"Trade Taxes Are Expensive"

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Abstract: This paper examines the welfare implications of trade reforms in the presence of a government budget constraint. There is consensus about gains from opening up to trade. The less investigated question is, whether a coordinated tax reform, where the tariff revenue cuts are compensated with increases in distortionary domestic taxes, will still be welfare improving or not. This paper uses a CGE model to generate "Marginal Cost of Funds" (MCF) figures for 32 countries to answer this question. The results suggest that there are significant welfare gains from further trade liberalization, especially for developing countries.

Key Words: Tax Reform, Trade Liberalization, Welfare Gain, Marginal Cost of Funds, Computable General Equilibrium Model

JEL Classifications: F13, F15, H20

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I. Introduction

This paper focuses on the welfare implications of trade reforms and compensating taxation. Recognizing the importance of the revenue-raising aspect of trade barriers, it investigates a direct cost: loss of tax revenue from liberalized trade, which must be made up from increases in other distortionary taxes. Since this loss can be substantial for developing countries, the welfare implications of trade liberalization become an important issue. The net effect can be a loss.

It is well-known that distortionary taxes (both domestic and trade) impose welfare costs. Collecting \$1 tax revenue creates a distortion in the economy which exceeds \$1. Hence, all distortionary taxes are expensive tools that generate revenue for the government. However, a government with a binding budget constraint can still choose between domestic and trade taxes. A useful policy recommendation would be to choose the "cheaper" tax, which causes less welfare decrease. This paper shows that, for most of the developing countries, trade taxes are the more "expensive" tool compared with output taxes[1].

The empirical results illustrate the welfare costs of trade taxes versus output taxes for 32 countries. For 26 of them, trade taxes are the more "expensive" distortion, hence a trade liberalization compensated with an increase in output taxes is welfare improving. The results of this paper might be of special interest for developing countries and for organizations like the WTO, the World Bank and IMF, which advise developing countries on their economic policies.

In recent years, many countries have followed the path of trade liberalization, eliminating or lowering their trade barriers, and opening their economies to international competition[2]. The growth

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[1] This finding is in tune with the well-known principle that the optimal policy for a small country is to raise revenue by completely replacing trade taxes with taxes on the net demand of households (Dixit 1985), which is a corollary to the Diamond-Mirrlees (1971) production efficiency theorem.

[2] In Latin America, trade policy reforms started in countries like Chile and Mexico in the mid-1980s, followed by Argentina, Brazil, Peru and Venezuela. In Asia, around the same time, China, the Philippines, Taiwan and Vietnam

performance of early liberalizers, such as Hong Kong, Singapore and South Korea, have motivated the rest of the developing world to acknowledge trade liberalization as a powerful policy tool to improve their economic performance and raise standards of living[3]. Indeed, trade theory provides us with the insight that eliminating trade barriers enhances economic efficiency, promotes growth and helps correct domestic market failures.

Although gains from trade are indisputable in theory, barriers to trade are still widespread in practice. There are three main reasons why they are so prevalent: interest groups may favor protection, restricting trade can be an optimal policy (infant industry, strategic trade policy, etc...), and finally trade barriers raise significant revenue for the government. The last one is the most relevant for developing countries[4] and the motivation for this paper.

The current literature on trade liberalization acknowledges that trade taxes constitute an important part of government revenue in developing countries and can also be substantial in some cases for developed countries. In low income countries trade taxes account for approximately a quarter of the total tax revenues[5]. Ebrill, Stotsky and Gropp (1999) report that in a group of selected developing countries in Africa, trade taxes account for about 5.5 percent of GDP on average in 1995. Keen and Lightart (1999) reveal that tariff revenue accounts for approximately 27 percent of the total tax revenue in Africa, and Matusz and Tarr (1999) report that explicit trade taxes account for 38 percent (19 percent) of total revenues in low (middle) income countries. According to Evenett and Madani (2000), as a consequence of this heavy reliance on trade taxation, “certain developing countries have postponed, slowed or reversed trade liberalization measures on the grounds that losses in trade tax revenues undermine their

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employed openness policies. Even in Africa, where trade taxes are still higher compared to the rest of the world, countries like Ghana, Nigeria, Tanzania and Zaire have recently started to liberalize their trade policies.

[3] Although the most recent round of trade talks in Doha, Qatar, were brought to a standstill in the fall of 2003, recently all participants showed interest to carry on with promises to liberalize trade further. There are high expectations from this liberalization process.

[4] The cost of raising revenue through domestic taxes is very high in developing countries (such as African countries). The lack of necessary infrastructure to monitor, administer and collect domestic taxes makes it easier to rely on tariffs.

[5] For OECD countries the same ratio is only 0.5%. From Government Finance Statistics, 1997.

government's budget constraint."

This paper builds on Anderson's (1999) study by investigating in more depth the Marginal Cost of Funds (MCF) calculations for distortionary taxation. MCF for any tax increase is given by the ratio of the incremental compensation, which is required to maintain real income to the incremental tax revenue. After finding the MCF for two different types of taxes, a revenue neutral shift from the tax with high MCF to the tax with low MCF is welfare improving.

In particular, this paper aims to shed light on the following question: "Are trade taxes "more expensive" compared with other distortionary taxes?" If there are "cheaper" distortionary taxes that we can replace the trade taxes with, a revenue-neutral trade reform would be welfare improving. This policy recommendation would not only rely on the "gains from trade" argument to encourage countries opening up to trade, but also address their concerns of losing government revenue.

This study contributes to the growing research program on welfare implications of trade liberalization in several dimensions. The first is the utilization of an increasingly popular and very intuitive welfare measurement tool, the marginal cost of funds (MCF). The second is the large number of countries[6] that this measurement tool is applied to in the context of a computable general equilibrium (CGE) model, to answer the question posed in the title. In contrast to the small number of existing MCF calculations in the literature, a *common* CGE structure is used for the set of countries. Third, the explicit usage of intermediate imported inputs to make the model employed in this study more realistic (especially for the developing countries).

The layout of the paper is as follows. Section II covers prior literature in the field. Section III sets out the intuition of the compensated MCF and the formal derivation. Section IV lays out the model.

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[6] Partially due to complexity of modeling and setting up the SAM (Social Accounting Matrix), most CGE models are built to run for only one country. One of the most recent and most comprehensive studies involving MCF figures and CGE modeling was done by Devarajan, Thierfelder and Suthiwart-Narueput (2000) and covers only 3 countries (Cameroon, Bangladesh and Indonesia).

Section V examines the empirical work, the elasticities employed in the study, the calibration procedure and the mechanics of the CGE model. Section VI reports the empirical results. Section VII concludes the paper.

II. Prior Literature

The literature does not offer much guidance on coordinated tariff-tax reforms, which take into account the binding budget constraint of many developing countries. Most of the research on the welfare effects of piecemeal trade reform typically employs lump-sum transfers[7] to compensate for the revenue consequences of the tariff reform. Thus, most of the conventional literature simply assumes no distortionary taxes other than tariffs[8].

