifically, a local currency-based global multi-sectoral model.

The history of the world economy shows that economic interdependence of nations has been strengthened through trade and investment. Project LINK is a pioneering macroeconometric model which describes a global economy in the context of economic interdependence. Subsequently, many institutions and scholars construct multi-county macroeconometric models such as the International Monetary Fund’s Global Economy Model (Pesenti, 2008), Fair’s (1994) Multi-Country Model, Taylor’s (1993) Multi-Country Model. However, recent economic deregulation enables firms to investment overseas. In fact, firm-level foreign direct investment is growing rapidly. Therefore, macroeconometric models are not necessarily adequate for global economic analysis. Instead, a global model at sector level is more appropriate for analyzing the current world economy. Regarding multi-country multi-sectoral models, the following four types of models have been developed: 1) computable general equilibrium (CGE) model such as the Michigan model (Deardorff and Stern, 1986), the GTAP model (Hertel, 1996) and the G-Cubed

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model (McKibbin and Wilcoxen, 1999) , 2) the INFORUM system which interlinks national input-output models with a trade linkage model (Almon, 1991; Uno, 2002), 3) single-period international input-output model (Torii et al. 1989; Kosaka, 1994; Yano and Kosaka, 2003), and 4) price-linked multi-country multi-sectoral model (Yano and Kosaka, 2015). However, the first three models have shortcomings: a typical CGE model lacks statistical foundations of parameters; the INFORUM system might have inconsistency between classifications in input-output tables and trade matrix; a single-period international input-output model has limitations in specifications and estimation of behavioral equations due to the use of only a single-period international input-output table. A price-linked multi-country multi-sectoral model improves the flaws of these three models, yet it has a drawback: that is, a currency problem. The model in Yano and Kosaka (2015) is denominated in international dollars. In reality, however, economic agents make their decisions by focusing on economic performance of their economies in their currencies rather than a foreign currency. In addition, it is quite difficult to include the economic effects of exchange rate fluctuation in a model denominated in a single currency. This shows that we must build a local currency-based model in order to analyze economic issues. To do this, this paper shows an approach to compile international input-output tables in constant prices and local currencies. The structure of a local currency-based global multi-sectoral model with economies of scale and monopoly is also presented.

The rest of this paper consists of three sections. Section 2 illustrates the method to construct local-currency-based international input-output tables in constant prices. Section 3 shows the model structure. Section 4 demonstrates an application example of the model. Finally, section 5 provides conclusions.

2. Local-Currency-Based International Input-Output Tables in Constant Prices

2.1. Currency Conversion

International input-output tables are typically denominated in a single currency: e.g., the OECD Intercountry Input-Output Tables are evaluated in U.S. dollars. In contrast, local currency-based international input-output tables consist of variables in currencies h (country which supplies goods) and k (country which demands goods). Following the double deflation technique, intermediate goods (Part A of Figure 1), final demand, exports to the third world, statistical discrepancies (Part B of Figure 1), and output (Part C of Figure 1) are denominated in currency h. On the contrary, value added (Part D of Figure 2) is converted into that in currency k. In order to hold the consistency between the summation of inputs and demands, intermediate goods (Part A of Figure 1) are evaluated by currency k as well: i.e., we have two sets of intermediates (one is evaluated by currency h and the other is by currency k). Consequently, the following five parts should be obtained: i) intermediates evaluated by currency h, ii) intermediates evaluated by currency k, iii) final demand, exports to the third world, and statistical discrepancies evaluated by currency h, iv) output evaluated by currency h, and v) value added evaluated by currency k.

2.2. Deflation

In order to deflate an input-output table, the double deflation technique is normally applied. By contrast, Dietzenbacher and Hoen (1998) and Hoen (2002) develop a different deflating procedure which uses the RAS method. As Dietzenbacher and Hoen (1998) and Hoen (2002) point out, his approach would be more proper than double deflation. However, the RAS approach requires various data in constant prices in advance of deflation. According to Hoen (2002, p.78), the following data in constant prices are required for deflating international input-output tables: sectoral output, sectoral exports to and imports from the third world, sectoral value added, and totals of final demand components of each economy which consists the corresponding tables. On many occasions, it is not easy to obtain the required data even for developed countries. Therefore, we employ Yano and Kosaka's (2015) simpler approach which uses the principles of double deflation. The double deflation method requires price data for each sector and economy prior to deflation: however, it is rare to find proper set of these data. Viewing sectoral GDP deflator as the corresponding sector's value added deflator in the international input-output framework, Yano and Kosaka (2015) obtain sectoral price equations of all economies by backtracking the double deflation method and compute the values by solving the system of the resultant price equations.

2.3. The Detailed Procedure

Consider a general case where international input-output tables have *n* sectors and *r* countries. The procedure of constructing local currency-based international input-output tables in constant prices is described as follows:

Step 1: Unification of sector classification

Sector classifications of international input-output tables and GDP deflators are not always identical. Therefore, we unify the sector classifications of these data, if necessary.

Step 2: *Construction of international input-output tables in current prices and local currencies*

Prior to deflating international input-output tables, we construct those in current prices and local currencies. It is worth noting that intermediate goods in currency *k* are computed by converting intermediate goods in currency *h* into those in currency *k* since international input-output tables are deflated by currency *h*.

Step 3: *Computation of sectoral prices by using the corresponding sector's GDP deflators*

Following double deflation, value added deflator is written as:

$$PVA_j^k = \frac{XXK_j^k - \sum_{h=1}^{r}\sum_{i=1}^{n} XH_{ij}^{hk}\frac{e^k}{e^h} - WM_j^k}{\frac{XXK_j^k}{P_j^k} - \sum_{h=1}^{r}\sum_{i=1}^{n}\frac{XH_{ij}^{hk}}{P_i^h}\frac{e^{k*}}{e^{h*}} - \frac{WM_j^k}{PIM^k}} \qquad j = 1,2, \dots, n;\ k = 1, 2, \dots, r \qquad (1)$$

where PVA_j^k is value added deflator in sector *j* of country *k*, XXK_j^k is output in sector *j* of country *k* in current prices and currency *k*, WM_j^k is imports from the rest of the world in sector *j* of country

