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Intermediate Imported Inputs Matter

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Abstract: In a “simple” model, where all imports are treated as final goods, trade taxes shift the consumption away from imported goods. It is intuitive that in a more “advanced” model, where imports can be both, final goods and intermediates, tariffs impose additional distortion on the production. This paper tests this intuition by employing two sets of CGE models for six different countries and demonstrates a reversal in policy recommendations for opening up the economy when imported intermediates are included in the model explicitly. Implications are of special interest for modelers and institutions which provide trade policy recommendations.

Key Words: Intermediate Imported Inputs, Policy Modeling, Trade Liberalization, Tax Reform, Welfare Analysis, Marginal Cost of Funds (MCF), Computable General Equilibrium Model

JEL Classifications: F13, F15, H20, D58

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I. Introduction and Literature Survey

Over half of international trade occurs in intermediate inputs. The significance of imported intermediates in trade policy and welfare analysis is also repeatedly acknowledged in the literature\(^2\). Recently, Deardorff (2005) underlines that imported inputs present an additional source of gain from trade. Falk and Wolfmayr (2005) investigate the employment effect of trade in intermediate imported inputs. Jones (2000) claims that trade liberalization, along with technological advancements, liberalization in regulations and reduction in the costs of services, may fragment the production processes “with a reallocation of the various segments among countries previously unable to compete in producing the integrated commodity”. Employing general equilibrium theory, he analyzes the welfare and income distribution effects of trade liberalization and technological change when not only final goods but also factors of production and intermediate imported inputs can cross borders. Many other papers and surveys focus on the consequences of dividing the production processes across international borders, either through assembly line production, outsourcing and foreign direct investment. Amiti (2000) states that according to new trade theories, trade liberalization of the intermediate inputs market may expand both upstream and downstream industries. Amiti and Konings (2005) investigate the effects of trade liberalization on plant productivity in Indonesia and show that the largest gains arise from reducing tariffs on intermediate imported inputs\(^3\). This paper provides empirical evidence about how policy recommendations for trade liberalization are affected when intermediate imported inputs are not modeled explicitly.


\(^3\) A 10 percentage point fall in output tariffs increases productivity by about 1%, whereas an equivalent fall in input tariffs leads to a 3% productivity gain for all firms and an 11% productivity gain for importing firms.
The inclusion of intermediate imported inputs to the production structure is the key
difference between the two models used and compared. For the six countries investigated,
the share of imported intermediates to total imports is very high (which generally holds for
many developing countries)\textsuperscript{4}. In fact, for all six of the countries\textsuperscript{5}, welfare cost estimates of
trade liberalization that were calculated with a “simple model” treating all imports as final
goods change drastically when instead of the “simple model” the “advanced model” with
intermediate imported inputs is employed (see Section III for the model layout). In the
“simple model”, imports are treated as final consumption goods, and high trade taxes shift
the consumption away from imported goods towards domestically produced goods. In the
“advanced model”, where imports can be both, final goods and intermediates, trade taxes
impose distortion not only on the consumption side but also on the production side. High
trade taxes distort the production by causing a shift away from imported intermediates
toward domestic intermediates. Therefore, it is intuitive that in the “advanced model” trade
taxes generate more distortion and become relatively “more expensive” for most of the
countries in the sample. This intuition is tested by employing two different CGE models for
six different countries. The switch from the “simple” to the “advanced” model changes
policy recommendations dramatically.

This study contributes to the growing field of research on welfare implications of
trade liberalization by emphasizing the explicit usage of intermediate imported inputs. This
makes the policy modeling more realistic, especially for the developing countries. The
results are consistent with the findings of the existing literature, underlining the importance
of intermediate imported inputs.

\textsuperscript{4} It is about 70\% for most of the developing countries.

\textsuperscript{5} China, Korea, Malaysia, Morocco, Uruguay, Viet Nam
The impact of the recommended policy change (compensated trade liberalization) is measured by an increasingly popular and very intuitive welfare measurement tool, the marginal cost of funds (MCF).

The layout of the paper is as follows. Section II lays out the model. Section III examines the empirical work by investigating the data sources and the social accounting matrix (SAM). Section IV reports the empirical results, and section V lays out the conclusion of the paper.