However, recently, research in the area of coordinating tariff reductions with domestic tax reforms has gained momentum[9]. Clarete and Whalley (1987) find that, at the margin, trade taxes have considerably higher distortionary costs per unit of tax revenue raised. According to the theoretical paper of Keen and Lightart (1999), combining any tariff cut with a consumption tax reform, which leaves the consumer prices unchanged, increases both welfare and public revenue. Their compensating policy tool, domestic consumption taxes, differs from the one used in this paper, output taxes[10], and their experiment is not revenue-neutral. But their findings are consistent with the findings of this paper: tariff reforms are favorable in the context of coordinated tariff-tax packages. Rajaram (1994) examines whether the revenue effects of tariff reform proposals of the World Bank were anticipated and complemented by other tax measures. He finds out that in many cases they are neither anticipated, nor complemented. Abed (1998) stresses the link between trade liberalization and domestic tax reform and details the types of tax reforms

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[7] Note that although it is very convenient to implement, there is no application of "lump sum" taxation into the real economy.

[8] The theoretical results of piecemeal policy reform, obtained under the assumption that all distortions are tariffs, may not hold if there are other distortions such as a production subsidy/tax, Beghin and Karp (1992).

[9] Clarete and Whalley (1987), Greenaway and Milner (1991), Mitra (1992), Rajaram (1994), Abed (1998), Keen and Lightart (1999), Ebrill et al (1999).

[10] Dervis, de Melo and Robinson (1982) also employ distortionary taxation on output.

that would support trade reform by generating the compensatory revenue and, in the long run, reduce the distortionary effects of tax and tariff systems. Findings in outcome of these studies suggest the necessity for further investigation.

The starting point for this paper is a study by Anderson (1999), where he determines that a revenue neutral trade reform may not always improve welfare. To measure welfare effects, Anderson uses the concept of the compensated Marginal Cost of Funds (MCF)[11] from the public finance literature and generates sufficient conditions for the revenue-neutral trade reform to be welfare increasing. He analyzes an example of a simple efficient tax by using a uniform radial change in the consumer tax vector to compensate uniform radial reductions in tariffs, in other words, taxing all the consumption at the same rate[12]. In the empirical part of his paper, Anderson presents a small-scale CGE model of the Korean economy in 1963, and provides an example of welfare-decreasing replacement, despite higher average trade taxes than consumption taxes. His result shows that no presumption is obtained; replacing trade taxes with distortionary consumption taxes cause a decrease in welfare. There is a need to investigate under which circumstances Anderson's result is likely, and to study welfare implications for further cases of compensation with distortionary taxation.

A summary of a literature survey on MCF reveals its differing definitions and widespread usage. Ahmad and Stern (1990) contribute to the public finance literature by using the comparison of "marginal social costs" to evaluate "shadow" revenue neutral marginal shifts from one tax to another. The difference between their approach and the one used in this paper, is that they focus on the role of shadow prices and distributional values whereas our results use the compensated[13] MCFs to compare policy reforms across

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[11] Explained in detail in section III.

[12] According to Hatta (1977), uniform radial tariff cuts with lump sum taxes are always welfare improving. As mentioned before, according to Dixit (1985), the optimal policy for a small country is to raise revenue by completely replacing trade taxes with taxes on the net demand of households (which is a straight forward application of the Diamond-Mirrlees (1971) theorem that consumption taxes dominate trade taxes at the optimum).

[13] It is important to point out that the MCF used in this study is the compensated version of MCF. A crucial property of the compensated MCF concept is that it is comparable across economies, model specifications and parameterizations. This allows an investigation into the determinants of differing MCFs. Its use in this research is

countries. Devarajan, Squire and Suthiwart-Narueput (1995) stress the usefulness of MCF, especially for projects that are characterized by public costs and private benefits. Other papers by Mayshar (1991) and Allgood and Snow (1998) try to define the different methods of calculating MCF estimates and explain the wide discrepancy between the estimates in the literature. Devarajan, Thierfelder and Suthiwart-Narueput (2000) argue, "if the MCF across different tax instruments varies greatly, directions for revenue-neutral tax reform are readily apparent". They provide MCF estimates for three developing countries – Cameroon, Bangladesh and Indonesia, and conclude that "the potential for revenue-neutral (or even revenue-increasing) tax reforms in developing countries is enormous." They claim that MCF analysis provides the necessary groundwork for tax reform efforts. Slemrod and Yitzhaki (2001) use the MCF as the main concept to evaluate distortionary cost of fund raising. Rutherford (2001) uses MCF for 5 different tax instruments for Columbia to assess possibilities of tax reform. His analysis is undertaken with the Columbian National Department of Planning, confirming the policy makers' increased attention towards MCF estimates.

The significance of imported intermediates in trade policy and welfare analysis is repeatedly acknowledged in the literature[14]. For the 32 countries investigated in this paper, the share of imported intermediates to total imports is very high (especially for developing countries)[15].

different than the prevailing usage in the public economics and relevant trade or tax reform literature (Snow and Warren, 1996) where the uncompensated, or money metric utility, version of MCF is widely employed. The uncompensated MCF is inherently non-comparable across models or countries because it is a money metric measure of utility. A more detailed discussion will follow in section III under "formal derivation".

[14] Markusen (1989), Lopez and Panagariya (1992), Lopez-de-Silanes, Markusen and Rutherford (1992).

[15] It is about 70% for most of the developing countries. Intuitively, 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.

III. Marginal Cost of Funds (MCF)

A) Basic Intuition

An increase in taxes will decrease the real income of the consumer and raise tax revenue for the government at the same time. The Marginal Cost of Funds (MCF) for any tax increase gives the ratio of the marginal compensation required to maintain real income to the marginal tax revenue raised by this tax increase. In other words, it is the marginal cost of raising another dollar of tax revenue.

Below is the simplest formula of the MCF, where we assume a single imported good.

Consider a small open economy with an imported good at international price p^*, which is selling domestically for p due to a tariff[16]. Assume that all goods are tradable, and there are no other distortions in the economy. Denoting the quantity of imports by m, MCF after a small perturbation in the tariff can be defined as follows:

$$MCF = \frac{mdp}{[m + (p - p^*)m_p]dp} \qquad (1)$$

where mdp is the marginal compensation and $[m + (p - p^*)m_p]dp$ is the marginal tax revenue change. Here and for the remainder of the paper, a subscript denotes partial differentiation. For a single import, due to the substitution effect the scalar excess demand slope m_p <0, hence, MCF>1. Intuitively, it takes more than one dollar of compensation to maintain real income, when \$1 of added tariff revenue is raised.

[16] Note that "p" here is the domestic price of a single import, whereas "p" in the formal derivation, on the next page, will denote the relative price vector of private goods.

B) Formal Derivation

The formal derivation uses a simplified version of the model laid out in Section IV and serves mainly to verify the intuition.

The framework of the model is built on the representative consumer's expenditure function, $e(p,u)$, and the gross domestic product function, $g(p,v)$.

The expenditure function, $e(p,u)$ gives the minimum expenditure on private goods needed to reach a utility of u, where p is the relative price vector for private goods.