k in current prices and currency k, P_j^k is price in sector j of country k, XH_{ij}^{hk} is good i in sector j of country k delivered from country h in current prices and currency h, P_i^h is price in sector i of country h, e^k is the exchange rate of country k, e^h is the exchange rate of country h, e^{k*} is the base-year exchange rate of country k, e^{h*} is the base-year exchange rate of country h, and PIM^k is import deflator of country k. Rearranging equation (1) yields equation for P_j^k as:

$$P_j^k = \frac{XXK_j^k}{\omega_j^k} \qquad j = 1,2, \dots, n; k = 1, 2, \dots, r \tag{2}$$

where $\omega_j^k = \sum_{h=1}^{r} \sum_{i=1}^{n} \frac{XH_{ij}^{hk}}{P_i^h} \frac{e^{k*}}{e^{h*}} + \frac{WM_j^k}{PIM^k} + \frac{XXK_j^k - \sum_{h=1}^{r} \sum_{i=1}^{n} XH_{ij}^{hk} \frac{e^k}{e^h} - WM_j^k}{PVA_j^k}$. Collecting equation (2) of all sectors and countries and solving the resultant simultaneous system give sectoral prices of all countries in local currencies.

Step 4: *Deflation of international input-output tables in current prices and local currencies*

Applying the double deflation technique, we deflate intermediate goods, final demand components, exports to the rest of the world, statistical discrepancies, and output at the sector level by using the corresponding sector's price obtained in the previous step. Intermediate goods in currency k are deflated by using intermediate goods in constant prices and currency h as:

$$XKR_{ij}^{hk} = XHR_{ij}^{hk} \times \frac{e^{k*}}{e^{h*}} \qquad i, j = 1, 2, \dots, n; h, k = 1,2, \dots, r \tag{3}$$

where XKR_{ij}^{hk} is intermediate goods i in sector j of country k delivered from country h in constant prices and currency k and XHR_{ij}^{hk} is intermediate goods i in sector j of country k delivered from country h in constant prices and currency h.

2.4. Computed Prices by Sector and Country

This paper employs OECD's Intercountry Input-Output Tables 2015 edition and United Nations' National Accounts in order to make international input-output tables in constant prices and local currencies. Since sector classifications differ between the two data sources, we reorganized sector classification as in Table 1. Regions are also aggregated as Table 2 shows. Following the steps described in the previous section, we computed price by sector and country. The computed prices for selected countries are presented in Table 3.

3. The Model

3.1. The Theoretical Structure

3.1.1. Total Output

Based on the demand structure of an international input-output table, total output is determined by the following equation:

$$XXR_i^h = \sum_{j=1}^{n}\sum_{k=1}^{r} XHR_{ij}^{hk} + \sum_{k=1}^{r} CPHR_i^{hk} + \sum_{k=1}^{r} CNHR_i^{hk} + \sum_{k=1}^{r} CGHR_i^{hk} + \sum_{k=1}^{r} IHR_i^{hk} + \sum_{k=1}^{r} IVHR_i^{hk} + \sum_{k=1}^{r} EXHR_i^{h} + QHR_i^{h} \tag{4}$$

where XXR_i^h is total output in sector *i* of country *h* in constant prices and currency *h*, XHR_{ij}^{hk} is intermediate goods delivered from sector *i* of country *h* to sector *j* of country *k* in constant prices and currency *h*, $CPHR_i^{hk}$ is private consumption of country *k* delivered from sector *i* of country *h* denominated in constant prices and currency *h*, $CPNR_i^{hk}$ is nonprofit institution serving household of country *k* delivered from sector *i* of country *h* in constant prices and currency *h* (exogenous), $CGHR_i^{hk}$ is government consumption of country *k* delivered from sector *i* of country *h* in constant prices and currency *h* (exogenous), IHR_i^{hk} is fixed investment of country *k* delivered from sector *i* of country *h* in constant prices and currency *h*, $IVHR_i^{hk}$ is inventories of country *k* delivered from sector *i* of country *h* in constant prices and currency *h* (exogenous), $EXHR_i^{hk}$ is exports to the rest of the world in sector *i* of country *h* in constant prices and currency *h* (exogenous) and QHR_i^h is statistical discrepancies in sector *i* of country *h* in constant prices and currency *h* (exogenous).

3.1.2. Firm Behavior

In this paper, we consider a case of monopoly. The producer in sector *j* of country *k* is assumed to have the following modified version of a generalized Ozaki cost function:[1]

$$UC_j^k = \sum_{i=1}^{n} a_{ij}^k XXR_j^k PXK_{ij}^k + a_{Lj}^k \left(XXR_j^k\right)^{\beta_{Lj}^k} w_j^k \exp\left(b_{Lj}^k T\right) + a_{Kj}^k \left(XXR_j^k\right)^{\beta_{Kj}^k} PK_j^k \exp\left(b_{Kj}^k T\right) \tag{5}$$

where UC_j^k is unit cost in sector *j* of country *k* denominate in the currency *k*, XXR_j^k is total output in sector *j* of country *k* in constant prices and currency *k*, PXK_{ij}^k is price for intermediate goods in sector *j* of country *k* delivered from sector *i* in constant prices and currency *k* $\left(XKR_{ij}^k = \sum_{h=1}^{r} XKR_{ij}^{hk}\right)$, w_j^k is the wage rate in sector *j* of country *k* evaluated in current prices and denominated in currency *k*, PK_j^k is price of capital in sector *j* of country *k* denominated in currency *k* and T is time trend.

Applying the Shephard's lemma yields the following demand for input factors:

$$XKR_{ij}^k = a_{ij}^k XXR_j^k \tag{6}$$

[1] As for a generalized Ozaki cost function, see Nakamura (1990).

$$L_j^k = a_{Lj}^k \left(XXR_j^k\right)^{\beta_{Lj}^k} \exp\left(b_{Lj}^k T\right) \tag{7}$$

$$KR_j^k = a_{Kj}^k \left(XXR_j^k\right)^{\beta_{Kj}^k} \exp\left(b_{Kj}^k T\right) \tag{8}$$

where L_j^k is employment in sector *j* of country *k* and KR_j^k is capital stock in sector *j* of country *k* denominated in currency *k*.

