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A NOTE ON TAXES, PRICES, WAGES, AND WELFARE IN GENERAL EQUILIBRIUM MODELS

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Abstract

Changes in real wages are often used to measure welfare changes. There is a problem, however, in interpreting measures of changes in factor returns when analyzing the impact of changes in taxes — such as tariffs and indirect taxes — that operate as wedges in product and factor markets versus direct taxes that do not work through the price system. One must account for both how the tax is collected and where the tax revenue goes. We sort out how a shift in tax structure will affect the real wage in a model which isolates the price, wage, revenue, and welfare effects. We start from a simple general equilibrium model which accounts for all income and expenditure flows in the economy and includes both traded and domestic goods. We analyze the impact of changes in indirect taxes and tariffs on prices and factor income and demonstrate the pitfalls of using real factor returns as a welfare indicator. There is a transfer effect on factor returns arising from any shift between indirect and direct taxes, regardless of any efficiency effects. Next, we add explicit factor markets to the model and describe the implications for income distribution in an extension of the Jones trade model. We find that the transfer effect dampens the magnification effect of a price change on factor returns, but does not reverse the Stolper-Samuelson results.

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Introduction

Calculating the impact of changes in taxes has been a major theme of general equilibrium analysis in the field of public finance. A common approach, in both theoretical and empirical work, is to do comparative statics analysis. First, write down a model with an equilibrium in product and factor markets that includes various taxes. Then, change the taxes and determine the new equilibrium values of output, employment, prices, and wages. Finally, compare the two equilibria to see what has changed, and by how much. The new solution potentially involves changes in all prices and quantities, and many measures of changes in welfare can be used. In the empirical literature, commonly reported measures include changes in real wages, household income, gross domestic product (GDP), absorption, and equivalent and/or compensating variation.

The removal of distortions may generate efficiency gains that should be reflected in an increase in GDP, which measures changes in aggregate production. Changes in welfare should be measured by changes in aggregate demand or consumption, which shows up as a change in aggregate absorption. The equivalent and compensating variation measures provide a more refined way of measuring changes in aggregate absorption that take into account knowledge about the underlying expenditure and utility functions.[1] Changes in real wages and household income are often presented to measure welfare changes, tracking changes in absorption back to income generation in factor markets.

Using changes in factor incomes, including real wages, to measure changes in welfare seems reasonable and provides a first cut at addressing issues of income distribution. Indeed, much of the policy debate about the effects of changes in taxes, including tariffs, revolves around changes in wages and profits rather than any measure of aggregate welfare. Changes in relative factor returns have a strong impact on the distribution of income and are certainly of major, often vocal, concern to interest groups. Consider, for example, the debate about the effect of trade liberalization on wages.[2]

There is a problem, however, in using measures of changes in factor returns when analyzing the impact of changes in taxes that operate in product and factor markets such as tariffs and indirect taxes, including the value-added tax. One must account for both how the tax is collected and where the tax revenue goes. Consider, for example, a switch from an income tax to a value-added tax. The income tax is a direct tax at the household (or corporate) level, and will

[1]See Shoven and Whalley (1992), pp. 123-128, for a nice description of the use of equivalent and compensating variations measures in computable general equilibrium models.

[2]Hinojosa and Robinson (1992) discuss the labor market issues in NAFTA. See Burfisher, Robinson, and Thierfelder (1994) and Levy and van Wijnbergen (1994) for empirical analysis of wage changes linked to NAFTA. The literature on the “wage-trade” debate is voluminous and beyond the scope of this paper.

have only an indirect effect on product and factor prices. The value-added tax has a direct effect on product and factor markets, and works its way to household incomes through changes in factor payments (wages and profits). In terms of the national accounts, the switch from an income tax to a value-added tax changes a transfer to a tax that works through the price system. The problem is that, even if the change does not change aggregate absorption, there will be changes in wages and prices that potentially confuse the welfare analysis. In particular, any change from a direct tax to an indirect tax, even if the change is revenue-neutral and does not change aggregate absorption, will lead to a fall in real factor returns, and vice versa.