The gross domestic product function, $g(p,v)$ gives the maximized value of private production at prices p, where v represents the vector of primary factors of production in a convex technology with constant returns to scale (CRS) and perfect competition. By the exhaustion of product theorem, the gross domestic product function measures the total payments to factors.

The following set up gives the simplest case where the public goods are not included in the equations to simplify the analysis[17]. Moreover, the prices of the non-distorted goods are suppressed.

The net expenditure on private goods at domestic prices can be defined as

$$E(p,u,v) = e(p,u) - g(p,v) \tag{2}$$[18]

The private budget constraint is as follows:

$$E(p,u,v) = 0 \tag{3}$$[19]

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[17] Including an exogenously determined G, and hence using dG=0 would bring us to the same result.
[18] Note that all goods are assumed to be tradable. Otherwise, we must solve for the non-traded goods prices. Non-traded goods are formally handled by $E(p,u,v) \equiv \max_h [e(p,h,u) - g(p,h,v)]$.
[19] Note that (3) implies that there are no direct transfers to the representative consumer.

denoting the net expenditure on the private goods.

The government budget constraint is:

$$(p-p^*)' E_p(p,u,v) - \beta = 0 \tag{4}$$

The first term gives the tariff revenue of the government where $(p-p^*)$ denotes the price wedge (tariff) and E_p gives the vector of excess demands. The second term, β, denotes external transfer. Eventually, β will pay for a reduction in revenue from other taxes.

Now we can introduce a package of tariff changes by perturbing the domestic price vector p. Changes in domestic prices can be denoted as $dp^i = W^i p \cdot d\tau$, where W^i is a diagonal matrix of weights (i standing for a member of an index set[20]) and $d\tau$ is a scalar.

The next step is to discuss the effect of an exogenous change in the external transfer, $d\beta$, solved for the exogenous change in dp and in welfare du. Totally differentiating the government budget constraint:

$$E_p' Wp \cdot d\tau + (p-p^*)' E_{pp} Wp \cdot d\tau + (p-p^*)' E_{pu} \cdot du = d\beta \tag{5}$$

and the private budget constraint:

$$E_p' Wp \cdot d\tau = -E_u du \tag{6}$$

The endogenous tax reduction, $dp^i = W^i p d\tau$, is financed by this external transfer. In other words, government budget constraint is first altered by an external transfer, $d\beta$, then balanced by an endogenous change in taxes, $d\tau$, where $d\tau$ is given by:

[20] For notational convenience, this index will be suppressed in the remainder of the derivation.

$$d\tau = -\frac{1}{E_p'Wp + (p-p^*)'E_{pp}Wp}d\beta - \frac{1}{E_p'Wp + (p-p^*)'E_{pp}Wp}(p-p^*)E_{pu}du \qquad (7)$$

Equation (7) is obtained using the government budget constraint only. Solving for $d\tau$ from the private budget constraint (6), we obtain:

$$\frac{-E_u du}{E_p'Wp} = d\tau \qquad (8)$$

Substituting (7) into (8) we end up with:

$$\frac{E_u du}{E_p'Wp} = \frac{1}{E_p'Wp + (p-p^*)'E_{pp}Wp}d\beta + \frac{1}{E_p'Wp + (p-p^*)'E_{pp}Wp}(p-p^*)E_{pu}du \qquad (9)$$

Multiplying both sides by $\frac{E_p'Wp}{d\beta}$, and rearranging terms, we find (10):

$$\frac{E_u du}{d\beta} = \frac{E_p'Wp}{E_p'Wp + (p-p^*)'E_{pp}Wp} + \frac{E_p'Wp}{E_p'Wp + (p-p^*)'E_{pp}Wp}(p-p^*)\frac{E_{pu}}{E_u}\frac{E_u du}{d\beta}$$

Rewriting (10) we end up with a term that includes MCF,

$$\frac{E_u du}{d\beta}(1 - MCF(p-p^*)\frac{E_{pu}}{E_u}) = MCF\ , \qquad (11)$$

where $MCF \equiv \frac{E_p'Wp}{E_p'Wp + (p-p^*)'E_{pp}Wp}$, and (12)

E_p denotes the vector of excess demand,

E_{pp} is the matrix of compensated price derivatives of excess demand,

E_u is the change in excess demand with respect to change in utility,

$(p-p^*)'E_{pu}du$ is the income effect on tax revenues, and

$1/[1-MCF(p-p^*)'E_{pu}/E_u]$ gives the price of an additional unit of money metric utility in terms of external compensation, the shadow price of foreign exchange or the fiscal multiplier.

The intuition behind the right hand side of (12) is straightforward; the nominator stands for the private marginal cost of the tariff change or in other words, it is the magnitude effect of a unit tariff change on the representative agent. The denominator gives the net revenue raised by the tariff change. All changes are at constant utility (u). Going back to the scalar case introduced in the introduction of this section, we can see that (1) and (12) give the same intuition. The MCF in the scalar case can be reduced to:

$$MCF = \frac{1}{1+(p-p^*)m_p/m} \tag{13}$$

The nominator reports one unit of external transfers, and the denominator gives the revenue raised due to tariff reductions financed by this external transfer.

Equation (11) also gives us the direct relationship between the money metric (or the uncompensated) and compensated MCF. The difference between these two measures is captured by μ in (14) below, known as the "shadow price of foreign exchange" in the international trade literature, also called the "fiscal multiplier" by Anderson and Martin (1995):

$$\mu = \frac{1}{1-MCF(p-p^*)\dfrac{E_{pu}}{E_u}} \tag{14}$$

The fiscal multiplier describes the price of an additional unit of money metric[21] utility in terms of

[21] Money metric utility measures transform utils into expenditure units.

external compensation[22].

The compensated MCF is simply the money metric MCF (MMCF) divided by this "fiscal multiplier":

$$MCF = MMCF / \mu \tag{15}$$

MCF, as described in (12), is the compensated (utility constant) marginal cost of raising another dollar for external transfer by using tariffs. The fiscal experiment is donating an external dollar to the government and inducing a one dollar reduction in tax revenue generated from tariffs. This experiment gives us the compensated benefit of MCF, the willingness to pay for a dollar of external transfer to finance a tax reduction. The important difference between the money metric version of MCF and the compensated MCF is that the money metric version of MCF does not have the "willingness to pay" interpretation; hence it doesn't allow international or interregional comparisons.

This experiment can be extended to two sets of taxes[23]. One group of taxes is altered exogenously, and another group of taxes change endogenously to maintain the tax revenue at a constant level. For this analysis, we need to calculate MCF^i and MCF^j for two group of goods i and j, respectively. Let p^j denote the vector of prices of the subset of goods whose tax rates are varied exogenously, and p^i denote the vector of prices of the subset of goods whose tax rates are varied endogenously. Defining the exogenous change in taxes for the j set of goods as $dp^j = W^j p^j d\tau^j$, we solve the differential of the government budget constraint for the endogenous change, $dp^i = W^i p^i \cdot d\tau^i$.

The solution for $d\tau^i / d\tau^j$ is (16)

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[22] The fiscal multiplier is generally positive and greater than one (Hatta, 1997), but may be also less than one under some circumstances (Fullerton, 1991).