The allocation of intermediate input by sector into source countries is determined by the Armington's (1969) approach as:

$$XKR_{ij}^{hk} = \left(\frac{bx_{ij}^{hk} PXK_{ij}^k}{P_i^{hk}}\right)^{\gamma_j^k} XKR_{ij}^k \tag{9}$$

where $P_i^{hk} = P_i^h \left\{\left(\frac{e^k}{e^h}\right) \middle/ \left(\frac{e^{k^*}}{e^{h^*}}\right)\right\}$ and P_i^h is price in sector *i* of country *h* denominated in currency *h*. Price for the Armington aggregate, PXK_{ij}^k, is expressed as:

$$PXK_{ij}^k = \left[\sum_{h=1}^{r} \left(bx_{ij}^{hk}\right)^{\gamma_j^k} \left(P_i^{hk}\right)^{1-\gamma_j^k}\right]^{\frac{1}{1-\gamma_j^k}} \tag{10}$$

Intermediate goods delivered from sector *i* of country *h* to sector *j* of country *k* in constant prices and currency *h*, XHR_{ij}^{hk}, is written as:

$$XHR_{ij}^{hk} = XKR_{ij}^{hk} \left(\frac{e^{h^*}}{e^{k^*}}\right) \tag{11}$$

3.1.3. Sectoral Price

Taking partial derivative of the cost function gives the following marginal cost:

$$MC_j^k = \sum_{i=1}^{n} a_{ij}^k PXK_{ij}^k + a_{Lj}^k \beta_{Lj}^k \left(XXR_j^k\right)^{\beta_{Lj}^k - 1} w_j^k \exp\left(b_{Lj}^k T\right) + a_{Kj}^k \beta_{Kj}^k \left(XXR_j^k\right)^{\beta_{Kj}^k - 1} PK_j^k \exp\left(b_{Kj}^k T\right) \tag{12}$$

where MC_j^k is marginal cost in sector *j* of country *k* denominate in the currency *k*. Thus, the expression for sectoral price is written as:

$$P_j^k = \frac{\epsilon_j^k}{\epsilon_j^k - 1} MC_j^k \tag{13}$$

3.1.4. The Wage Rate

Slightly modifying the Philipps curve, we explain the sectoral wage rate by price deflator for private consumption and labor productivity as:

$$w_j^k = w_j^k \left(PCP^k, \frac{XXR_j^k}{L_j^k} \right) \tag{14}$$

where PCP^k is price deflator for private consumption in country *k* denominated in currency *k*.

3.1.5. Household Behavior

3.1.5.1. Private Consumption by Sector

Household of country *k* solves the following utility maximization problem:

$$\max \prod_{i=1}^{n} \left(CPKR_i^k \right)^{d_i^k} \tag{15}$$

subject to

$$YK^k = \sum_{i}^{n} PCPK_i^k CPKR_i^k \tag{16}$$

where $CPKR_i^k$ is private consumption for goods *i* in country *k* in constant prices and currency *k*, YK^k is household income of country *k* in current prices and currency *k*, and $PCPK_i^k$ price for private consumption for goods *i* in country *k* denominated in currency *k*. As a result of this utility maximization problem, we obtain the following equation:

$$CPKR_i^k = \frac{d_i^k}{PCPK_i^k} YK^k \tag{17}$$

3.1.5.2. Private Consumption by Sector and Country

Similar to the allocation of intermediate goods into source countries, we apply the Armington's (1969) approach to allocation sectoral private consumption as:

$$CPKR_i^{hk} = CPKR_i^k \left[\frac{bc_i^{hk} PCPK_i^k}{P_i^{hk}} \right]^{\nu_i^k} \tag{18}$$

where bc_i^{hk} is distribution parameter, $CPKR_i^{hk}$ is private consumption of country *k* delivered from sector *i* of country *h* in constant prices and currency *k* and ν_i^k is elasticity of substitution in sector *j* of country *k*. Price for the Armington aggregate for private consumption is written as:

$$PCPK_i^k = \left[\sum_{h=1}^{r} \left(bc_i^{hk}\right)^{\nu_i^k} \left(P_i^{hk}\right)^{1-\nu_i^k}\right]^{\frac{1}{1-\nu_i^k}} \tag{19}$$

3.1.5.3. Price for Private Consumption at the Macro Level

As one of the results of utility maximization, price for private consumption of country *k* denominated in currency *k* is formulated as:

$$PCPK^k = \prod_{i=1}^{n} \left(\frac{PCPK_i^k}{d_i^k}\right)^{d_i^k} \tag{20}$$

3.1.5.4. Household Income

Since the main source of household income is wages. Thus, household income is written as:

$$YK^k = YK^k \left(\sum_{j=1}^{n} w_j^k L_j^k\right) \tag{21}$$

3.1.6. Fixed Investment

Given capital stock explained by firm behavior, fixed investment is determined as follows:

$$IKR^k = IKR^k \left(\sum_{j=1}^{n} KR_j^k\right) \tag{22}$$

where IKR^k is fixed investment in country *k* in constant prices and currency *k* and DKR^k is depreciation in country *k* in constant prices and currency *k* (exogenous).

Fixed investment at the macro level is allocated into by using fixed coefficients as follows: based on Leontief. In detail, investment of sector *i* in country *k*, can be written as:

$$IKR_i^k = a_{IR_i^k} IKR^k \tag{23}$$

where IKR_i^k is fixed investment of sector *i* in country *k* in constant prices and currency *k* and $a_{IR_i^k}$ is the ratio of IKR_i^k to IKR^k.

Allocation to source countries is determined by the Armington approach as:

$$IKR_i^{hk} = IKR_i^k \left[\frac{bv_i^{hk} PIK_i^k}{P_i^{hk}}\right]^{\mu_i^k} \tag{24}$$

where IKR_i^{hk} is fixed investment of country *k* delivered from sector *i* of country *h* in constant prices and currency *k* and bv_i^{hk} is distribution parameter. Price for the Armington aggregate regarding fixed investment is expressed as:

$$PIK_i^k = \left[\sum_{h=1}^{r} \left(bv_i^{hk}\right)^{\mu_i^k} \left(P_i^{hk}\right)^{1-\mu_i^k}\right]^{\frac{1}{1-\mu_i^k}} \tag{25}$$

3.2. Estimation Results of Selected Variables

For parameter estimation, panel data method is employed. Since the unobservable individual effects are assumed to present country-specific or sector-specific factors, the fixed-effect model is applied. Data for the year 1995 is omitted since the euro is launched in 1999.