In this paper we sort out how a shift in tax structure will affect the real wage in a model which isolates the price, wage, revenue, and welfare effects. We start from a simple general equilibrium model that includes traded and domestic goods, and then analyzes the impact of changes in indirect taxes and tariffs on prices and wages. We demonstrate the pitfalls of using real factor returns as a welfare indicator when analyzing such changes. There is a "transfer effect" on factor returns arising from any shift between indirect and direct taxes, regardless of any efficiency effects. Then we add factor markets to the model and describe the implications for income distribution. We find that the transfer effect dampens the magnification effect of a price change on factor returns but does not reverse the Stolper-Samuelson results.

The 1-1-2-3 Model

Table 1 presents a simple general equilibrium model of one country, with one factor of production (labor), two production activities, and three commodities — hence, the 1-1-2-3 model. The model starts from the 1-2-3 model (one country, two activities, three commodities) of Devarajan, Lewis, and Robinson (1993) and adds labor. It can also be seen as an extension of Jones (1965, 1974). The country produces two goods, one sold on the domestic market (D) and one exported (E). A third commodity (M) is imported, and is not produced domestically. This model is a good analytic representation of a large class of empirical computable general equilibrium (CGE) models.[3]

Equations 1 and 2 describe production technology. Labor (L) is used to produce an aggregate good (X in equation 1), which can be transformed into domestic goods or exports (D and E in equation 2). In CGE models, the transformation function is usually a constant elasticity of transformation (CET) function. Equation 3 describes absorption (Q) as an aggregation of domestic and imported goods (D and M) — often given as a constant elasticity of substitution (CES) function. Equations 4 and 5 reflect the first-order conditions for profit and utility maximization for the corresponding transformation and aggregation functions. Equations 6 and 7 relate domestic prices (P^e and P^m) to world prices (π^e and π^m), given the exchange rate (R). The

[3]See de Melo and Robinson (1989) and Devarajan, Lewis, and Robinson (1990, 1993), who describe the properties of the 1-2-3 model in detail and show how it stylizes the behavior of most trade-focused, single and multi-country CGE models.

domestic price of imports (P^m) includes a tariff wedge. Equations 8, 9, and 10 are adding-up equations and serve to define aggregate prices (P^x and P^q) of X and Q and the wage (W). There is an indirect-tax wedge between the value of total factor payments (equation 8) and the value of sales (equation 9). Equation 11 defines the trade balance, with the value of exports set equal to the value of imports, both in world prices.

The model has 12 endogenous variables ($X, Q, D, E, M, P^x, P^q, P^e, P^m, P^d, R$, and W) and 11 equations. Aggregate employment, L, is assumed to be exogenous. The model can only determine relative prices, and one of the goods must be chosen as numeraire, with the corresponding price set to 1.[4] The model then determines 11 variables (5 quantities and 6 relative prices).

The various nominal flows generated by the model, which reflect receipt and expenditure accounts of the various economic actors, are shown in Table 2. This table is a social accounting matrix (SAM), with each entry representing a payment by the column account to the row account. The column and row sums for each economic actor must be equal, given the requirement of receipt and expenditure balance. Balance in the activity, commodity, government, and world accounts reflects the receipt-expenditure equations in the model (equations 8, 9, 10, and 11). The SAM has an explicit household account, which receives as income wages and government transfers and which spends all its income on goods. This household account is implicit in the model equations, given that the model satisfies Walras' Law.[5]

The SAM also reflects the national accounts and standard price indices. Welfare analysis would be based on real absorption, Q, and its composition (D and M). Production is measured by production (X) which equals real GDP at factor cost. Changes in production "efficiency" would be measured by changes in X (shifts in the production possibility frontier) or its composition (D and E, representing shifts along the frontier).[6] Measuring GDP at market prices involves taxes which are incorporated into the price system. The price P^q corresponds to the consumer price index. It includes imports (measured at tariff-ridden prices) and excludes exports. The price P^x corresponds to the GDP deflator (at factor cost). It includes exports and excludes imports. The GDP deflator at market prices would be P^x@$T^{x,}$, which includes indirect taxes.

From the SAM alone, one can see a link between taxes and wages. Assume, for example,

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[4]The model also satisfies Walras' Law, but this has already been taken into account by leaving out the income-expenditure equation, which says that the value of total expenditure (equation 9) equals the value of total wages (equation 8) plus government revenue.

[5]Note that if the trade balance were not zero, there would need to be an entry in the SAM from the world account to the household account. The trade balance is income (positive or negative) to the household.