II. Model

The computable general equilibrium (CGE) model used in this paper represents a small open market economy. It assumes perfect competition and constant returns to scale (CRTS) in production. There are three sectors: agriculture, manufacturing and services. Labor and capital are the two primary factors used in the production of each sectoral output. They are not sector specific, and are perfectly mobile across sectors. Other inputs into the production structure are the domestic and imported intermediates, which are also imperfectly substitutable for each other. A multi-level nesting of all the factors of production (see Figure 1) constructs the sectoral output. Each sector then decides how much of the sectoral output will be produced as exports or domestic products for domestic consumption, which are imperfect substitutes in supply (Figure 2). The households and the government consume composite consumption goods, which are combinations of domestic and imported consumption goods. The Armington specification between imports and domestic goods indicates imperfect substitution in demand (Figure 3). The representative

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6 The “advanced model” described in this part is taken from Erbil (2006).
consumer has a Cobb-Douglas utility function in the three aggregates. Expenditure functions arise from these Cobb-Douglas preferences and their CES subutility functions. The household revenue comes from factor payments to capital and labor and transfers from the government. Government consumption equals its revenue from different types of taxation (including trade taxes) plus foreign transfers (remittances) minus transfers to households. In this simple model, the government does not supply a public good. The world price of exports and imports is assumed to be exogenous due to the small country assumption. Trade is taxed via tariffs on imports. The other distortion is the output tax that applies to all domestic production.

Below is the equation by equation mathematical model statement.

A) Production Block, Factor Markets and Intermediate Inputs

The domestic production process combines value added (VA) from labor (L) and capital (K) and composite intermediate input (V) from domestic (X) and imported intermediate inputs (XI) to produce goods and services on a sectoral basis according to the nested constant elasticity of substitution (CES) production structure below:

\[ Y_i = TOP_i \left[ h_iVA_i^{\frac{\sigma_i - 1}{\sigma_i}} + (1 - h_i)V_i^{\frac{\sigma_i - 1}{\sigma_i}} \right]^{\frac{\sigma_i}{\sigma_i - 1}}, \text{SECTORAL OUTPUT} \]  

relates output to value added (VA) and composite intermediates (V).

\[ VA_i = AD_i \left[ \gamma_iL_i^{\frac{\sigma_i - 1}{\sigma_i}} + (1 - \gamma_i)K_i^{\frac{\sigma_i - 1}{\sigma_i}} \right]^{\frac{\sigma_i}{\sigma_i - 1}}, \text{VALUE-ADDED} \]  

---

7 The model presented here is in concordance with most of the standard CGE models in GAMS and it follows the neoclassical-structuralist modeling tradition that is presented in Dervis, de Melo, and Robinson (1981). A more detailed discussion on the choice of the structure of the model and functional forms can be found in, “A Standard CGE Model in GAMS,” by Löfgren, Lee Harris and Robinson (2001) and “CGE Modeling for Regional Analysis,” by Schreiner, Marcouiller, Tembo and Vargas (1999).
relates value-added to labor (L) and capital (K).

\[ V_i = AVD_i[k_iX_i^{\frac{\sigma_i - 1}{\sigma_i}} + (1 - k_i)XI_i^{\frac{\sigma_i - 1}{\sigma_i}}]^{\frac{\sigma_i}{\sigma_i - 1}}, \] COMPOSITE INTERMEDIATE (3)

relates the composite intermediate to imported (XIi) and domestic intermediate inputs (Xi). The subscript “i” stands for the three different sectors of the model, where i=agriculture, industry or services.

- \( Y_i \) denotes the sectoral output,
- \( VA_i \) is the value-added,
- \( V_i \) is the composite intermediate input
- \( L_i \) and \( K_i \) are the two factors of production, labor and capital,
- \( X_i \) and \( XI_i \) are domestic and imported intermediate goods used in production,
- \( TOP_i, AD_i \) and \( AVD_i \) are shift parameters,
- \( h_i, \gamma_i \) and \( k_i \) are share parameters (also known as the distribution parameters)
- \( \tau_i, \sigma_i \) and \( \upsilon_i \) are the elasticities of substitution between \( VA_i \) and \( V_i, L_i \) and \( K_i \), and \( X_i \) and \( XI_i \) respectively.\(^8\)

In setting out (3) as it is, substitution between sectoral domestic intermediates is suppressed, and the same is true for sectoral imported intermediates.

The marginal products of factors of production, wage and rent, are derived from the value-added function using the MV=MP principle of perfect competition:

\(^8\) For a more detailed discussion about elasticities and sensitivity analysis, see Erbil (2006).
\[
\frac{\partial \text{WAGE}_i}{\partial L_i} = \left( \frac{1}{\sigma_i} \right) \gamma_i \sigma_i \text{PVA}_i (\text{VA}_i / L_i)^{1/\sigma_i} \), \quad \text{WAGES} \quad \text{(4)}
\]

\[
\frac{\partial \text{RENT}_i}{\partial K_i} = \left( \frac{1}{\sigma_i} \right) (1 - \gamma_i) \sigma_i \text{PVA}_i (\text{VA}_i / K_i)^{1/\sigma_i} \), \quad \text{RENTS} \quad \text{(5)}
\]

where \( \text{PVA}_i \) stands for the price of the value-added good.