[23] This section closely follows the setup of the differential tax case by Anderson and Martin (1995).

$$\frac{d\tau^i}{d\tau^j} = \frac{-1}{E_{p^i}'W^i p^i + (p-p^*)' E_{\bullet i} W^i p^i} + \frac{-1}{E_{p^i}'W^i p^i + (p-p^*)' E_{\bullet i} W^i p^i} (p-p^*)' E_{pu} \frac{du}{d\tau^j}$$

where $E_{\bullet i}$ is the matrix $\begin{pmatrix} E_{ii} \\ E_{ji} \end{pmatrix}$, which captures the substitution effect.

Solving $d\tau^i / d\tau^j$ together with the differential of the private budget constraint we obtain:

$$(1 - MCF^i (p-p^*)' \frac{E_{pu}}{E_u}) E_u \frac{du}{d\tau^j} = \left(\frac{MCF^i}{MCF^j} - 1 \right) E_{p^j}' p^j \qquad (17)$$

where MCF^i is defined as:

$MCF^i = \dfrac{E_{p^i}'W^i p^i d\tau^i}{E_{p^i}'W^i p^i d\tau^i + (p-p^*)' E_{\bullet i} W^i p^i d\tau^i}$ and MCF^j is also defined similarly.

$(1 - MCF^i (p - p^*)' \dfrac{E_{pu}}{E_u})$ is the fiscal multiplier for endogenous taxes.

The intuition tells us that if the taxes for group i goods are more costly, in other words if MCF^i > MCF^j (which indicates that the term in the brackets, $\left(\dfrac{MCF^i}{MCF^j} - 1 \right)$, is positive), an increase in taxes for group j goods accompanied by a revenue neutral cut in taxes for group j goods will be welfare improving.

IV. The Model

The computable general equilibrium (CGE) model used in this paper simulates the working of 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 imperfectly substitutable for each other. A multi-level nesting of all the factors of production 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. 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. The representative 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. The social accounting matrix for the benchmark year, the calibration process and the magnitude and sources of the elasticities used in CES and CET aggregation functions are discussed in the next sections. Figure 1 puts the production block, supply behavior and demand behavior together and gives the sectoral flow of commodities in the economy.

V. EMPIRICAL WORK

A) Data Sources

The data set used in the empirical analysis comes primarily from 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 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 GTAP4 are, OECD's PSE (producer subsidy equivalent) database, Development Economics Analytical Data Base (DAD) maintained by the Development Economics Prospects Group of the World Bank, various GATT/IDB sources and individual contributors[24].

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.

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.

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[24] A detailed documentation for GTAP 4 and GTAP 5 databases can be found at www.gtap.org.

B) Elasticities

Table 1 reports the different elasticity values used in the CES and CET functions to mark the production, supply and demand choices in the model, and compares them with elasticities used in similar CGE models of small open economies.

The second column shows the elasticities used in this paper, whereas the third column reports the range of estimates from various sources (listed in the footnotes) and the substitution elasticities reported in the GTAP documentations. All the elasticities of substitution are constant across all three sectors of the economy for all the countries explored in the model[25]. This simplifying assumption does not change the results of the paper. The sensitivity analysis utilized in the next section shows that the empirical MCF estimates are not very sensitive to the elasticities of substitution.

VI. Empirical Analysis and Results

Before laying out the empirical results of this paper, it is helpful to take a look at the empirical magnitudes of the MCF estimates from previous studies. Table 2 includes MCF figures obtained by using either analytical formulae or numerical simulation. These empirical results from previous studies present a wide range for MCF figures[26].

The CGE model has proved useful for studying the welfare effects of trade reforms in the presence of binding government budget constraints. This section reports estimates of MCF^{TY} and MCF^{TM}, the marginal cost of funds, of indirect taxes, and tariffs, respectively. In the majority of countries (26 out

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[25] This simplification is mostly due to limitations of availability of elasticity estimates for the countries in the sample.

[26] It is important to note that the MCFs reported above are the money metric or uncompensated version of the MCF. As explained in section III, the uncompensated and compensated MCF concepts are linked to each other with the "fiscal multiplier": the compensated MCF is simply the uncompensated MCF divided by the "fiscal multiplier". Since the "fiscal multiplier" is generally positive and greater than one (Hatta (1977)), the compensated MCFs are smaller in absolute value than their money metric versions. The results presented below are for the compensated version of MCF, and have a narrower range (1.001-1.558) for 32 countries than the uncompensated MCF figures reported in Table 1.

of 32), the MCF for indirect taxes (MCF^{TY}) is lower than the MCF for tariffs (MCF^{TM}). This comparison tells us, that for the first six countries reported in Table 3, the trade taxes are the "cheaper" distortion, and therefore replacing indirect taxes with trade taxes is beneficial. 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 in the first six countries in Table 3, but the preferred policy tool for the remainder of the 32 countries.

To enhance the intuition, going over the MCF results of one country can be helpful: For Turkey, the MCF for tariffs is 1.27, and the MCF for indirect taxes is 1.041. These estimates are reasonable since their magnitudes are similar to the figures presented in Table 2. These results show that the MCF for indirect taxes is significantly lower than the MCF for tariffs for Turkey. These findings for Turkey are in the expected direction, since the output taxes in the model are low (between zero and 5.8%) and the tariffs are relatively higher (they go up to 21%). The comparison of MCF^{TY} and MCF^{TM} gives us the answer to the original question: "Are trade taxes the more expensive revenue generating policy tool?"

In the simplest sense, we can say that to raise $1, while keeping the government budget constraint constant[27], one has to spend $1.27 when using tariffs as the policy tool, and only $1.041 when using the output taxes. Hence, output taxes are the "cheaper" distortion, and therefore replacing trade taxes with indirect taxes is beneficial. Trade taxes are relatively more expensive for Turkey.

As explained in Section III, the MCF figures in Table 3 reflect each country's willingness to pay for a dollar of external transfer to finance a tax reduction. The net benefit of tax reform which switches from trade to production taxes can be determined from Table 3. It is simply given by MCF(trade) - MCF(production). Korea, China, Poland and the Philippines have the highest potential welfare gains. Their welfare gain would be $0.354, $0.288, $0.251 and $0.24, respectively, for each dollar raised, if they switched from tariffs to output taxes as the revenue collecting policy instrument. Finland, Turkey,

[27] Government consumption is fixed, and equal to government revenue.

Vietnam, Zambia and Tanzania also gain significantly from a tax reform, whereas Argentina, Venezuela and Singapore gain only \$0.022, \$0.022 and \$0.039, respectively.

C) Sensitivity Analysis

As seen in Table 4, the MCF figures are not very sensitive to changes in the elasticity of substitution between imported goods and domestic products (Armington elasticity). Elasticities up to 25% above and below the benchmark year elasticity (EPSI=2) do not affect the direction of the results. In other words, MCF^{TM} remains higher than MCF^{TY} over the entire range, indicating that replacing trade taxes with output taxes would be welfare improving for the economy in question.