[6]Note that production is efficient in a second best environment given the tax structure.

that the composite good is the numeraire, so that its price, P^q, is set to one. Now consider an experiment where indirect taxes and/or tariffs are lowered — a typical liberalization experiment. Also assume for the moment that real absorption, Q , does not change — for some reason there are no reallocation effects from the liberalization. Given the numeraire, the value of total absorption ($P^q \cdot Q$) also does not change. However, government tax revenue falls. If household income is to remain adequate to buy *Q*, which the model and the SAM require, then the wage must rise, even though there are no changes in quantities, in order to offset the lower government transfers. This "transfer effect" on the real wage is independent of any efficiency effects.

The problem is that the taxes are embodied in the price system, so reducing them will change some prices, regardless of changes in quantities. In the experiment, the rise in wages is exactly offset by a reduction in government transfers — the transfer effect. Real household income does not change at all, even though the wage rises. Welfare measures such as equivalent or compensating variation will not change. It is only the real wage measure that is misleading.

The Transfer Effect in the 1-1-2-3 Model

The transfer effect involves a relationship between prices and taxes. In the 1-1-2-3 model, it can be seen by substituting the price equations (6 and 7) into equations 9 and 10. Repeating equation 8, the model can be reduced to four equations:

$$W \cdot L \quad P^x \cdot X \tag{12}$$

$$P^x \cdot T^x \cdot X \quad P^d \cdot D \quad R \cdot E \cdot \pi^e \tag{13}$$

$$P^q \cdot Q \quad P^d \cdot D \quad R \cdot T^m \cdot M \cdot \pi^m \tag{14}$$

$$P^d \quad \mathrm{H}(R, T^m, \pi^m, \pi^e) \tag{15}$$

Equation 15, summarizes the equilibrium relationship between world prices, the exchange rate, and the tariff rate and the price of the domestically supplied good, *D*. This relationship will depend on the various substitution and transformation elasticities.[7]

Log differentiate equations 12–15, assuming world prices are constant and that no quantities change. Define S^m as the share of imports in the value of total absorption and S^e as the share of exports in the value of total production. Use a hat (ˆ) over a variable to denote a log differential. The result is four equations in five price-change variables:

$$\hat{W} \quad \hat{P}^x \tag{16}$$

$$\hat{P}^x \quad (1 \quad S^e) \cdot \hat{P}^d \quad S^e \cdot \hat{R} \quad \hat{T}^x \tag{17}$$

[7]Devarajan, Lewis, and Robinson (1993) sort out the relationship between domestic prices, the exchange rate, and world prices in this model.

$$\hat{P}^{q} = (1 - S^{m})\cdot\hat{P}^{d} + S^{m}\cdot(\hat{R} + \hat{T}^{m}) \qquad (18)$$

$$\hat{P}^{d} = \eta_{1}\cdot\hat{R} + \eta_{2}\cdot\hat{T}^{m} \qquad (19)$$

where:

$$S^{e} = \frac{P^{e}\cdot E}{P^{x}\cdot X}$$

$$S^{m} = \frac{P^{m}\cdot M}{P^{q}\cdot Q}$$

In equation 19, world prices are assumed not to change, so the entire price transmission effect works through changes in the exchange rate and the tariff. The price transmission elasticities, η_{1} and η_{2}, will generally both be positive if the elasticity of substitution between imports (*M*) and domestic goods (*D*) is greater than one.[8]

As usual, one price has to be fixed by choice of numeraire. The model assumes a zero trade balance, so that $S^{e} = S^{m}$. Substitute equation 16 into 17 and subtract equation 18. The result is an equation for the change in the real wage as a function of changes in indirect taxes and tariffs:

$$\hat{W} - \hat{P}^{q} = -\hat{T}^{x} - S^{m}\cdot\hat{T}^{m} \qquad (20)$$

The percent change in the real wage equals minus the percent change in the indirect tax rate minus the import share weighted percent change in the tariff rate (where the rate variables are expressed as one plus the *ad valorem* rate). If indirect taxes or tariffs fall, the real wage rises. This equation holds regardless of what happens to any other prices and certainly does not depend on choice of numeraire.