In other words, at the sectoral level, value added consists of payments to both labor and capital:

\[
\text{PVA}_i \cdot \text{VA}_i = \text{WAGE}_i L_i + \text{RENT}_i K_i
\]

The sectoral demand for labor and capital are determined by equations (4) and (5) respectively:

\[
L_i = \text{VA}_i \left( \left( \frac{1}{\sigma_i} \right) \gamma_i \sigma_i \left( \text{PVA}_i / \text{WAGE}_i \right) \right)^{\sigma_i} \quad \text{(7)}
\]

\[
K_i = \text{VA}_i \left( \left( \frac{1}{\sigma_i} \right) (1 - \gamma_i) \sigma_i \left( \text{PVA}_i / \text{RENT}_i \right) \right)^{\sigma_i} \quad \text{(8)}
\]

The total supply of labor and capital are assumed to be invariant with respect to the wage rate and rent. Both of the factors of production are assumed to be perfectly mobile across all three sectors\(^9\), therefore their returns are the same across all sectors, and the labor market and capital market equilibrium conditions are given by:

\[
\sum_i L_i = L \quad \text{and} \quad \sum_i K_i = K \, , \quad \text{(9) and (10)}
\]

\(^{9}\) Alternatively, capital could be assumed sector specific \( K_i = \overline{K}_i \), where \( \overline{K}_i \) is the fixed stock of capital by sector. In that case, the return of capital (RENT) would be determined as a residual from equation (5) after labor is paid the value of its marginal product.
where $L$ and $K$ represent the fixed amounts of endowments obtained from the SAM (social accounting matrix) of the benchmark year.

Similarly, the prices of intermediate inputs, $PX_i$ and $PXI_i$, can be derived from the composite intermediate inputs function:

$$PX_i = \frac{\partial V_i}{\partial X_i} = \left(\frac{1}{\frac{\sigma - 1}{\sigma}}\right)k_i PXV_i \left(V_i / X_i\right)^{1/\sigma}$$  \hspace{1cm} (11)$$

$$PXI_i = \frac{\partial V_i}{\partial XI_i} = \left(\frac{1}{\frac{\sigma - 1}{\sigma}}\right)(1 - k_i) PXV_i \left(V_i / XI_i\right)^{1/\sigma}$$  \hspace{1cm} (12)$$

where $PXV$ is the price of the composite intermediate good.

At the sectoral level, value of the composite intermediate inputs consists of payments to both domestic and imported intermediate inputs.

$$PXV_i \cdot V_i = PX_i \cdot X_i + PXI_i \cdot XI_i$$  \hspace{1cm} (13)$$

where $V_i$ is the price of the composite intermediate good.

The sectoral demand for domestic and imported intermediates are determined by equations (14) and (15) respectively:

$$X_i = V_i \left[\left(\frac{1}{\frac{\sigma - 1}{\sigma}}\right)k_i \left(PXV_i / PX_i\right)\right]^\frac{1}{\sigma}$$  \hspace{1cm} (14)$$

$$XI_i = V_i \left[\left(\frac{1}{\frac{\sigma - 1}{\sigma}}\right)(1 - k_i) \left(PXV_i / PXI_i\right)\right]^\frac{1}{\sigma}$$  \hspace{1cm} (15)$$

Figure 1 lays out the production structure.
B) Supply Behavior

Above, we laid out the choice of the producer between factors of production and intermediate inputs. After the producer decides on the combination of inputs, the next choice he faces is either to produce for the domestic market or for the export market. At this stage, sectoral domestic output is allocated between exports and domestic sales on the assumption that suppliers minimize cost (or maximize sales revenue) for any aggregate output level. The CET (constant returns to transformation) joint production (or also referred to as: output transformation) function marks this choice, which makes the domestic products and exports imperfect substitutes in supply. The CET function, which applies to commodities that are both exported and sold domestically, is identical to a CES function except for negative elasticities of substitution.

\[ Y_i = \text{CETS}_i \left( \alpha_i \cdot E_i \cdot \frac{ELA + 1}{ELA, i} + (1 - \alpha_i) \cdot DO_i \cdot \frac{ELA + 1}{ELA, i} \right), \text{CET Function} \]  

relates exports to domestic products in production

- \( Y_i \) denotes the sectoral output,
- \( E_i \) is the exported good,
- \( DO_i \) is the domestic good,
- \( \text{CETS}_i \) is the shift parameter,
- \( \alpha_i \) is the share parameter (also known as the distribution parameter)
- \( ELA \) is the CET elasticity of substitution between \( E_i \) and \( DO_i \).