From the sample countries presented above, we can calculate the empirically determined elasticity of the MCF with respect to the elasticity of substitution. For MCF^{TM} (tariffs) the elasticity is within the range of 0.0122 and 0.0408, and for MCF^{TY} (output taxes), it is even smaller, between $4\text{x}10^{-4}$ and 0.0186. Intuitively, MCFs rise as elasticity of substitution increases, showing that the own terms have greater responsiveness with respect to changes in elasticity of substitution than cross-effect terms.

VII. Conclusion

Trade taxes constitute an important source of revenue for most developing countries. In many cases, a tariff reform can considerably decrease government revenue and pose a serious fiscal challenge. The fiscal impact of the tariff reduction depends directly on the size of the tariff cut, the responsiveness of imports to the tax change, relative importance of import tariffs as a source of government revenue, and indirectly on what happens to the other tax bases. In theory, many studies conveniently offset the revenue loss of the government by a hypothetical lump-sum transfer. However, in practice lump-sum transfers do not exist. Lately, the importance of the revenue implications of trade liberalization has been widely acknowledged among economists, especially in international organizations such as the World Bank and the IMF. Recent policy recommendations that have evolved from their research on the interaction of trade liberalization and domestic tax systems suggest that for developing countries with binding government budget constraints, it is a priority to implement comprehensive reform packages of the domestic tax system to accompany trade liberalization[28].

This paper investigates whether trade taxes or output taxes will be more costly in welfare terms. A CGE model for a small open economy is employed to investigate a sample of 32 countries. The production structure assumes perfect competition and constant returns to scale. Intermediate imported inputs are nested within the production structure. To raise the same amount of revenue for the government, trade taxes and output taxes are used as policy tools. They each impact the welfare of the consumer differently. A comparison is made by using the marginal cost of funds as the measurement tool for these welfare implications. Switching from the "more expensive" distortion (in welfare terms) to the "cheaper" one would be welfare increasing. Countries with higher marginal cost of funds estimates for tariffs than for other revenue raising tools, such as the output taxes, will be better off at the end of a tariff reform.

The results of the empirical part of this paper indicate that for 26 out of 32 countries investigated in this study, trade taxes are the "more expensive" distortion. In other words, a tariff cut, financed by raising the indirect taxes to compensate the government for the lost tariff revenue, would be welfare increasing. The relevant policy recommendation that emerges from these results is that there is still a strong potential for many countries to liberalize their trade. This would not only satisfy international organizations that advocate for freer trade, but also be welfare improving for the liberalizing country. The fact that 24 of these 26 countries are developing countries makes this recommendation even more encouraging. Essentially, as stated in the title, trade taxes are expensive[29].

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[28] See Ebrill, Stotsky and Gropp (1999).

[29] Intuitively, the presence of imports in both the production and the consumption side increases the amount of distortions that are imposed by a tariff, thereby making the taxes on imports an "expensive" policy tool. The model employed in this paper allows for a realistic presentation of the distortions in the economy, which turns out to be

The empirical results for MCF estimates appear reasonable based on the range of the estimates obtained from the literature (Table 1). They are also not sensitive to the choice of elasticity of substitution (Table 4). The results are promising in that they offer an opportunity of welfare gain along with trade liberalization for many countries in the sample. Korea, China, Poland and the Philippines have the highest potential welfare gains. Their welfare gain would be $0.354, $0.288, $0.251 and $0.24, respectively, for each dollar raised, if they switched from tariffs to output taxes as the revenue collecting policy instrument.

These results encourage further research with different policy tools and different model specifications. Introduction of distortionary income taxation, taxes on private domestic consumption, value-added taxes or other distortions, such as quotas, including the cost of tax administration in the model, along with making the model dynamic, would provide new marginal cost of funds estimates, which could help shape policy recommendations for developing countries.

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crucial for making the correct policy recommendations. Preliminary results of this paper, reported from a smaller sample (only 15 countries) and a simpler model (treating imports only as final goods, and omitting imported intermediate inputs in production), suggested that trade taxes are actually the "cheaper" distortion for 11 out of 15 countries.

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FIGURES and TABLES:

Figure 1: ***Flow of Commodities***

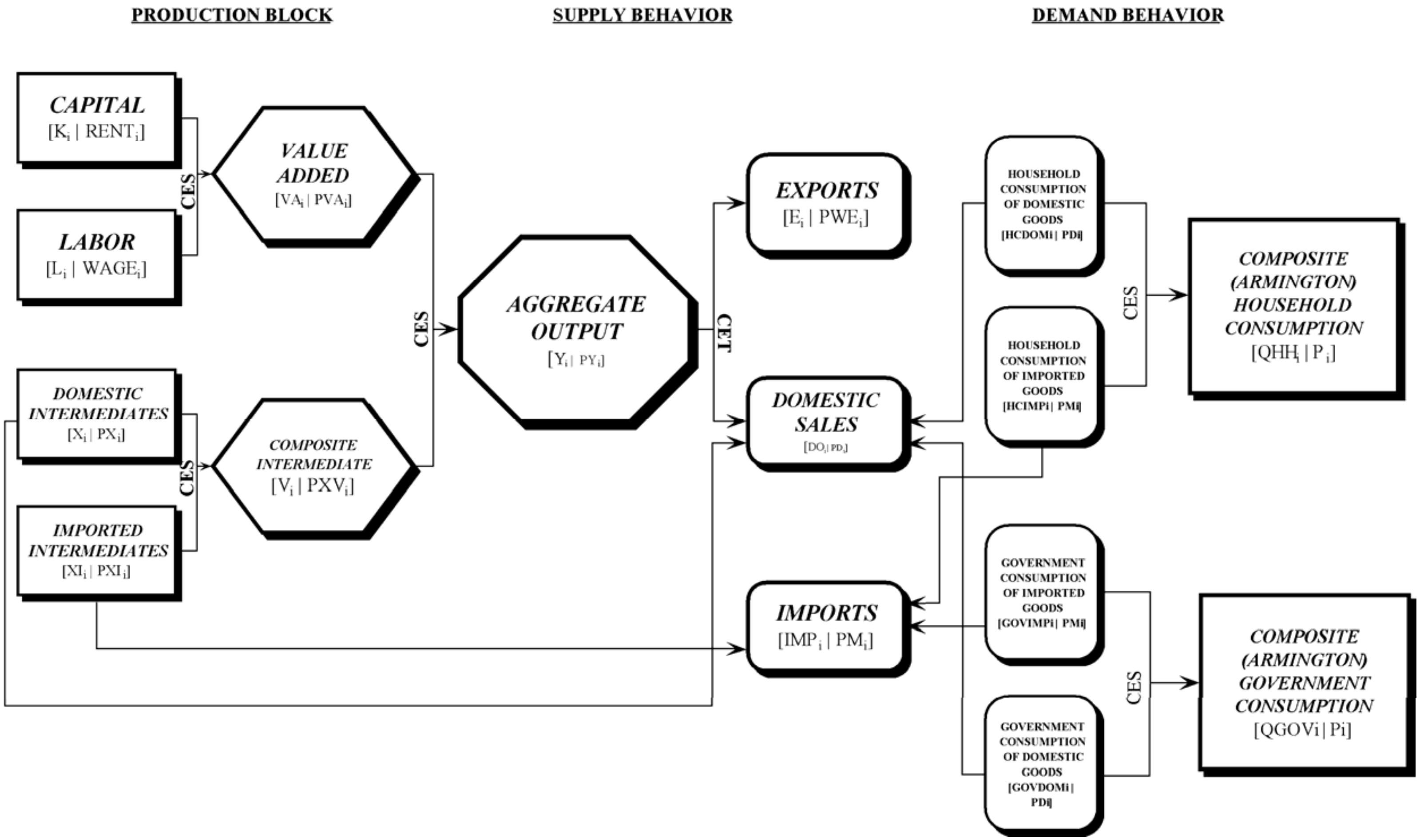

Table 1: Elasticities used in the paper and a comparison with the relevant literature:

ELASTICITIES	Erbil	Literature and GTAP
σ_i elasticity of substitution between capital and labor (production - CES) [1]	**1.2**	**0.9-1.8**
υ_i elasticity of substitution between domestic and imported inputs (production - CES) [2]	**2**	**0.4-3.55**
τ_i, elasticity of substitution between value added and composite intermediate (production - CES) [3]	**0.1**	**0-1.68**
ELA_i, elasticity of substitution between exports and domestically consumed domestic products (supply – CET) [4]	**3**	**2.9-3.9**
$EPSI_i$, elasticity of substitution between imports and domestic products (demand – CES) [5]	**2**	**0.4-3.55**

[1] Griliches (1967), Dhrymes and Zarembka (1970), Zarembka (1970), Fishelson (1979), and Moroney (1972).
[2] De Melo and Tarr (1992).
[3] Close to Leontief function (perfectly inelastic).
[4] De Melo and Tarr (1992).
[5] De Melo and Tarr (1992), Anderson (1999).

Table 2: MCF Estimates from Previous Studies

Country	***Tax Type***	***Estimate***	***Source***
United States	*Surcharge*	1.17-1.56	*Ballard, Shoven and Whalley (1985)*
	Labor	1.21-1.24	*Stuart (1984)*
	Labor	1.32-1.47	*Browning (1987)*
	Labor	1.08-1.14	*Ahmed and Croushore (1994)*
Sweden	*Surcharge*	0.67-4.51	*Hansson and Stuart (1995)*
New Zealand	*Labor*	1.18	*Diewert and Lawrence (1994)*
India	*Excise*	1.66-2.15	*Ahmed and Stern (1987)*
	Sales	1.59-2.17	*Ahmed and Stern (1987)*
	Import	1.54-2.17	*Ahmed and Stern (1987)*
Bangladesh	*Import*	0.82-2.18	*Devarajan, Thierfelder and Suthiwart-Narueput (2000)*
Cameroon	*Indirect Taxes*	0.48-1.32	*Devarajan, Thierfelder and Suthiwart-Narueput (2000)*
Indonesia	*Imports*	0.70-1.91	*Devarajan, Thierfelder and Suthiwart-Narueput (2000)*

Table 3: Multi-country MCF results

	COUNTRY	MCF^{TM}	MCF^{TY}
1	***JAPAN***	1.125	1.442
2	***MEXICO***	1.024	1.340
3	***SRI LANKA***	1.241	1.337
4	***SWEDEN***	1.176	1.200
5	***G.BRITAIN***	1.016	1.173
6	***DENMARK***	1.013	1.029
		$MCF^{TM}<MCF^{TY}$	
1	***CHINA***	1.556	1.268
2	***KOREA***	1.488	1.134
3	***SINGAPORE***	1.372	1.333
4	***INDIA***	1.311	1.155
5	***VENEZUELA***	1.295	1.273
6	***VIETNAM***	1.281	1.078
7	***TURKEY***	1.270	1.041
8	***GERMANY***	1.262	1.207
9	***ZAMBIA***	1.255	1.062
10	***POLAND***	1.252	1.001
11	***PHILLIPINES***	1.241	1.001
12	***FINLAND***	1.241	1.008
13	***THAILAND***	1.206	1.122
14	***URUGUAY***	1.200	1.026
15	***TANZANIA***	1.196	1.010
16	***PERU***	1.176	1.003
17	***MOROCCO***	1.153	1.002
18	***UGANDA***	1.148	1.000
19	***ZIMBABWE***	1.139	1.001
21	***HUNGARY***	1.106	1.005
22	***MOZAMBIQUE***	1.105	1.052
23	***BOTSWANA***	1.099	1.001
24	***MALAYSIA***	1.092	1.037
25	***CHILE***	1.083	0.995
26	***INDONESIA***	1.060	1.001
27	***ARGENTINA***	1.057	1.035
		$MCF^{TM}>MCF^{TY}$	

Table 4: Sensitivity Analysis

% increase in substitution elasticity[1]	POLAND	
	MCF^{TM}	MCF^{TY}
-25%(EPSI=1.5)	1.239416	1.00073
0% (EPSI=2)	1.252193	1.000731
25%(EPSI=2.5)	1.26335	1.000732

% increase in substitution elasticity	MOZAMBIQUE	
	MCF^{TM}	MCF^{TY}
-25%(EPSI=1.5)	1.10244	1.05041
0% (EPSI=2)	1.10582	1.0517
25%(EPSI=2.5)	1.11013	1.05466

% increase in substitution elasticity	SWEDEN	
	MCF^{TM}	MCF^{TY}
-25%(EPSI=1.5)	1.16517	1.19403
0% (EPSI=2)	1.17577	1.1996
25%(EPSI=2.5)	1.18452	1.20337

[1] Reminder: EPSI denotes the substitution elasticity between imported goods and domestic products (Armington elasticity).

APPENDIX

(for referees - not for publication)

A) Calculating MCFs in the Computable General Equilibrium (CGE) Model

To understand the mechanics of the empirical work, it is essential to mention once again that the MCF figures calculated here stem from a “compensated equilibrium”. In CGE models, such as the one employed in this study, more than one step is required to obtain the compensated MCF.

Below, the procedure of calculating MCF of trade taxes is laid out:

- In the first step, the model is perturbed with a transfer of a small external exogenous amount, $d\beta$, into the government budget. This amount is offset by an endogenous proportionate change in the trade tax vector, $dp_i = W^i p_i d\tau_i$, where $d\tau_i$, is the endogenous scalar. The simulation calculates the change in money metric utility, $\frac{E_u du}{d\beta}$, in equation (15). This is the uncompensated MCF (MMCF) for trade taxes.