3.2.1. Employment by Sector

For estimation, we assume that parameters β_{Lj}^k and b_{Lj}^k are common among countries. Thus, by taking logarithms of equation (7), the estimation equation of employment by sector is expressed as:

$$\ln L_j^k = a_{Lj}^k + \beta_{Lj} \ln XXR_j^k + b_{Lj} T \tag{26}$$

Table 4 demonstrates the estimation results for the parameters β_{Lj} and b_{Lj} for all sectors. Although β_{L2} and β_{L7} are not statistically significant, the parameter β_{Lj} is all positive and less than the unity. This implies that economies of scale are found for labor demand in exception to the mining and utilities as well as other services sectors.

3.2.2. Sectoral Price

Table 5 illustrates estimation results of equation (13) for the agriculture, manufacturing and other services sectors. All estimated coefficients are greater than one and statistically significant. This indicates that substantial markups exist. Particularly, the markups in the other services sector are slightly greater than those in the agriculture and manufacturing sectors. We also note that coefficients exceed the unity and statistically significant for the rest of industrial sectors.

3.2.3. Private Consumption by Sector and Country

Taking logarithms of equation (18) gives the estimated equation of private consumption by sector and country as:

$$\ln \frac{CPKR_i^{hk}}{CPKR_i^k} = \nu_i^k \ln bc_i^{hk} + \nu_i^k \ln \frac{PCPK_i^k}{P_i^{hk}} \tag{27}$$

Estimation results of equation (27) for the manufacturing sector are presented in Table 6. The elasticity of substitution ranges from 0.66 to 1.16. Particularly, Belgium, Finland, Germany, Ireland, Sweden, Brazil, Russia and Chinese Taipei are elastic (greater than the unity) whereas Japan, South Korea, Mexico, Turkey, Indonesia, India, Thailand are inelastic (less than 0.9).

3.3. Results for the Final Test

In order to test model performance for the years 2000, 2005, 2008, 2009, 2010 and 2011, we compute the root mean square percentage errors (RMSPEs) of the weighted average of sectoral price and aggregate output. As Table 7 shows RMSPEs of the average price are greater than 10 percent for Australia, Ireland, Japan, Mexico, Turkey, the United Kingdom, Indonesia and India while we also found critical errors regarding aggregate output for Australia, Belgium, Ireland, Mexico, Spain, Turkey, the United Kingdom, the United States and China. These errors might result from estimation with the data set of mixture of developed and developing countries. Under the circumstance of data availability for econometric estimation, we can conclude that the model shows certain performance.

It is also worth noting that statistically insignificant parameters are employed for the construction of the global multi-sectoral model as long as the signs are correct. As for the Armington approach, the base-year fixed proportion is applied for the case of wrong sign. Approximately 34 percent, 32 percent and 61 percent of intermediates, private consumption, investment are explained by the fixed proportions, respectively.

4. Application Example

As an example of model applications, we examine the effects of 10 percent depreciation of the Japanese yen in 2005.

4.1. Macroeconomic Effects

Table 8 presents the effects on the average price and aggregate output. We found the negative impacts on the following countries: Australia, Canada, Greece, South Korea, Mexico, the United States, Indonesia, India, Thailand and Chinese Taipei. Among these countries, the negative effects on Indonesia, India and Chinese Taipei are slightly large. With respect to output, we also found that the effects on Australia and the United States are relatively large. By contrast, Turkey, Brazil and China have large positive impacts.

In absolute value, the maximum effect is 0.21 percent. Compare to the change in the Japanese yen (10 percent), the effects on price and output are small.

4.2. Sectoral Effects

Table 9 demonstrates the effects on sectoral price and output. Regarding Japan, price in the construction sector declines whereas those in the other sectors rise. Particularly, we found large positive effects in the agricultural sector, the trade sector and the transportation sectors. In contrast, output increases for all sectors in Japan.

For the others, countries with negative macro impacts have price and output decrease for all sectors. As for sectoral price, we found the maximum positive impacts in all sectors of China whereas the maximum negative impacts are found in Indonesia (agriculture, mining and utilities, construction), India (manufacturing) and Chinese Taipei (trade, transportation and other services). Regarding output, Japan (manufacturing), Turkey (Mining and utilities, trade and transportation), China (agriculture and other services) and Russia (construction) have the greatest positive impacts within sectors while India (manufacturing and trade) and Chinese Taipei (agriculture, mining and utilities, construction, transportation and other services) face the largest negative impacts within sectors.

Among sectors, we found relatively large impacts on both price and output in the agricultural sector. By contrast, the impacts on output in the construction sector is quite limited. In total, the effects on output are far greater than those on price.

4.3. Discussion

By the depreciation of the yen, price of the Japanese goods denominated in U.S. dollars falls while Japan faces price rise in imported goods denominated in the Japanese yen. The former increases exports of the while the latter decreases imports. With these effects, Japan’s price and output increase. Particularly, domestic price change of Japan is only 0.03 percent while the exchange rate changes 10 percent. Thus, Japan’s relative price is greatly improved. This results in an output increase.

For the other countries than Japan, Japan’s price decrease in U.S. dollars can yield two outcomes. First, price in both U.S. dollars and local currencies falls. This could result in increases of demand and price. Second, Japan’s relative price improves. This could be a cause of decreases in export demand and price. Although further analysis is required, it might be tentatively concluded that the impacts through the first route are greater than those through the second one in countries with positive effects (the reverse occurs to countries with negative effects).

5. Conclusions

In this paper, we constructed international input-output tables evaluated in constant prices and denominated in local currencies. We also developed the theoretical structure of a local-currency-based multi-country multi-sectoral model with economies of scale and monopoly. Similar to widely used CGE models, the model has micro foundations; however, most parameters of the model are econometrically estimated.

One of the objectives of developing the model is application to policy analysis on global economic problems. The model can analyze typical international economic issues such as trade policy and regional trade agreements. However, the model also has potential to analyze both international trade and money in one framework since the model is described in local currencies. For this purpose, construction of a model on international finance is necessary. Also, an improvement of model performance is required. These are our future research topics.