The export supply and the supply of domestic products are determined by solving the optimization problem of the producer (the least cost procedure):
Using \( \frac{\partial Y_i / \partial E_i}{\partial Y_i / \partial D_O_i} = \frac{PWE_i}{PD_i} \), we have \( \left( \frac{(1 - \alpha_i)PWE_i}{\alpha_i \cdot PD_i} \right)^{ELA} = \frac{E_i}{D_O_i} \) \(^{(17)}\) and \(^{(18)}\)

where PWE\(_i\) is the world price of the exports (exogenous due to the small country assumption) and PD\(_i\) stands for the price of the domestic good. Equation \(^{(18)}\) defines the optimal mix between exports and domestic sales. It is derived from the first-order conditions for cost minimization (or revenue maximization) of the producer \(^{(17)}\) and assures that an increase in export price-domestic price ratio will generate an increase in the export-domestic demand ratio (a shift towards the higher price).

At the sectoral level, value of the gross output is equal to the value of exports plus the value of domestic products.

\[ P_Y \cdot Y_i = PWE_i \cdot E_i + PD_i \cdot D_O_i \] \(^{(19)}\)

PY\(_i\) is the price of the sectoral output.

Figure 2 lays out the supply behavior in the model.

**C) Demand Behavior**

Imperfect substitutability between imports and domestic outputs sold domestically is captured by two CES (constant elasticity of substitution) aggregation functions, one for the households and the other for the government:

\[ Q_{H,i} = ARMI_i \left[ \beta^h_i HCIMP_{i}^{EPSI_{-1}} + (1 - \beta^h_i) HCDOM_{i}^{EPSI_{-1}} \right]^{EPSI_{-1}} \] \(^{(20)}\)

\[ Q_{GOV,i} = ARMIII_i \left[ \beta^g_i GCIMP_{i}^{EPSI_{-1}} + (1 - \beta^g_i) GCDOM_{i}^{EPSI_{-1}} \right]^{EPSI_{-1}} \] \(^{(21)}\)

where,
- $Q_{HH,i}$ denotes the household composite good,
- $Q_{GOV,i}$ denotes the government composite good,
- $HC_{IMP,i}$ is the household consumption of the imported goods,
- $HC_{DOM,i}$ is the household consumption of the domestic good
- $GC_{IMP,i}$ is the government consumption of the imported goods,
- $GC_{DOM,i}$ is the government consumption of the domestic good
- $ARMI_i$ and $ARMI_{II}$ are the shift parameters,
- $\beta_{i}^{h}$, $\beta_{i}^{g}$, are the Armington share parameters between imports and domestic goods for households and the government, respectively,
- $EPS_{i}$ is the CES elasticity of substitution between imports and domestic products.

These functions are often referred to as “Armington” functions\(^\text{10}\). The prices and the substitution elasticities that the consumers and government face are the same, and the domestic demands by the households and the government are for composite commodities that are made up of imports and domestic outputs. The household and government Armington functions, (22) and (23) above, relate imported goods to domestic products in consumption, for the households and the government, respectively.

At the sectoral level, imports are equal to the sum of the household demand for imported goods, the government demand for imported goods and the demand for intermediate imported inputs:

$$IMP_i = HC_{IMP,i} + GOV_{IMP,i} + XI_i$$  \hspace{1cm} (22)

where IMP is the sectoral import.

\(^{10}\) Named after Paul Armington who introduced imperfect substitutability between imports and domestic commodities in economic models (Armington 1969).
Similarly, domestic sales are equal to the sum of the household demand for domestic goods, the government demand for domestic goods and the demand for intermediate domestic inputs:

\[ DO_i = HCDOM_i + GOVDOM_i + X_i \]  \hspace{1cm} (23)

Figure 3.3 describes the demand behavior.

**D) Households**

The household revenue is the sum of received payments to factors of productions and transfers from the government:

\[ HR = WAGE \cdot L + RENT \cdot K + THG \]  \hspace{1cm} (24)

THG is the lump-sum transfer from government to the households (or vice versa), determined residually to clear the market.

The utility of the consumer is modeled as a Cobb-Douglas function:

\[ UTILITY = \prod_i QHH_i^{HBS_i} \]  \hspace{1cm} (25)

The consumer derives utility from consuming the household composite good, a mix of household consumption of domestic and imported goods from all three sectors.

The Marshallian consumer demand functions are derived maximizing the utility function subject to the household budget constraint:

\[ \max UTILITY = \prod_i QHH_i^{HBS_i} \]
\[ \text{subject to } HR = \sum_i QHH_i \cdot P_i \]  \hspace{1cm} (26)
which leads to

$$QHH_i = HBS_i \times HR / P_i , \quad (27)$$

where $HBS_i = QHH_i / HR$, is the household budget share \( (28)\)

Starting with the Cobb-Douglas utility function of the consumer from (26), the expenditure function \( (EFCT) \) is derived:

$$EFCT = \prod_i P_i^{HBS_i} HBS_i^{HBS_i} \times UTILITY \quad (29)$$

The money metric version of marginal cost of funds \( (MCF) \) is then calculated by using the utility and expenditure functions:

$$MMCF = ECOEFF_0 \times [UTILITY_i - UTILITY_0] , \quad (30)^{11}$$

$$ECOEFF = \prod_i P_i^{HBS_i} / HBS_i^{HBS_i} \quad \text{is the price part of the expenditure function} \quad (31)$$

**E) Government Sector and the Tax Structure**

This model has two tax instruments; tariffs on imports and output taxes on domestically produced goods. Government revenues are determined by:

$$GR = INTAX + TARIFF + REMIT - THG , \quad (32)$$

where INTAX is the indirect tax revenue, TARIFF stands for the tariff revenue, REMIT for remittances from abroad and THG is a lump-sum transfer from government to the households (or vice versa).