- Second step starts with the injection of the same small external exogenous amount, $d\beta$, into the government budget. However, this time it is offset by a lump sum transfer, $d\theta$, from the government to the private sector. Running the CGE model, the change in money metric utility, μ, is calculated. μ, the shadow price of foreign exchange, is equal to:

$$\mu = \frac{1}{1 - MCF(p - p^*)\frac{E_{pu}}{E_u}} \tag{A1}$$ [1]

There is a direct relationship between the money metric MCF (MMCF), μ and the compensated MCF:

$$\begin{aligned} MMCF &= \frac{MCF}{1 - MCF(p - p^*)\frac{E_{pu}}{E_u}} \\ &= \frac{\mathrm{MCF}}{1 - \mathrm{MCF}(1/\mu - 1)} \\ &= \mathrm{MCF} * \mu \end{aligned} \tag{A2}$$

- Third step is simply dividing the result of step1 by the result of step2; $\dfrac{\frac{E_u du}{d\beta}(= step1)}{\mu(= step2)}$ =

$$MCF = \frac{MMCF}{\mu} \tag{A3}$$

In (A3), (A2) is solved for MCF given the calculations of μ and MMCF.

The calculation of MCF of indirect taxes follows the same structure.

GAMS (General Algebraic Modeling System) system is employed to solve the CGE model and to calculate the MCFs.

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[1] μ is derived by subbing $\frac{d\theta}{d\beta} = \tau + (p - p^*)' E_{pu} / d\beta$ (government budget constraint) into the private government budget constraint, and solving for the rate of change in money metric utility.

B) Details of the Model

Below is the equation by equation mathematical model statement[2].

I. 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:

$$Y_i = TOP_i[h_i VA_i^{\frac{\tau_i - 1}{\tau_i}} + (1-h_i)V_i^{\frac{\tau_i - 1}{\tau_i}}]^{\frac{\tau_i}{\tau_i - 1}} \text{, SECTORAL OUTPUT} \qquad \text{(B1)}$$

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

$$VA_i = AD_i[\gamma_i L_i^{\frac{\sigma_i - 1}{\sigma_i}} + (1-\gamma_i)K_i^{\frac{\sigma_i - 1}{\sigma_i}}]^{\frac{\sigma_i}{\sigma_i - 1}} \text{, VALUE-ADDED} \qquad \text{(B2)}$$

relates value-added to labor (L) and capital (K).

$$V_i = AVD_i[k_i X_i^{\frac{\vartheta_i - 1}{\vartheta_i}} + (1-k_i)XI_i^{\frac{\vartheta_i - 1}{\vartheta_i}}]^{\frac{\vartheta_i}{\vartheta_i - 1}} \text{, COMPOSITE INTERMEDIATE} \qquad \text{(B3)}$$

relates the composite intermediate to imported (XI_i) and domestic intermediate inputs (X_i). The subscript "i" stands for the 3 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,

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2 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).

- 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,γ_i and k_i are share parameters (also known as the distribution parameters)

- τ_i, σ_i and υ_i are the elasticities of substitution between VA_i and V_i, L_i and K_i, and X_i and XI_i

respectively[3].

In setting out (B3) 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:

$$WAGE_i = \frac{\partial VA_i}{\partial L_i} = \left(\frac{1}{AD^{\frac{\sigma_i - 1}{\sigma_i}}}\right)\gamma_i PVA_i (VA_i / L_i)^{1/\sigma_i} \text{, WAGES} \quad \text{(B4)}$$

$$RENT_i = \frac{\partial VA_i}{\partial K_i} = \left(\frac{1}{AD^{\frac{\sigma_i - 1}{\sigma_i}}}\right)(1-\gamma)_i PVA_i (VA_i / K_i)^{1/\sigma_i} \text{, RENTS} \quad \text{(B5)}$$

where 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:

$$PVA_i \cdot VA_i = WAGE_i L_i + RENT_i K_i \quad \text{(B6)}$$

The sectoral demand for labor and capital are determined by equations (B4) and (B5) respectively:

$$L_i = VA_i \left[\left(\frac{1}{AD^{\frac{\sigma_i - 1}{\sigma_i}}}\right)\gamma_i (PVA_i / WAGE_i)\right]^{\sigma_i} \quad \text{(B7)}$$

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3 Section IV looks into elasticities in more detail.

$$K_i = VA_i[(\frac{1}{AD^{\frac{\sigma_i - 1}{\sigma_i}}})(1-\gamma_i)(PVA_i / RENT_i)]^{\sigma_i} \quad \text{(B8)}$$

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[4], therefore their returns are the same across all sectors, and the labor market and capital market equilibrium conditions are given by:

$$\sum_i L_i = L \text{ and } \sum_i K_i = K , \quad \text{(B9) and (B10)}$$

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:

$$PX_i = \frac{\partial V_i}{\partial X_i} = (\frac{1}{AVD^{\frac{\vartheta_i - 1}{\vartheta_i}}})k_i PXV_i (V_i / X_i)^{1/\vartheta_i} \quad \text{(B11)}$$

$$PXI_i = \frac{\partial V_i}{\partial XI_i} = (\frac{1}{AVD^{\frac{\vartheta_i - 1}{\vartheta_i}}})(1-k)_i PXV_i (V_i / XI_i)^{1/\vartheta_i} \quad \text{(B12)}$$

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.

$$PXV_i \cdot V_i = PX_i \cdot X_i + PXI_i \cdot XI_i \quad \text{(B13)}$$

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4 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 (B5) after labor is paid the value of its marginal product.

where is the price of the composite intermediate good.

The sectoral demand for domestic and imported intermediates are determined by equations B14 and B15 respectively:

$$X_i = V_i[(\frac{1}{AVD^{\frac{\vartheta_i - 1}{\vartheta_i}}})k_i(PXV_i / PX_i)]^{\vartheta_i} \tag{B14}$$

$$XI_i = V_i[(\frac{1}{AVD^{\frac{\vartheta_i - 1}{\vartheta_i}}})(1-k_i)(PXV_i / PXI_i)]^{\vartheta_i} \tag{B15}$$

II. 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.

$$Y_i = CETS_i(\alpha_i \cdot E_i^{\frac{ELA+1}{ELA}} + (1-\alpha_i)DO_i^{\frac{ELA+1}{ELA}})^{\frac{EL1}{ELA+1}} \text{, CET Function} \tag{B16}$$

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,
- $CETS_i$ is the shift parameter,

- α_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):

$$\text{Using } \frac{\partial Y_i / \partial E_i}{\partial Y_i / \partial DO_i} = \frac{PWE_i}{PD_i}, \rightarrow \left(\frac{(1-\alpha_i)PWE_i}{\alpha_i \cdot PD_i} \right)^{ELA} = \frac{E_i}{DO_i} \qquad \text{(B17) and (B18)}$$

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 (B18) 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 (B17) 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.

$$PY_i \cdot Y_i = PWE_i \cdot E_i + PD_i \cdot DO_i \qquad \text{(B19)}$$

PY_i is the price of the sectoral output.