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Figure 1: A Structure of International Input-Output Tables

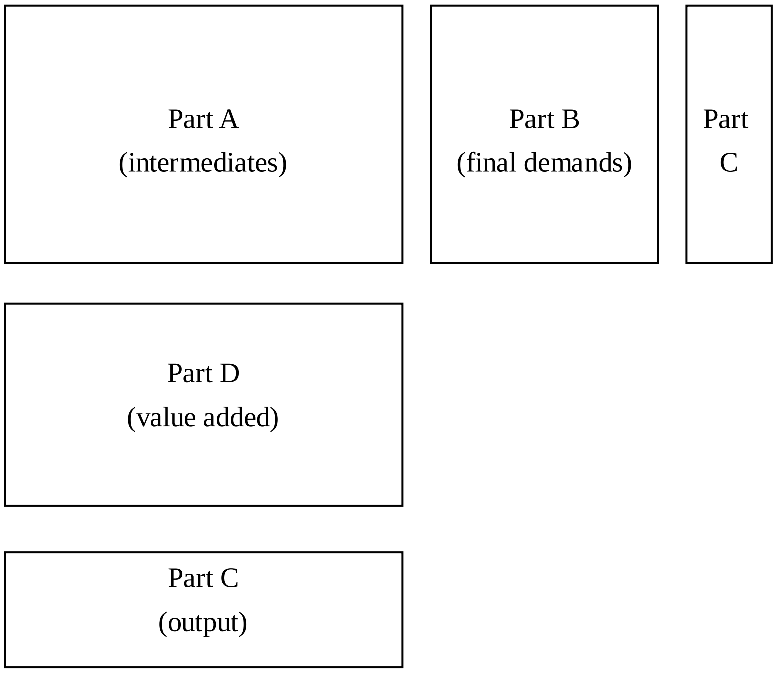

Table 1: Sector Classification

	New Sector Classification (7 sectors)	OECD ICIO Classification (34 sectors)
1	Agriculture, forestry and fishing	(01) Agriculture, forestry and fishing
2	Mining and utilities	(02) Mining and quarrying, (19) Electricity, gas and water supply
3	Manufacturing	(03) Food products, beverages and tobacco, (04) Textiles, textile products, leather and footwear, (05) Wood and products of wood and cork, (06) Pulp, paper, paper products, printing and publishing, (07) Coke, refined petroleum products and nuclear fuel, (08) Chemicals and chemical products, (09) Rubber and plastics products, (10) Other non-metallic mineral products, (11) Basic metals, (12) Fabricated metal products, (13) Machinery and equipment, nec , (14) Computer, Electronic and optical equipment, (15) Electrical machinery and apparatus, nec, (16) Motor vehicles, trailers and semi-trailers, (17) Other transport equipment, (18) Manufacturing nec; recycling
4	Construction	(20) Construction
5	Trade, accommodation and food service activities	(21) Wholesale and retail trade; repairs, (22) Hotels and restaurants
6	Transportation, storage and communication	(23) Transport and storage, (24) Post and telecommunications
7	Other services	(25) Financial intermediation, (26) Real estate activities (27) Renting of machinery and equipment, (28) Computer and related activities, (29) R&D and other business activities, (30) Public admin. and defense; compulsory social security, (31) Education, (32) Health and social work, (33) Other community, social and personal services, (34) Private households with employed persons

Table 2: Regional Classification

No	Code	Country	No	Code	Country
1	AUS	Australia	16	NOR	Norway
2	AUT	Austria	17	PRT	Portugal
3	BEL	Belgium	18	ESP	Spain
4	CAN	Canada	19	SWE	Sweden
5	DNK	Denmark	20	TUR	Turkey
6	FIN	Finland	21	GBR	United Kingdom
7	FRA	France	22	USA	United States
8	DEU	Germany	23	BRA	Brazil
9	GRC	Greece	24	CHN	China
10	IRL	Ireland	25	IDN	Indonesia
11	ITA	Italy	26	IND	India
12	JPN	Japan	27	RUS	Russian Federation
13	KOR	Republic of Korea	28	THA	Thailand
14	MEX	Mexico	29	TWN	Chinese Taipei
15	NLD	Netherlands			
30	ROW	Estonia, Luxembourg, Slovakia, Slovenia, Cyprus, Lithuania, Latvia, Malta, Czech Republic, Hungary, Poland, Chile, Iceland, Israel, New Zealand, Brunei Darussalam, Cambodia, Bulgaria, Croatia, Colombia, Costa Rica, Hong Kong, Romania, Tunisia, Argentina, Malaysia, Philippines, Saudi Arabia, Singapore, Switzerland, Viet Nam, South Africa, Rest of the world			

Table 3: Selected Countries' Computed Sectoral Prices

Australia

	Sector 1	Sector 2	Sector 3	Sector 4	Sector 5	Sector 6	Sector 7
1995	0.137	0.114	0.073	0.062	0.092	0.097	0.154
2000	0.916	0.685	0.816	0.811	0.839	0.864	0.823
2005	1.000	1.000	1.000	1.000	1.000	1.000	1.000
2008	1.049	1.291	1.108	1.140	1.128	1.112	1.161
2009	1.047	1.141	1.090	1.171	1.145	1.134	1.199
2010	1.107	1.348	1.107	1.205	1.189	1.153	1.239
2011	1.131	1.329	1.107	1.208	1.202	1.177	1.275

France

	Sector 1	Sector 2	Sector 3	Sector 4	Sector 5	Sector 6	Sector 7
1995	0.176	0.206	0.102	0.131	0.235	0.240	0.309
2000	0.873	0.842	0.814	0.787	0.844	0.865	0.849
2005	1.000	1.000	1.000	1.000	1.000	1.000	1.000
2008	1.015	1.049	1.049	1.149	1.054	1.028	1.087
2009	0.905	1.084	1.031	1.156	1.070	1.041	1.086
2010	1.041	1.130	1.054	1.183	1.076	1.034	1.106
2011	1.060	1.201	1.069	1.219	1.076	1.018	1.116

Germany

	Sector 1	Sector 2	Sector 3	Sector 4	Sector 5	Sector 6	Sector 7
1995	0.070	0.110	0.046	0.060	0.126	0.095	0.195
2000	0.845	0.790	0.732	0.814	0.815	0.691	0.854
2005	1.000	1.000	1.000	1.000	1.000	1.000	1.000
2008	0.978	1.188	1.023	1.082	1.009	0.967	1.024
2009	0.894	1.103	1.037	1.100	1.042	0.968	1.042
2010	1.047	1.149	1.059	1.127	1.056	0.983	1.061
2011	1.189	1.213	1.074	1.151	1.067	0.984	1.075