---

\(^{11}\) Equation 25 calculates the familiar money metric utility (using old prices as base):

$$MO = E(p^0, U^0) - E(p^0, U_1) , \quad \text{and it is equal to} \quad \frac{E_u du}{d\beta} \quad \text{in equation (2.15)}.$$
The market clearing condition in the government sector is:

$$GR = \sum_i Q_{GOV_i},$$ (33)

where $Q_{GOV_i}$ represents the government consumption (see (23)).

Both REMIT and THG are aggregates over all three sectors and are determined residually to clear the balance of payments and the government equilibria, respectively. REMIT balances the differences between the exports and imports of the economy, and THG makes sure that the government revenue is equal to the total government consumption.

**i) Tariffs**

$$PM_i = PWM_i(1 + PROPTM_i)$$ (34)

is the domestic price of imported goods. $PWM_i$ stands for the world price of imports.

$$TM_i = \frac{TARIFF_i}{IMP_i - TARIFF_i}$$ is the tariff rate, and

$$PROPTM_i = TM_i DTM$$ (36)

gives the change in the tariff rate, where $DTM$ depicts the radial cut (same across all three sectors) in the tariff rate\(^{12}\). Modeling the radial tax cut across the sectors is essential for the calculation of the marginal cost of funds\(^{13}\).

Rearranging (35) and (36):

$$TARIFF_i = \sum_i PROPTM_i \cdot PWM_i \cdot IMP_i$$ (37)

Tariffs also apply to imported intermediate inputs:

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\(^{12}\) The radial cut in the tariff rate implies that the change in all three sectors are the same percentage (for example, a 5% cut in tariffs for agricultural and industrial products and services).

\(^{13}\) The radial cut is explained in Section II, and built in the formal derivation of the MCF.
\[ PXI_i = PXIT_i (1 + PROPTM_i), \]  

where PXIT is the price for intermediate imported inputs net of tariffs.

**ii) Output Taxes**

Similarly,

\[ PYT_i = PY_i (1 + PROPTY_i) \]  

stands for the domestic price of sectoral output gross of taxes, where \( PY_i \) is the price of output net of taxes.

\[ PROPTY_i = TY_i DTY \]  

gives the change in the output tax rate, where

\[ TY_i = INDTAX_i / (Y_i - INDTAX_i) \]  

is the output tax rate,

and \( DTY \) depicts the radial cut (same across the three sectors) in the tariff rate.

Rearranging (41) and (42), we obtain:

\[ INDTAX_i = \sum_i PROPTY_i \cdot PYT_i \cdot Y_i \]  

**F) Closure Rules**

The model includes four macroeconomic balances:

the government balance, \( GR = \sum_i QGOV_i + THG \), stated in (31),

the external balance,

\[ \sum_i PWE_i \cdot E_i + WS = \sum_i PWM_i \cdot IMP_i \]  

and the two factor market equilibrium conditions, \( \sum_i L_i = L \) and \( \sum_i K_i = K \), stated in (9)
and (10).

In addition, the government consumption is set fixed to its initial value to mark the binding budget constraint of the government.

Both, world prices of imports and exports, PWM\textsubscript{i} and PWE\textsubscript{i}, are exogenous due to the small country assumption.

Figure 4 puts the production block, supply behavior and demand behavior together and gives the sectoral flow of commodities in the economy.

III. Empirical Work\textsuperscript{14}

A) Data Sources

The data set used in the empirical analysis comes primarily from the GTAP (Global Trade Analysis Project) database. Both, versions GTAP 4 and GTAP 5 were utilized.

GTAP 4 database, released in Fall 1998, covers 31 countries. All monetary values of the data are in $US millions and the base year for Version 4 is 1995. Most of its tariff information comes from the UNCTAD TRAINS database. The majority of the macro data on trade is compiled from the United Nation’s COMTRADE database. A large number of GTAP 4’s input-output (I/O) tables were initially inherited from the Australian Industry Commission’s SALTER project, the rest is compiled from the national government (such as departments of statistics) and academic sources for each country. Other data sources utilized in GTAP 4 are, OECD’s PSE (producer subsidy equivalent) database, Development Economics Analytical Data Base (DAD) maintained by the Development

\textsuperscript{14} The empirical work for the “advanced model” mimics the empirical part of Erbil (2006).
Economics Prospects Group of the World Bank, various GATT/IDB sources and individual contributors\textsuperscript{15}.