III. Demand Behavior

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

$$QHH_i = ARMI_i[\beta^h{}_i HCIMP_i^{\frac{EPSI_i-1}{EPSI_i}} + (1-\beta^h{}_i)HCDOM_i^{\frac{EPSI_i-1}{EPSI_i}}]^{\frac{EPSI_i}{EPSI_i-1}} \qquad \text{(B20)}$$

$$QGOV_i = ARMII_i[\beta^g{}_i GCIMP_i^{\frac{EPSI_i-1}{EPSI_i}} + (1-\beta^g{}_i)GCDOM_i^{\frac{EPSI_i-1}{EPSI_i}}]^{\frac{EPSI_i}{EPSI_i-1}} \qquad \text{(B21)}$$

where,

- QHH_i denotes the household composite good,
- $QGOV_i$ denotes the government composite good,
- $HCIMP_i$ is the household consumption of the imported goods,
- $HCDOM_i$ is the household consumption of the domestic good
- $GCIMP_i$ is the government consumption of the imported goods,
- $GCDOM_i$ is the government consumption of the domestic good
- $ARMI_i$ and $ARMII_i$ are the shift parameters,
- β_i^h, β_i^g, are the Armington share parameters between imports and domestic goods for households and the government, respectively,
- EPSI is the CES elasticity of substitution between imports and domestic products.

These functions are often referred to as "Armington" functions[5]. 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, (B22) and (B23) 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:

$$IMP_i = HCIMP_i + GOVIMP_i + XI_i \tag{B22}$$

where IMP is the sectoral import.

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:

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[5] Named after Paul Armington who introduced imperfect substitutability between imports and domestic commodities in economic models (Armington 1969).

$$DO_i = HCDOM_i + GOVDOM_i + X_i \tag{B23}$$

IV. Households

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

$$HR = WAGE \cdot L + RENT \cdot K + THG \tag{B24}$$

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:

$$UTILITY = \prod_i QHH_i^{\ HBS_i} \tag{B25}$$

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:

$$\begin{aligned} &\max UTILITY = \prod_i QHH_i^{\ HBS_i} \\ &subject\ to\ HR = \sum_i QHH_i \cdot P_i \end{aligned} \tag{B26}$$

which leads to

$$QHH_i = HBS_i * HR / P_i\ , \tag{B27}$$

where $HBS_i = QHH_i / HR$, is the household budget share (B28)

Starting with the Cobb-Douglas utility function of the consumer from (B26), the expenditure function (EFCT) is derived:

$$EFCT = \prod_i \frac{P_i^{HBS_i}}{HBS_i^{HBS_i}} * UTILITY \tag{B29}$$

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

$$MMCF = ECOEFF_0 * [UTILITY_1 - UTILITY_0]\text{, where} \tag{B30}$$[6]

$$ECOEFF = \prod_i \frac{P_i^{HBS_i}}{HBS_i^{HBS_i}} \text{ is the price part of the expenditure function} \tag{B31}$$

V. Government Sector and the Tax Structure

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

$$GR = INTAX + TARIFF + REMIT - THG\text{,} \tag{B32}$$

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).

The market clearing condition in the government sector is:

$$GR = \sum_i QGOV_i\text{,} \tag{B33}$$

where $QGOV_i$ represents the government consumption (see (B23)).

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.

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[6] Equation B25 calculates the familiar money metric utility (using old prices as base):
$MO = E(p^0, U^0) - E(p^0, U_1)$, and it is equal to $\frac{E_u du}{d\beta}$ in equation (15).

i) Tariffs

$$PM_i = PWM_i(1 + PROPTM_i) \quad \text{(B34)}$$

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

$TM_i = TARIFF_i / (IMP_i - TARIFF_i)$ is the tariff rate, and (B35)

$$PROPTM_i = TM_i DTM \quad \text{(B36)}$$

gives the change in the tariff rate, where DTM depicts the radial cut (same across all three sectors) in the tariff rate[7]. Modeling the radial tax cut across the sectors is essential for the calculation of the marginal cost of funds[8].

Rearranging (B35) and (B36):

$$TARIFF_i = \sum_i PROPTM_i \cdot PWM_i \cdot IMP_i \quad \text{(B37)}$$

Tariffs also apply to imported intermediate inputs:

$$PXI_i = PXIT_i(1 + PROPTM_i), \quad \text{(B38)}$$

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

ii) Output Taxes

Similarly,

$$PYT_i = PY_i(1 + PROPTY_i) \quad \text{(B39)}$$

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

$$PROPTY_i = TY_i DTY \quad \text{(B40)}$$

gives the change in the output tax rate, where

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[7] The radial cut in the tariff rate implies that the change in all three sectors is the same percentage (for example, a 5% cut in tariffs for agricultural and industrial products and services).

[8] The radial cut is explained in Section III, and built in the formal derivation of the MCF.

$$TY_i = INDTAX_i / (Y_i - INDTAX_i) \text{ is the output tax rate,} \tag{B41}$$

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

Rearranging (B41) and (B42), we obtain:

$$INDTAX_i = \sum_i PROPTY_i \cdot PYT_i \cdot Y_i \tag{B42}$$

VI. Closure Rules

The model includes four macroeconomic balances:

the government balance, $GR = \sum_i QGOV_i + THG$, stated in (3.31),

the external balance,

$$\sum_i PWE_i \cdot E_i + WS = \sum_i PWM_i \cdot IMP_i \tag{B43}$$

and the two factor market equilibrium conditions, $\sum_i L_i = L$ and $\sum_i K_i = K$, stated in (B9) and (B10).

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_i and PWE_i, are exogenous due to the small country assumption.

C) Social Accounting Matrix (SAM)

A Social Accounting Matrix (SAM) is a comprehensive, economy wide data framework, typically presenting the economy of a nation. Table C1 shows the SAM employed in the empirical part of this paper.

Table C1: Basic SAM structure used in the CGE model

	Agr	***Ind***	***Serv***
Agr	domestic intermediates	domestic intermediates	domestic intermediates
Ind	domestic intermediates	domestic intermediates	domestic intermediates
Serv	domestic intermediates	domestic intermediates	domestic intermediates
AgrImpInp	imported intermediates	imported intermediates	imported intermediates
IndImpInp	imported intermediates	imported intermediates	imported intermediates
ServImpInp	imported intermediates	imported intermediates	imported intermediates
Labor	factor payments	factor payments	factor payments
Capital	factor payments	factor payments	factor payments
Ind-tax	output taxes	output taxes	output taxes
Duties	tariffs	tariffs	tariffs
Imports	imports	imports	imports
Exports	exports	exports	exports
Hous-Con	household consumption of domestic goods	household consumption of domestic goods	household consumption of domestic goods
Imp.Hous-Con	household consumption of imported goods	household consumption of imported goods	household consumption of imported goods
Gov-Cons	household consumption of domestic goods	household consumption of domestic goods	household consumption of domestic goods
Imp.Gov-Con	household consumption of imported goods	household consumption of imported goods	household consumption of imported goods
DomesOut	domestic sales of domestic output	domestic sales of domestic output	domestic sales of domestic output

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[9]. 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 (B1), (B2) and (B3).

$CETS_i$ is the shift parameter for the CET function in (B16), and α_i is the share parameter indicating the share of exports in the sectoral output.

In the demand block, $ARMI_i$ and $ARMII_i$ are the shift parameters and β_i^h, and β_i^g, are the share parameters for the Armington functions in (B20) and (B21).

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: γ_i is the relative share of labor in production). After the calibration is complete the model is solved for the benchmark year.

[9] See the previous section for the production structure.