If the analysis involves a revenue-neutral switch between two taxes that are functions of prices, then there will be no transfer effect on the real wage. For example, lowering tariffs and making up the revenue by increasing indirect taxes (or value added taxes) will lead to no change in direct taxes (or lump-sum transfers), and will not lead to a change in the real wage from the transfer effect. The two terms on the right hand side of equation 20 will be of opposite signs and exactly cancel out.

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[8]The elasticity of substitution between imports and domestic goods it typically greater than one for OECD countries. When imports become more expensive, the price of the domestic substitute also increases as consumers shift towards the domestic goods. For developing countries, however, imports and domestic goods can be poor substitutes. When the price of imported goods increases, exports must increase to pay for the increased cost of essential imports. The price of domestic goods falls in this case and there is a negative transmission elasticity.

Policy Scenarios

The transfer effect is not just an abstract theoretical result, but has important implications for macro policy. Table 3 presents the four price-change equations in a tableau that shows the diagonal structure of the causal chain. Consider a country which decides to shift from an income tax to a value added tax (VAT), which is equivalent to t^x in the model.[9] From equation 20, the real wage must fall as income taxes fall, keeping household income constant. The effect can be quite large. Shifting from an income tax to a VAT rate of 20 percent, which is common, will generate a 20 percent fall in the real wage.

Assume that macro policy targets the consumer price index, P^q, as the inflation indicator. Keeping it fixed implies that the nominal wage and the producer price index (W and P^x) must both fall (equations 20 and 16). Given that P^q is fixed, P^d and R must either stay fixed or move in opposite directions. From equation 19, they cannot move in opposite directions when both transmission elasticities are positive, so they will remain fixed.[10] Then P^x and W will both fall with the change in T^x (equations 17 and 16). A fall in the nominal wage may lead to labor problems, even given that real average household income will be unchanged.

Alternatively, assume that macro policy makers target the wage or the before-tax producer price index, P^x, as their inflation indicator. If they hold P^x fixed, then the equilibrium nominal wage will also remain fixed (equation 16). In this case, at the final equilibrium, P^q (the consumer price index) must rise, which implies that P^d and R must both rise (equations 17, 18, and 19). The economy will have a rise in the consumer price index and the nominal exchange rate (a devaluation), while the wage remains constant. While these two alternatives are theoretically identical in terms of their effects on relative prices, they may not appear identical to macro policymakers and might also engender quite different reactions from workers, even though they are one-time adjustments.

Finally, consider the effect of trade reform which involves lowering tariffs and/or eliminating import rationing (which generates an import premium that behaves like a tariff except that the "revenue" does not go to the government but to whoever has import rights). In countries with heavy protection and high trade shares, reform will have large macro effects. Cutting tariffs will lead to a rise in the real wage (equation 20) and also to a depreciation of the real exchange rate (equation 19), assuming P^d is constant. Developing countries typically raise a large share of government revenue from tariffs, and trade shares are also typically high. For a trade share of 40

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[9]There is a distinction between an "origin" value added tax (VAT), which includes exports but excludes imports, and a "destination" VAT, which excludes exports and includes imports. The variable t^x corresponds to an origin VAT, while a European-style VAT is a destination VAT. To model a destination VAT, we would introduce a tax on D, which excludes exports, and increase tariffs by the VAT as well.

[10]When both transmission elasticities are negative, P^d and R move in opposite directions.

percent of GDP and a tariff rate of 30 percent, a fifty percent cut in tariffs would lead to a 5 percent rise in the real wage (0.40 · (1.30 - 1.15)/1.30 = .05).

If the nominal exchange rate, *R*, is fixed, the domestic price level, P^d, will fall. The consumer price index, P^q, will also fall (equation 18), as will P^x (equation 17). The nominal wage will also fall, but not by as much as P^q. The result will be general deflation, even though real wages will rise. Alternatively, fixing a price index and allowing the nominal exchange rate to adjust will lead to the same adjustment of relative prices, but will not be deflationary and will thus look different to economic agents.

The Transfer Effect and Income Distribution

In a model with one input, labor, the transfer effect describes the change in value added when tax revenue is redistributed to the household in a lump sum fashion. This model, by construction, does not allow any link between production structure, trade, and factor markets. Indeed, adding more factors of production does not affect the analysis, since we assume no changes in quantities.