GTAP 5 database was released in July 2001, and its regional coverage has been expanded from 31 to 54 countries. All monetary values of the data are in $US millions and the base year for Version 4 is 1997. Most of the data resources of GTAP 5 are identical to its previous version. One of the additions is the inclusion of IEA (International Energy Agency) – based energy use data.

An aggregation-constrained software package, GTAPAgg, allows any number of 10x10 (or smaller) aggregations of the GTAP Data Package. A 3x3 aggregation has been used to construct the data for the social accounting matrix (SAM) of this paper.

IV. Results

A) Simple Model (without intermediate imported inputs)

This section expands the empirical analysis to a set of 6 countries\textsuperscript{16}. The advanced model is laid out in detail in Chapter III. The simple model is the version where imports are not explicitly nested in the production and demand structure. Hence, the significant role of imported intermediates inputs in the production, as well as consumption structure of the economies of developing countries is not captured properly. We run the compensated trade liberalization scenario with the “simple model” first, where we collect back the government

\textsuperscript{15} A detailed documentation for GTAP 4 and GTAP 5 databases can be found at www.gtap.org.
\textsuperscript{16} The sample selection was due to data availability.
revenue lost to the fall in trade taxes (TM) by increasing output taxes (TY). Comparing the MCFs figures for both taxes presents the distortion each tax imposes on the economy.

In the simplest sense, we can say that to raise $1, while keeping the government budget constraint constant\(^{17}\), one has to spend $\text{MCF}^{TM}$ when using tariffs as the policy tool, and $\text{MCF}^{TY}$ when using the output taxes.

The MCF figures are given in Table 2 below:

Table 2: Results with the “Simple Model”

<table>
<thead>
<tr>
<th>COUNTRY</th>
<th>$\text{MCF}^{TM}$</th>
<th>$\text{MCF}^{TY}$</th>
</tr>
</thead>
<tbody>
<tr>
<td>China</td>
<td>1.254</td>
<td>1.838</td>
</tr>
<tr>
<td>Korea</td>
<td>1.088</td>
<td>1.151</td>
</tr>
<tr>
<td>Malaysia</td>
<td>1.159</td>
<td>3.627</td>
</tr>
<tr>
<td>Morocco</td>
<td>1.069</td>
<td>1.950</td>
</tr>
<tr>
<td>Uruguay</td>
<td>1.089</td>
<td>1.526</td>
</tr>
<tr>
<td>Viet Nam</td>
<td>1.307</td>
<td>2.089</td>
</tr>
</tbody>
</table>

As seen in Table 2 above, for all of the countries the MCF for indirect taxes (MCF\(^{TY}\)) is significantly higher than the MCF for tariffs (MCF\(^{TM}\)). This comparison tells us, that the trade taxes are the “cheaper” distortion, and therefore replacing indirect taxes with trade taxes would be beneficial. For example, in Korea, it would take $1.088 to raise $1 of tax

\(^{17}\) Government consumption is fixed, and equal to government revenue.
revenue using tariffs as the tax tool, whereas, to collect the same $1 employing output taxes would distort the economy by $1.151. This finding implies that a trade liberalization package, where the tariff loss will be compensated with an increase in indirect taxes, will be too costly (in welfare terms) for the consumer. Hence the policy recommendation would be against trade liberalization.

Intuition commands that in countries with higher trade taxes, a trade liberalization package would be less costly and more desirable. However, looking at China (32%), Viet Nam (21%) and Malaysia (16%), which all have relatively high trade taxes, the results from the “simple model” indicate that trade taxes are actually more desirable than output taxes ($MCF_{TM} < MCF_{TY}$). This is rather counterintuitive and raises questions about the validity of the “simple model”.

B) Advanced Model (with intermediate imported inputs)

Below are the results for the compensated MCF figures generated by using the “advanced model” which explicitly takes into account the presence of “intermediate imported inputs”: The advanced model is laid out in detail in Chapter III. The nested structure of the domestic and imported intermediate inputs in the production marks the difference between the “simple” and the “advanced model”. The “advanced model” accounts for the intermediate imported inputs explicitly, whereas in the “simple model” imports are geared towards final consumption by the households and the government. The introduction of intermediate imported inputs changes the results considerably.
As shown in Table 3 above, when we use the “advanced model” the MCF for indirect taxes \((\text{MCF}_\text{TY})\) is lower than the MCF for tariffs \((\text{MCF}_\text{TM})\), hence indirect taxes become the cheaper distortion for all of the six countries. In this case, replacing trade taxes with indirect taxes would be beneficial. This finding implies that compensated trade liberalization (where the tariff loss will be compensated with an increase in indirect taxes) would be welfare improving, hence the policy recommendation for all six countries would be for trade liberalization.