Japan

	Sector 1	Sector 2	Sector 3	Sector 4	Sector 5	Sector 6	Sector 7
1995	0.289	0.409	0.194	0.230	0.372	0.394	0.417
2000	1.023	1.130	1.057	1.020	1.027	1.048	1.017
2005	1.000	1.000	1.000	1.000	1.000	1.000	1.000
2008	0.908	0.924	0.967	1.020	1.026	0.971	0.982
2009	0.920	1.054	0.948	0.997	1.000	0.974	0.974
2010	0.937	0.996	0.923	0.985	0.989	0.957	0.963
2011	0.902	0.955	0.901	0.978	0.986	0.942	0.953

Mexico

	Sector 1	Sector 2	Sector 3	Sector 4	Sector 5	Sector 6	Sector 7
1995	0.151	0.138	0.059	0.074	0.169	0.152	0.202
2000	0.773	0.612	0.703	0.689	0.730	0.794	0.693
2005	1.000	1.000	1.000	1.000	1.000	1.000	1.000
2008	1.211	1.339	1.218	1.197	1.175	1.137	1.150
2009	1.259	1.248	1.293	1.245	1.241	1.185	1.195
2010	1.320	1.360	1.336	1.289	1.271	1.239	1.223
2011	1.451	1.583	1.413	1.367	1.331	1.259	1.267

Turkey

	Sector 1	Sector 2	Sector 3	Sector 4	Sector 5	Sector 6	Sector 7
1995	0.003	0.003	0.002	0.001	0.004	0.002	0.003
2000	0.204	0.244	0.223	0.224	0.267	0.250	0.295
2005	1.000	1.000	1.000	1.000	1.000	1.000	1.000
2008	1.231	1.412	1.276	1.320	1.318	1.306	1.355
2009	1.294	1.556	1.324	1.340	1.354	1.345	1.446
2010	1.449	1.607	1.377	1.399	1.399	1.387	1.495
2011	1.557	1.754	1.563	1.591	1.576	1.529	1.566

United States

	Sector 1	Sector 2	Sector 3	Sector 4	Sector 5	Sector 6	Sector 7
1995	0.133	0.186	0.090	0.088	0.210	0.202	0.226
2000	0.761	0.622	0.785	0.705	0.824	0.770	0.797
2005	1.000	1.000	1.000	1.000	1.000	1.000	1.000
2008	1.177	1.236	1.091	1.138	1.093	1.051	1.094
2009	1.040	1.080	1.069	1.132	1.122	1.054	1.099
2010	1.129	1.164	1.104	1.145	1.140	1.065	1.120
2011	1.299	1.242	1.161	1.181	1.165	1.083	1.143

Brazil

	Sector 1	Sector 2	Sector 3	Sector 4	Sector 5	Sector 6	Sector 7
1995	0.065	0.046	0.027	0.035	0.131	0.043	0.093
2000	0.633	0.559	0.584	0.612	0.600	0.619	0.659
2005	1.000	1.000	1.000	1.000	1.000	1.000	1.000
2008	1.193	1.205	1.168	1.170	1.296	1.236	1.213
2009	1.302	1.124	1.260	1.359	1.456	1.330	1.304
2010	1.312	1.328	1.300	1.496	1.531	1.407	1.399
2011	1.438	1.524	1.378	1.576	1.720	1.631	1.462

China

	Sector 1	Sector 2	Sector 3	Sector 4	Sector 5	Sector 6	Sector 7
1995	0.262	0.153	0.100	0.140	0.231	0.227	0.234
2000	0.813	0.927	0.819	0.839	0.857	0.871	0.785
2005	1.000	1.000	1.000	1.000	1.000	1.000	1.000
2008	1.248	1.246	1.129	1.153	1.142	1.149	1.153
2009	1.237	1.185	1.094	1.132	1.127	1.119	1.164
2010	1.347	1.308	1.166	1.206	1.204	1.175	1.245
2011	1.483	1.417	1.235	1.292	1.294	1.249	1.343

India

	Sector 1	Sector 2	Sector 3	Sector 4	Sector 5	Sector 6	Sector 7
1995	0.273	0.148	0.088	0.111	0.287	0.148	0.256
2000	0.799	0.733	0.774	0.732	0.774	0.864	0.781
2005	1.000	1.000	1.000	1.000	1.000	1.000	1.000
2008	1.319	1.207	1.211	1.247	1.221	1.132	1.218
2009	1.484	1.322	1.266	1.304	1.282	1.151	1.302
2010	1.651	1.454	1.356	1.399	1.408	1.183	1.424
2011	1.788	1.571	1.473	1.522	1.597	1.267	1.531

Table 4: Estimation Results of Employment by Sector

Parameter	Estimate	S. E.	p-value	Adj. R^2
β_{L1}	0.020	0.008	0.013	1.000
b_{L1}	-0.022	0.001	0.000	
β_{L2}	0.024	0.023	0.298	0.995
b_{L2}	0.037	0.002	0.000	
β_{L3}	0.092	0.019	0.000	0.999
b_{L3}	-0.013	0.001	0.000	
β_{L4}	0.157	0.026	0.000	0.998
b_{L4}	0.015	0.002	0.000	
β_{L5}	0.023	0.012	0.055	0.999
b_{L5}	0.011	0.001	0.000	
β_{L6}	0.023	0.010	0.023	0.999
b_{L6}	0.027	0.001	0.000	
β_{L7}	0.011	0.010	0.271	0.999
b_{L7}	0.022	0.001	0.000	

Note: S. E. is standard error. Adj R^2 is adjusted R-squared.