To analyze the transfer effect on income distribution, we need a model with two inputs, labor and capital. In the simplest form, this becomes a model with one country, two factors, two goods produced with separate sectoral production functions, and a third commodity consumed — the 1-2-2-3 model. The model equations appear in table 4. Two goods, D and E are produced using two inputs, L and K, equations (21) and (22). Factors are fully employed, equations (23) and (24), and all revenue from sales are paid to factors (zero profit conditions), equations (31) and (32). Other price equations and import demand are identical to those in the 1-1-2-3 model (table 1).[11] The model has 17 endogenous variables ($X, Q, D, E, M, L^e, L^d, K^d, K^e, P^x, P^q, P^e, P^m, P^d, R, W^l$ and W^k) and 16 equations. Labor (L) and capital stock (K) are assumed to be exogenous. The model can only determine relative prices, and one of the goods must be chosen as numeraire, with the corresponding price set to 1.

To describe the transfer effect, substitute equations (31) and (32) into equation (33) and use the full employment conditions, equations (23) and (24) for an expression of GDP at factor costs:

$$P^x \cdot X \quad W^l \cdot L \quad W^k \cdot K \tag{37}$$

Log differentiating, holding endowments constant:

$$\hat{P}^x \quad \beta^l \cdot \hat{W}^l \quad \beta^k \cdot \hat{W}^k \quad \hat{X} \tag{38}$$

[11]The 1-2-2-3 model is an extension of Jones (1965, 1974). See Robinson and Thierfelder (1996) for a detailed derivation of the 1-2-2-3 model.

$$\beta^k \quad \frac{W^k \cdot K}{W^k \cdot K \quad W^l \cdot L}$$

$$\beta^l \quad \frac{W^l \cdot L}{W^k \cdot K \quad W^l \cdot L}$$

Likewise, log differentiating the composite production and consumption goods:

$$\hat{P}^x \quad (1 \quad S^e)\cdot(\hat{P}^d \quad \hat{D}) \quad S^e\cdot(\hat{R} \quad \hat{E}) \quad \hat{X} \tag{39}$$

$$\hat{P}^q \quad (1 \quad S^m)\cdot(\hat{P}^d \quad \hat{D}) \quad S^m\cdot(\hat{R} \quad \hat{T}^m \quad \hat{M}) \quad \hat{Q} \tag{40}$$

Holding quantities constant and rearranging we find an expression analogous to equation (20):

$$\beta^k\cdot\hat{W}^k \quad \beta^l\cdot\hat{W}^l \quad \hat{P}^q \quad S^m\cdot\hat{T}^m \tag{41}$$

In a model with two factors, the transfer effect of an increase in the tariff rate is a reduction of the average wage, holding output constant.

To describe the transfer effect on income distribution, we need a model in which quantity changes. Movements along the production possibilities frontier (PPF) lead to changes in factor demands and therefore factor returns.

$$\beta^k\cdot\hat{W}^k \quad \beta^l\cdot\hat{W}^l \quad \hat{P}^q \quad S^m\cdot\hat{T}^m \quad S^e(\hat{E} \quad \hat{M}) \quad \hat{Q} \tag{42}$$

Assuming balanced trade:

$$\beta^k\cdot\hat{W}^k \quad \beta^l\cdot\hat{W}^l \quad \hat{P}^q \quad S^m\cdot\hat{T}^m \quad \hat{Q} \tag{43}$$

When a tariff increases, the downward pressure on factor returns is offset by the change in income needed to maintain the new level of household consumption.

To assess the impact of the transfer effect on income distribution, consider total income, the sum of factor payments and the lump-sum tariff revenue:

$$Y \quad W^l\cdot L \quad W^k\cdot K \quad T \tag{44}$$

$$T \quad t^m\cdot M\cdot\pi^m\cdot R \tag{45}$$

Log differentiating:

$$\hat{Y} \quad \gamma_l\cdot\hat{W}^l \quad \gamma_k\hat{W}^k \quad \gamma_t\cdot(\hat{t}^m \quad \hat{M} \quad \hat{R}) \tag{46}$$

$$\gamma_l \quad \frac{W^l\cdot L}{Y}$$

$$\gamma_k \quad \frac{W^k \cdot K}{Y}$$

$$\gamma_t \quad \frac{T}{Y}$$

Using equation (43), which describes the transfer effect when quantities can change and there is balanced trade, and simplifying the algebra, we find:[12]