V. Conclusion

The results clearly show the importance of appropriate modeling choice. If imports are modeled as final goods only (“simple model”), the policy recommendation doesn’t
favor compensated trade liberalization. In other words, cutting tariffs and compensating the lost government revenue by increasing other taxes (in the case, output taxes) has undesirable welfare implications.

However, if imports are allowed to enter the “advanced model” as intermediate inputs, as well as final consumption goods, the results change significantly. For all six countries that we investigate, compensated trade liberalization becomes favorable.

As mentioned before, in the “simple model”, where imports are treated as final goods only, high tariffs shift the consumption away from imported final goods towards domestically produced goods. In the “advanced model”, trade taxes impose distortion not only on the consumption side but also on the production side. High trade taxes distort the production by causing a shift away from imported intermediates toward domestic intermediates. It is intuitive that in the “advanced model” trade taxes generate more distortion compared to the “simple model”.

Many modelers, especially in the field of CGE modeling, where CGE models have been labeled by other economists as a “black box”, try hard to make their models “as simple as possible”. Sometimes the shortcuts in the models are also caused by unavailability of data. This paper calls for caution, by empirically proving, how a “too simplified” or “simplistic” model can generate false policy recommendations. Policy modelers should follow Albert Einstein’s principle and make their models “as simple as possible, but not simpler”.
References:


FIGURES

Figure 1: Production Structure

CAPITAL
[K, RENT]

LABOR
[L, WAGE]

DOMESTIC INTERMEDIATES
[X, PX]

IMPORTED INTERMEDIATES
[XI, PXI]

VALUE ADDED
[VA, PVA]

COMPOSITE INTERMEDIATE
[V, PXV]

SECTORAL OUTPUT
[Y, PY]

CES

CES

CES
Figure 2: Supply Behavior

AGGREGATE OUTPUT
\[ Y_{i|PY_i} \]

CET

EXPORTS
\[ E_{i|PWE_i} \]

DOMESTIC SALES
\[ DO_{i|PD_i} \]
Figure 3: Demand Behavior

DOMESTIC INTERMEDIATES
\([X_i, PX_i]\)

DOMESTIC SALES
\([SP_i, PD_i]\)

IMPORTS
\([IMP_i, PM_i]\)

IMPORTED INTERMEDIATES
\([XI_i, PXI_i]\)

HOUSEHOLD CONSUMPTION OF DOMESTIC GOODS
\([HCDOM_i, PD_i]\)

HOUSEHOLD CONSUMPTION OF IMPORTED GOODS
\([HCIMP_i, PM_i]\)

GOVERNMENT CONSUMPTION OF DOMESTIC GOODS
\([GOVDOM_i, PD_i]\)

GOVERNMENT CONSUMPTION OF IMPORTED GOODS
\([GOVIMP_i, PM_i]\)

COMPOSITE (ARMINGTON) HOUSEHOLD CONSUMPTION
\([QHFI_i, P_i]\)

COMPOSITE (ARMINGTON) GOVERNMENT CONSUMPTION
\([QGOVi, Pi]\)

CES

26
Figure 4: Flow of Commodities

PRODUCTION BLOCK

CAPITAL
[K, RENT,]

LABOR
[L, WAGE,]

DOMESTIC INTERMEDIATES
[N, PXi]

IMPORTED INTERMEDIATES
[N, PXi]

VALUE ADDED
[V, PVA]

AGGREGATE OUTPUT
[Y, PX]

SUPPLY BEHAVIOR

EXPORTS
[E, PWE,]

DOMESTIC SALES
[D, PS]

IMPORTS
[IMP, PM,]

DEMAND BEHAVIOR

HOUSEHOLD CONSUMPTION OF DOMESTIC GOODS
[HDOM, PD]

HOUSEHOLD CONSUMPTION OF IMPORTED GOODS
[HIMPORT, PD]

GOVERNMENT CONSUMPTION OF DOMESTIC GOODS
[GDOM, PD]

GOVERNMENT CONSUMPTION OF IMPORTED GOODS
[GIMPORT, PD]

COMPOSITE (ARMINGTON) HOUSEHOLD CONSUMPTION
[QH, P,]

COMPOSITE (ARMINGTON) GOVERNMENT CONSUMPTION
[QGOV, P]
**A.1 Social Accounting Matrix (SAM)**

A Social Accounting Matrix (SAM) is a comprehensive, economy wide data framework, typically presenting the economy of a nation. Table 1 shows the SAM employed in the empirical part of the “advanced model” of this paper.