Table 5: Estimation Results of Sectoral Price

Agricultural sector

Country	Estimate	S. E.	p-value
Australia	1.094	0.014	0.000
Austria	1.045	0.011	0.000
Belgium	1.005	0.012	0.000
Canada	1.177	0.019	0.000
Denmark	1.151	0.017	0.000
Finland	1.110	0.011	0.000
France	1.114	0.005	0.000
Germany	1.161	0.030	0.000
Greece	1.115	0.024	0.000
Ireland	1.073	0.028	0.000
Italy	1.098	0.012	0.000
Japan	1.163	0.021	0.000
South Korea	1.044	0.007	0.000
Mexico	1.065	0.004	0.000
Netherlands	1.087	0.011	0.000
Norway	1.092	0.014	0.000
Portugal	1.109	0.009	0.000
Spain	1.069	0.007	0.000
Sweden	1.188	0.013	0.000
Turkey	2.125	0.024	0.000
United Kingdom	1.196	0.017	0.000
United States	1.094	0.012	0.000
Brazil	1.211	0.013	0.000
China	2.129	0.074	0.000
Indonesia	1.560	0.029	0.000
India	1.067	0.002	0.000
Russia	1.539	0.025	0.000
Thailand	1.069	0.016	0.000
Chinese Taipei	1.703	0.016	0.000
Adj R^2	0.994		

Note: S. E. is standard error. Adj R^2 is adjusted R-squared.

Manufacturing sector

Country	Estimate	S. E.	p-value
Australia	1.253	0.006	0.000
Austria	1.279	0.016	0.000
Belgium	1.150	0.013	0.000
Canada	1.237	0.004	0.000
Denmark	1.241	0.010	0.000
Finland	1.151	0.015	0.000
France	1.214	0.010	0.000
Germany	1.285	0.021	0.000
Greece	1.506	0.037	0.000
Ireland	1.093	0.013	0.000
Italy	1.189	0.011	0.000
Japan	1.228	0.009	0.000
South Korea	1.171	0.005	0.000
Mexico	1.070	0.007	0.000
Netherlands	1.170	0.013	0.000
Norway	1.210	0.013	0.000
Portugal	1.233	0.014	0.000
Spain	1.223	0.011	0.000
Sweden	1.142	0.017	0.000
Turkey	1.134	0.006	0.000
United Kingdom	1.243	0.019	0.000
United States	1.189	0.021	0.000
Brazil	1.206	0.010	0.000
China	1.088	0.002	0.000
Indonesia	1.175	0.006	0.000
India	1.170	0.005	0.000
Russia	1.193	0.006	0.000
Thailand	1.177	0.004	0.000
Chinese Taipei	1.227	0.012	0.000
Adj R^2	0.994		

Note: S. E. is standard error. Adj R^2 is adjusted R-squared.

Other services sector

Country	Estimate	S. E.	p-value
Australia	1.498	0.006	0.000
Austria	1.545	0.012	0.000
Belgium	1.511	0.013	0.000
Canada	1.591	0.008	0.000
Denmark	1.709	0.009	0.000
Finland	1.588	0.014	0.000
France	1.565	0.005	0.000
Germany	1.502	0.014	0.000
Greece	1.518	0.024	0.000
Ireland	1.397	0.021	0.000
Italy	1.393	0.008	0.000
Japan	1.489	0.006	0.000
South Korea	1.510	0.011	0.000
Mexico	1.448	0.006	0.000
Netherlands	1.565	0.009	0.000
Norway	1.634	0.019	0.000
Portugal	1.580	0.016	0.000
Spain	1.608	0.017	0.000
Sweden	1.494	0.009	0.000
Turkey	1.268	0.011	0.000
United Kingdom	1.486	0.022	0.000
United States	1.526	0.007	0.000
Brazil	1.644	0.027	0.000
China	1.272	0.009	0.000
Indonesia	1.587	0.020	0.000
India	1.490	0.022	0.000
Russia	1.678	0.014	0.000
Thailand	1.500	0.020	0.000
Chinese Taipei	1.637	0.012	0.000
Adj R^2	0.989		

Note: S. E. is standard error. Adj R^2 is adjusted R-squared.

Table 6: Estimation Results of Private Consumption by Sector and Country (Manufacturing)

Country	Estimate	S. E.	p-value	Adj R^2
Australia	0.989	0.035	0.000	0.998
Austria	0.984	0.030	0.000	0.997
Belgium	1.119	0.042	0.000	0.998
Canada	0.932	0.029	0.000	0.998
Denmark	0.931	0.065	0.000	0.994
Finland	1.018	0.028	0.000	0.996
France	0.979	0.027	0.000	0.998
Germany	1.000	0.019	0.000	0.999
Greece	0.991	0.007	0.000	0.998
Ireland	1.079	0.032	0.000	0.997
Italy	0.945	0.012	0.000	0.999
Japan	0.819	0.040	0.000	0.999
South Korea	0.742	0.055	0.000	0.999
Mexico	0.668	0.087	0.000	0.998
Netherlands	0.996	0.072	0.000	0.997
Norway	0.996	0.045	0.000	0.999
Portugal	0.971	0.025	0.000	0.998
Spain	0.983	0.039	0.000	0.999
Sweden	1.055	0.031	0.000	0.996
Turkey	0.872	0.052	0.000	0.997
United Kingdom	0.983	0.027	0.000	0.994
United States	0.914	0.038	0.000	0.999
Brazil	1.084	0.056	0.000	0.999
China	0.951	0.050	0.000	0.999
Indonesia	0.866	0.076	0.000	0.997
India	0.726	0.103	0.000	0.998
Russia	1.155	0.049	0.000	0.997
Thailand	0.893	0.063	0.000	0.999
Chinese Taipei	1.014	0.037	0.000	0.999

Note: S. E. is standard error. Adj R^2 is adjusted R-squared.

Table 7: Final Test Results (Root Mean Square Percentage Errors)

Country	Average price	Aggregate output
Australia	15.118	14.319
Austria	7.489	4.277
Belgium	6.153	11.834
Canada	8.643	5.370
Denmark	8.722	8.771
Finland	6.251	6.088
France	4.866	4.936
Germany	5.343	7.782
Greece	4.437	2.062
Ireland	14.692	12.226
Italy	4.974	9.041
Japan	13.878	6.944
South Korea	6.667	7.065
Mexico	10.924	20.160
Netherlands	6.731	7.527
Norway	3.334	4.934
Portugal	6.594	9.851
Spain	9.540	14.767
Sweden	7.292	8.309
Turkey	19.738	26.253
United Kingdom	10.715	24.564
United States	2.749	11.481
Brazil	7.349	6.574
China	4.859	18.966
Indonesia	19.194	7.317
India	11.477	1.818
Russia	8.150	5.885
Thailand	3.376	4.430
Chinese Taipei	5.005	7.019

Table 8: Percent Deviations of Average Price and Aggregate Output from the Baseline