$$\hat{Y} \quad \hat{W}^l \cdot \gamma_l \cdot \left(1 \quad \frac{t^m}{(1 \quad t^m)} \right) \quad \hat{W}_k \cdot \gamma_k \left(1 \quad \frac{t^m}{(1 \quad t^m)} \right) \quad \gamma_t \cdot \left(\frac{(\hat{P}^q \quad \hat{Q})}{S^m} \quad \hat{M} \quad \hat{R} \right) \tag{47}$$

$$0 \leq t^m \leq \infty$$

$$0 \leq \left(1 \quad \frac{t^m}{(1 \quad t^m)} \right) \leq 1$$

The transfer effect reduces the change in factor prices, but it does not change the sign. These factor price changes are linked to commodity prices as described in the Stolper-Samuelson theorem. For example an increase in the tariff on the labor-intensive good in the capital-abundant country will increase the real return to labor and decrease the real return to capital. We find that the transfer effect does not change the sign of the factor price change that comes out of general equilibrium trade models. It does, however, dampen the magnification effect of the change in commodity prices on factor returns.

Conclusion

We use a simple general equilibrium model to analyze the links between changes in *ad valorem* taxes and the real wage. In analyzing the tax-price-wage link, we distinguish between "efficiency effects" on wages, incomes, and welfare and a "transfer effect" which will lead to changes in the real wage even when there is no impact on household income and aggregate absorption. We show that an increase indirect taxes — even if the policy change is revenue neutral and does not change aggregate absorption — will reduce real wages. This result suggests

[12]See annex one for the complete derivation.

that it is misleading to equate welfare with real wages. Instead, one must use a measure such as compensating or equivalent variation which accounts for changes in household income from all sources. In models with more than one factor, the transfer effect affects the average factor return but does not alter the pattern of income redistribution among factors following a price shock.

The theoretical model is a simple representation of standard, trade-focused, CGE models. The results from this analysis, however, are quite general and will apply to any general equilibrium model that captures the full price system. When analyzing major changes in the tax system, such as the introduction of a value added tax or significant reduction of import protection, the transfer effect can be quite large. The results indicate the importance of using care when analyzing the impact of tax changes on factor returns, as well as on welfare.

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Table 1 — 1-1-2-3 Model Equations

$$X = \mathrm{V}(L) \tag{1}$$

$$X = \mathrm{G}(D, E) \tag{2}$$

$$Q = \mathrm{F}(D, M) \tag{3}$$

$$\frac{E}{D} = \mathrm{g}\left(\frac{P^e}{P^d}\right) \tag{4}$$

$$\frac{M}{D} = \mathrm{f}\left(\frac{P^m}{P^d}\right) \tag{5}$$

$$P^m = T^m \cdot \pi^m \cdot R \tag{6}$$

$$P^e = \pi^e \cdot R \tag{7}$$

$$P^x \cdot X = W \cdot L \tag{8}$$

$$P^x \cdot T^x \cdot X = P^d \cdot D + P^e \cdot E \tag{9}$$

$$P^q \cdot Q = P^d \cdot D + P^m \cdot M \tag{10}$$

$$\pi^e \cdot E = \pi^m \cdot M \tag{11}$$

Variable	Name	Variable	Name
X	Production	P^x	Price of X
D	Domestic sales	P^d	Price of D
E	Exports	P^e	Price of E
M	Imports	P^m	Price of M
Q	Composite good	P^q	Price of Q
L	Labor	π^e	World price of E
$T^m = 1 + t^m$	Tariff mark-up	π^m	World price of M
$T^x = 1 + t^x$	Indirect tax mark-up	R	Exchange rate

Notation	Name	Notation	Name
G	Transformation function	f	Import demand function
g	Export supply function	V	Production function
F	Composite good function		

Table 2 — SAM for 1-1-2-3 the Model

	Activities	Commodities	Households	Government	World
Activities		$P^d \cdot D$			$\tilde{E}$
Commodities			$P^q \cdot Q$		
Households	$W \cdot L$			$\tilde{T}^x \quad \tilde{T}^m$	
Government	$\tilde{T}^x$	$\tilde{T}^m$			
World		$\tilde{M}$			