**Table A.1: Basic SAM structure used in the CGE model**

<table>
<thead>
<tr>
<th></th>
<th>Agr</th>
<th>Ind</th>
<th>Serv</th>
</tr>
</thead>
<tbody>
<tr>
<td>Agr</td>
<td>domestic intermediates</td>
<td>domestic intermediates</td>
<td>domestic intermediates</td>
</tr>
<tr>
<td>Ind</td>
<td>domestic intermediates</td>
<td>domestic intermediates</td>
<td>domestic intermediates</td>
</tr>
<tr>
<td>Serv</td>
<td>domestic intermediates</td>
<td>domestic intermediates</td>
<td>domestic intermediates</td>
</tr>
<tr>
<td>AgrImp</td>
<td>imported intermediates</td>
<td>imported intermediates</td>
<td>imported intermediates</td>
</tr>
<tr>
<td>IndImp</td>
<td>imported intermediates</td>
<td>imported intermediates</td>
<td>imported intermediates</td>
</tr>
<tr>
<td>ServImp</td>
<td>imported intermediates</td>
<td>imported intermediates</td>
<td>imported intermediates</td>
</tr>
<tr>
<td>Labor</td>
<td>factor payments</td>
<td>factor payments</td>
<td>factor payments</td>
</tr>
<tr>
<td>Capital</td>
<td>factor payments</td>
<td>factor payments</td>
<td>factor payments</td>
</tr>
<tr>
<td>Ind-tax</td>
<td>output taxes</td>
<td>output taxes</td>
<td>output taxes</td>
</tr>
<tr>
<td>Duties</td>
<td>tariffs</td>
<td>tariffs</td>
<td>tariffs</td>
</tr>
<tr>
<td>Imports</td>
<td>imports</td>
<td>imports</td>
<td>imports</td>
</tr>
<tr>
<td>Exports</td>
<td>exports</td>
<td>exports</td>
<td>exports</td>
</tr>
<tr>
<td>Hous-Con</td>
<td>household consumption of domestic goods</td>
<td>household consumption of domestic goods</td>
<td>household consumption of domestic goods</td>
</tr>
<tr>
<td>Imp.Hous-Con</td>
<td>household consumption of imported goods</td>
<td>household consumption of imported goods</td>
<td>household consumption of imported goods</td>
</tr>
<tr>
<td>Gov-Cons</td>
<td>household consumption of domestic goods</td>
<td>household consumption of domestic goods</td>
<td>household consumption of domestic goods</td>
</tr>
<tr>
<td>Imp.Gov-Con</td>
<td>household consumption of imported goods</td>
<td>household consumption of imported goods</td>
<td>household consumption of imported goods</td>
</tr>
<tr>
<td>DomesOut</td>
<td>domestic sales of domestic output</td>
<td>domestic sales of domestic output</td>
<td>domestic sales of domestic output</td>
</tr>
</tbody>
</table>
Note that the SAM used in this paper doesn’t follow the principle of double-entry, and hence is not a square matrix. The first 3x6 submatrix (3 columns, 6 rows) builds the I-O (input-output) matrix for domestic and imported intermediate inputs which enter into the production structure\(^{19}\). The rows indicated as “AgrImpInp,” “IndImpInp” and “ServImpInp” are only present in the “advanced model”. The rows “Labor” and “Capital” are factor payments from the three different sectors in the economy. The indirect tax (Ind-tax) used in the empirical analysis is the output tax that the government collects from the producers. “Duties” report the import taxes, “Imports” and “Exports” are the values of trade outflow and inflow. The household consumption is detailed in “Hous-Con”, household consumption of domestic goods, and “Imp.Hous-Con”, household consumption of imported goods. The same separation holds for the government sector. “DomesOut” gives the domestic sales of domestic output. The total domestic output is the sum of “Export” and “DomesOut”. Output taxes apply to total domestic output. All entries are in $US millions.

The calibration is done with the benchmark data presented in the SAM. All the shift and share parameters for the CES and CET functions are calculated using the benchmark values.

In the production block, TOP\(_i\), AD\(_i\) and AVD\(_i\) are the shift parameters and h\(_i\), γ\(_i\) and k\(_i\) are the share parameters for the CES functions, stated in (1), (2) and (3).

CETS\(_i\) is the shift parameter for the CET function in (16), and α\(_i\) is the share parameter indicating the share of exports in the sectoral output.

\(^{19}\) See Section III for the production structure.
In the demand block, ARMI, and ARMII, are the shift parameters and $\beta^h_i$ and $\beta^g_i$, are the share parameters for the Armington functions in (20) and (21).

The shift parameters are also known as the efficiency parameters or the parameters indicating the state of technology. After they are calibrated from the benchmark data, they stay constant throughout the analysis. The share parameters, also known as the distribution parameters, give the relative shares of the inputs into the corresponding CES/CET functions (e.g. $\gamma_i$ is the relative share of labor in production). After the calibration is complete the model is solved for the benchmark year.