Country	Average price	Aggregate output
Australia	-0.081	-1.223
Austria	0.049	0.428
Belgium	0.047	0.485
Canada	-0.054	-0.897
Denmark	0.037	0.270
Finland	0.034	0.254
France	0.028	0.282
Germany	0.032	0.312
Greece	-0.055	-0.814
Ireland	0.038	0.172
Italy	0.044	0.444
Japan	0.028	1.080
South Korea	-0.042	-0.693
Mexico	-0.064	-1.025
Netherlands	0.036	0.310
Norway	0.018	0.108
Portugal	0.070	0.887
Spain	0.080	0.721
Sweden	0.040	0.317
Turkey	0.129	1.853
United Kingdom	0.050	0.563
United States	-0.080	-1.471
Brazil	0.111	0.909
China	0.176	1.474
Indonesia	-0.161	-1.131
India	-0.210	-1.653
Russia	0.101	1.134
Thailand	-0.055	-0.707
Chinese Taipei	-0.200	-1.891

Table 9: Percent Deviations of Sectoral Price and Output from the Baseline

Sectoral price

Country	Sector 1	Sector 2	Sector 3	Sector 4	Sector 5	Sector 6	Sector 7
Australia	-0.101	-0.055	-0.085	-0.099	-0.112	-0.086	-0.065
Austria	0.051	0.038	0.051	0.077	0.060	0.049	0.037
Belgium	0.052	0.041	0.049	0.069	0.058	0.044	0.037
Canada	-0.082	-0.029	-0.056	-0.070	-0.079	-0.067	-0.043
Denmark	0.037	0.014	0.043	0.069	0.045	0.026	0.032
Finland	0.032	0.034	0.038	0.047	0.039	0.034	0.025
France	0.036	0.027	0.034	0.043	0.037	0.028	0.020
Germany	0.034	0.028	0.038	0.054	0.042	0.029	0.022
Greece	-0.087	-0.034	-0.031	-0.050	-0.120	-0.028	-0.032
Ireland	0.035	0.034	0.027	0.106	0.042	0.034	0.025
Italy	0.053	0.040	0.050	0.062	0.053	0.043	0.029
Japan	0.067	0.007	0.034	-0.024	0.072	0.055	0.007
South Korea	-0.066	-0.034	-0.033	-0.067	-0.074	-0.053	-0.037
Mexico	-0.099	-0.029	-0.061	-0.051	-0.118	-0.083	-0.039
Netherlands	0.037	0.020	0.040	0.064	0.044	0.032	0.030
Norway	0.020	0.008	0.023	0.033	0.025	0.019	0.017
Portugal	0.091	0.042	0.071	0.090	0.101	0.073	0.050
Spain	0.082	0.053	0.078	0.119	0.104	0.070	0.055
Sweden	0.040	0.027	0.042	0.073	0.051	0.037	0.034
Turkey	0.155	0.082	0.128	0.105	0.190	0.156	0.081
United Kingdom	0.060	0.029	0.060	0.080	0.072	0.050	0.037
United States	-0.114	-0.050	-0.077	-0.092	-0.140	-0.100	-0.063
Brazil	0.108	0.089	0.133	0.176	0.108	0.148	0.078
China	0.327	0.140	0.159	0.190	0.190	0.192	0.153
Indonesia	-0.005	-0.051	-0.250	-0.238	-0.153	-0.099	-0.097
India	-0.214	-0.115	-0.227	-0.338	-0.245	-0.201	-0.093
Russia	0.196	0.128	0.062	0.050	0.149	0.134	0.081
Thailand	-0.050	-0.002	-0.069	-0.050	-0.077	-0.051	-0.018
Chinese Taipei	-0.102	-0.112	-0.235	-0.159	-0.277	-0.215	-0.113

Sectoral output

Country	Sector 1	Sector 2	Sector 3	Sector 4	Sector 5	Sector 6	Sector 7
Australia	-1.305	-1.912	-1.256	-0.318	-1.547	-1.285	-1.199
Austria	0.576	0.601	0.308	0.179	0.547	0.606	0.453
Belgium	0.721	0.708	0.492	0.150	0.619	0.458	0.482
Canada	-1.230	-1.188	-1.108	-0.121	-1.092	-0.978	-0.745
Denmark	0.459	0.457	0.242	0.076	0.391	0.033	0.326
Finland	0.331	0.316	0.192	0.062	0.368	0.389	0.281
France	0.448	0.462	0.278	0.062	0.383	0.338	0.257
Germany	0.402	0.452	0.249	0.102	0.431	0.367	0.339
Greece	-1.042	-1.114	-0.798	-0.130	-1.204	-0.325	-0.832
Ireland	0.455	0.466	0.013	0.029	0.362	0.589	0.206
Italy	0.617	0.617	0.395	0.133	0.571	0.530	0.434
Japan	1.211	0.850	2.021	0.131	1.229	1.303	0.271
South Korea	-0.936	-0.905	-0.672	-0.055	-0.865	-0.962	-0.745
Mexico	-1.233	-1.045	-1.176	-0.018	-1.174	-1.296	-0.947
Netherlands	0.444	0.451	0.384	0.080	0.414	0.274	0.249
Norway	0.134	0.210	0.069	0.036	0.160	0.064	0.094
Portugal	1.252	1.233	0.887	0.181	1.240	1.001	0.798
Spain	0.997	0.997	0.749	0.215	1.086	0.773	0.648
Sweden	0.466	0.578	0.226	0.136	0.406	0.390	0.348
Turkey	2.499	2.023	1.819	0.154	2.004	2.244	1.707
United Kingdom	0.891	0.711	0.505	0.237	0.918	0.734	0.471
United States	-1.641	-1.677	-1.456	-0.294	-1.767	-1.671	-1.467
Brazil	1.102	0.913	0.927	0.207	1.188	1.124	0.850
China	3.103	1.482	1.136	0.118	1.519	2.036	2.459
Indonesia	-1.383	-1.964	-1.101	-0.116	-1.354	-1.397	-0.977
India	-2.693	-1.591	-1.536	-0.318	-2.154	-2.072	-1.535
Russia	2.497	0.587	1.066	0.323	1.437	1.374	1.155
Thailand	-0.727	-0.639	-0.820	-0.199	-0.796	-0.804	-0.408
Chinese Taipei	-3.751	-2.396	-1.308	-0.410	-2.110	-2.724	-2.828