The variables are defined in Table 1 and nominal magnitudes are indicated by variables with a tilde (˜):

$$\tilde{T}^x \quad t^x \cdot P^x \cdot X$$
$$\tilde{T}^m \quad t^m \cdot R \cdot \pi^m \cdot M$$
$$\tilde{E} \quad R \cdot \pi^e \cdot E$$
$$\tilde{M} \quad R \cdot \pi^m \cdot M$$

$$\text{GDP}(\text{factor cost}) \quad W \cdot L \quad P^x \cdot X$$
$$\text{GDP}(\text{market prices}) \quad P^x \cdot X \quad \tilde{T}^x \quad \tilde{T}^m \quad P^q \cdot Q \quad \tilde{E} \quad \tilde{M}$$

Table 3 — Coefficient Tableau for Price Change Equations

	Endogenous variables					
Equation	$\hat{W}$	$\hat{P}^{x}$	$\hat{P}^{q}$	$\hat{P}^{d}$	$\hat{R}$	Exogenous variables
16	1	-1				0
17		1		$(1 \quad S^{e})$	S^{e}	$\hat{T}^{x}$
18			1	$(1 \quad S^{m})$	S^{m}	$S^{m} \cdot \hat{T}^{m}$
19				1	η_{1}	$\eta_{2} \cdot \hat{T}^{m}$

Table 4 — 1-2-2-3 Model Equations

$$D \quad V^{d}(L^{d},K^{d}) \tag{21}$$

$$E \quad V^{e}(L^{e},K^{e}) \tag{22}$$

$$\left(\frac{K^{d}}{L^{d}}\right) \quad h\left(\frac{W^{k}}{W^{l}}\right) \tag{23}$$

$$\left(\frac{K^{e}}{L^{e}}\right) \quad i\left(\frac{W^{k}}{W^{l}}\right) \tag{24}$$

$$K \quad A_{k,e}\cdot E \quad A_{k,d}\cdot D \tag{25}$$

$$L \quad A_{l,e}\cdot E \quad A_{l,d}\cdot D \tag{26}$$

$$X \quad G(D,E) \tag{27}$$

$$Q \quad F(D,M) \tag{28}$$

$$\frac{M}{D} \quad \mathrm{f}\left(\frac{P^{m}}{P^{d}}\right) \tag{29}$$

$$P^{m} \quad T^{m}\cdot \pi^{m}\cdot R \tag{30}$$

$$P^{e} \quad \pi^{e}\cdot R \tag{31}$$

$$P^{d} \quad W^{l}\cdot A_{l,d} \quad W^{k}\cdot A_{k,d} \tag{32}$$

$$P^{e} \quad W^{l}\cdot A_{l,e} \quad W^{k}\cdot A_{k,e} \tag{33}$$

$$P^{x} \quad P^{d}\cdot \frac{D}{X} \quad P^{e}\cdot \frac{E}{x} \tag{34}$$

$$P^{q}\cdot Q \quad P^{d}\cdot D \quad P^{m}\cdot M \tag{35}$$

$$\pi^{e}\cdot E \quad \pi^{m}\cdot M \tag{36}$$

Variable	Name	Variable	Name
X	Composite production good	P^x	Price of X
D	Domestic production	P^d	Price of D
E	Export good production	P^e	Price of E
M	Imports	P^m	Price of M
Q	Composite good	W^l	Payment to labor
L	Labor	W^k	Payment to capital
K	Capital	P^q	Price of Q
V^j	Production function, j = d,e	π^e	World price of E
$A_{i,j}$	Input requirement of good i (L or K) to make one unit of good j (D or E)	π^m	World price of M
$T^m \quad 1 \quad t^m$	Tariff mark-up	R	Exchange rate

Notation	Name	Notation	Name
G	Transformation function	f	Import demand function
g	Export supply function	h	Capital demand function in production of good d
F	Composite good function	i	Capital demand function in production of good e

Annex One: Derivation of Income Distribution Changes

To assess the impact of the transfer effect on income distribution, consider total income, the sum of factor payments and the lump-sum tariff revenue:

$$Y \quad W^{l} \cdot L \quad W^{k} \cdot K \quad T \tag{A-1}$$

$$T \quad t^{m} \cdot M \cdot \pi^{m} \cdot R \tag{A-2}$$

Log differentiating:

$$\hat{Y} \quad \gamma_{l} \cdot \hat{W}^{l} \quad \gamma_{k} \hat{W}^{k} \quad \gamma_{t} \cdot (\hat{t}^{m} \quad \hat{M} \quad \hat{R}) \tag{A-3}$$

$$\gamma_{l} \quad \frac{W^{l} \cdot L}{Y}$$

$$\gamma_{k} \quad \frac{W^{k} \cdot K}{Y}$$

$$\gamma_{t} \quad \frac{T}{Y}$$

Equation (43) in the text describes the transfer effect when quantities can change and there is balanced trade:

$$\beta^{k} \cdot \hat{W}^{k} \quad \beta^{l} \cdot \hat{W}^{l} \quad \hat{P}^{q} \quad S^{m} \cdot \hat{T}^{m} \quad \hat{Q} \tag{A-4}$$

This can be rearranged to show:

$$\hat{T}^{m} \quad \frac{\hat{P}^{q} \quad \hat{Q} \quad (\beta_{k} \cdot \hat{W}^{k} \quad \beta^{l} \cdot \hat{W}^{l})}{S^{m}} \tag{A-5}$$

and by definition:

$$T^{m} \quad (1 \quad t^{m})$$

$$\hat{T}^{m} \quad \hat{t}^{m}$$

Substituting equation (A-5) into equation (A-3):

$$\hat{Y} \quad \gamma_{l} \cdot \hat{W}^{l} \quad \gamma_{k} \cdot \hat{W}^{k} \quad \frac{\gamma_{t}}{S^{m}} \left(\hat{P}^{q} \quad \hat{Q} \quad (\beta_{k} \cdot \hat{W}^{k} \quad \beta_{l} \cdot \hat{W}^{l}) \right) \quad \gamma_{t} \cdot (\hat{M} \quad \hat{R}) \tag{A-6}$$

and combining the coefficients on the changes in factor returns, this becomes:

$$\hat{Y} \quad \hat{W}^{l} \cdot \left(\gamma_{l} \quad \frac{\gamma_{t}}{S^{m}} \cdot \beta_{l} \right) \quad \hat{W}^{k} \cdot \left(\gamma_{k} \quad \frac{\gamma_{t}}{S^{m}} \cdot \beta_{k} \right) \quad \gamma_{t} \cdot \left(\frac{(\hat{P}^{q} \quad \hat{Q})}{S^{m}} \quad \hat{M} \quad \hat{R} \right) \tag{A-7}$$

The coefficient on $\hat{W}^{l}$ can be simplified as follows:

$$\gamma_l \quad \frac{\gamma_t}{S^m}\cdot\beta_l \quad \frac{w^l\cdot L}{Y} \quad \frac{T\cdot P^x\cdot X}{Y\cdot P^m\cdot M}\cdot\left(\frac{W^l\cdot L}{(W^l\cdot L \quad W^k\cdot K)}\right) \tag{A-8}$$

$$\gamma_l \quad \frac{\gamma_t}{S^m}\cdot\beta_l \quad \gamma_l\cdot\left(1 \quad \frac{t^m\cdot M\cdot\pi^m\cdot R}{(1 \quad t^m)\cdot\pi^m\cdot R\cdot M}\right) \tag{A-9}$$

$$\gamma_l \quad \frac{\gamma_t}{S^m}\cdot\beta_l \quad \gamma_l\left(1 \quad \frac{t^m}{(1 \quad t^m)}\right) \tag{A-10}$$

The coefficient on $\hat{W}^{k}$ similarly simplifies and the change in income becomes:

$$\hat{Y} \quad \hat{W}^l\cdot\gamma_l\cdot\left(1 \quad \frac{t^m}{(1 \quad t^m)}\right) \quad \hat{W}_k\cdot\gamma_k\left(1 \quad \frac{t^m}{(1 \quad t^m)}\right) \tag{A-11}$$

$$\gamma_t\cdot\left(\frac{(\hat{P}^q \quad \hat{Q})}{S^m} \quad \hat{M} \quad \hat{R}\right)$$

$$0 \le t^m \le \infty$$

$$0 \le \left(1 \quad \frac{t^m}{(1 \quad t^m)}\right) \le 1$$

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