Terms of Trade Effects: Theory and Methods of Measurement

Marshall B. Reinsdorf*

Marshall.Reinsdorf@BEA.gov

WP2009-01

January 2009

Changes in export and import prices that increase the opportunity for trading gains raise real income, and changes in these prices that reduce trading gains reduce real income. Even though trade is less important for the US economy than it is for many other economies, trading gains have a median absolute effect on US real GDI of 0.2 percentage points in annual data. The petroleum price shocks that occurred in late 1973 and in 1980 subtracted more than a full percentage point from the annual growth of real GDI, and in the first half of 2008 price increases in petroleum and other imported commodities subtracted 2 percentage points from the annual rate of growth of real GDI, making it negative despite the steady growth of real GDP. On the other hand, when petroleum prices are excluded, we find that US terms of trade have improved steadily since 1996. Combined with the contribution from a falling relative price of tradables excluding petroleum, these terms of trade improvements have increased the growth rate of US real GDI by an average of 0.15 percentage points. On a cumulative basis over the past 11 years, therefore, these effects have increased real GDI by over 1.7 percent.

* I am grateful to Ulrich Kohli for helpful discussions and to Erwin Diewert for helpful comments on an earlier draft of this paper. The views expressed in this paper are solely those of the author and should not be attributed to the Bureau of Economic Analysis, nor the Department of Commerce.

1. Introduction

Over the past half century the openness of the world's economies has grown rapidly as lower tariffs and advances in communication and transportation have lowered trading costs and advances in logistics have made complex, trans-national supply chains more manageable. As a result, export and import prices have an increased importance in determining the real consumption possibilities, or real income, of many nations. Information on these effects is therefore an important part of the picture of macroeconomic performance covered by national accounts.

A nation's real consumption possibilities depend not only on the volume of goods and services that it produces, but also on its gains from trading its own output for the output of other nations. Rising export prices or falling import prices increase the gains from trade, while falling export price or rising import prices reduce the gains from trade. Consequently, the change in the terms of trade—defined as the ratio of the exports price index to the imports price index—indicates the direction of the influence of trade prices on real gross domestic income (GDI).[1] Nations that export or import large amounts of volatile crude commodities regularly experience terms of trade shocks large enough to cause significant swings in real GDI over the short run. In first half of 2008, for example, a terms of trade shock made the growth rate of US real GDI negative even though US real GDP rose at a rate of 1.8 percent per year. Yet even over the longer run, substantial effects on real GDI are not unusual: a quarter of the countries in table 1 of Kohli (2004) register effects of 0.4 percent per year or more on the average growth rate of real GDI over a 16 year interval ending in 1996.

This paper first introduces the concept of real GDI in a Laspeyres framework, finding that the definition that deflates a part of income by the import price index lacks a sound justification even

[1] This paper uses the term "real GDI" as it is used in the System of National Accounts (SNA.) In the US National Income and Product Accounts (NIPAs), "real GDI" and "real GNI" refer to income-side estimates of production concepts, so "command-basis GNP" is used for the income concept that the SNA calls "real GNI." This paper also uses the SNA term "volume index" for what the NIPAs call a "quantity index," but it follows the terminology of the NIPAs and the academic literature in using the term "real GDP."

though it is widely used and is accepted by the international guidelines found in the SNA (United Nations, 1993 and 2008.) The paper next uses the economic approach to index numbers to develop theoretical economic measures of the terms of trade, trading gains and real GDI. Laspeyres and Paasche indexes are shown to provide upper or lower bounds for these economic concepts, and the averages of these bounds provided by Fisher indexes provide point estimates that accurately account for substitution effects. To analyze the sources of change in real GDI the paper develops formulas for the contributions of changes in the terms of trade and in the relative price of tradables. An application of these measurement techniques to US data reveals that, with petroleum imports excluded, improving terms of trade and falling prices of tradables made substantial contributions to US real GDI growth over the period from 1996 to 2007.

2. Real GDI as a Measure of the Purchasing Power of Gross Income

2.1 Difference between Real GDI and Real GDP

In nominal terms, production as measured by GDP is conceptually identical to the gross income arising from production as measured by GDI. One might therefore suppose that real GDP can serve as a measure of real GDI. Yet consideration of a special case where the correct measure of real GDI is clearly different from real GDP shows that it is a distinct concept.

The Laspeyres volume index is a common way of measuring real GDP that can be used to illustrate this point. Let $\mathbf{p}_{Dt}\cdot\mathbf{q}_{Dt}$, $\mathbf{p}_{Xt}\cdot\mathbf{q}_{Xt}$ and $\mathbf{p}_{Mt}\cdot\mathbf{q}_{Mt}$ be inner products of the price and quantity vectors for gross domestic final expenditures (GDFE), exports and imports, respectively, and let $P_D^{Paasche}$, $P_X^{Paasche}$ and $P_M^{Paasche}$ be Paasche price indexes. The Laspeyres volume index of GDP is:

$$V_{GDP}^{Lasp} \equiv \frac{\mathbf{p}_{Dt}\cdot\mathbf{q}_{Dt+1} + \mathbf{p}_{Xt}\cdot\mathbf{q}_{Xt+1} - \mathbf{p}_{Mt}\cdot\mathbf{q}_{Mt+1}}{\mathbf{p}_{Dt}\cdot\mathbf{q}_{Dt} + \mathbf{p}_{Xt}\cdot\mathbf{q}_{Xt} - \mathbf{p}_{Mt}\cdot\mathbf{q}_{Mt}}$$

$$= \frac{\mathbf{p}_{Dt+1}\cdot\mathbf{q}_{Dt+1}/P_D^{Paasche} + \mathbf{p}_{Xt+1}\cdot\mathbf{q}_{Xt+1}/P_X^{Paasche} - \mathbf{p}_{Mt+1}\cdot\mathbf{q}_{Mt+1}/P_M^{Paasche}}{\mathbf{p}_{Dt}\cdot\mathbf{q}_{Dt} + \mathbf{p}_{Xt}\cdot\mathbf{q}_{Xt} - \mathbf{p}_{Mt}\cdot\mathbf{q}_{Mt}}. \quad (1)$$

To keep the exposition simple, the foreign income receipts and payments that are included in gross national income (GNI) but not in GDI are assumed to be zero.[2] Then balanced trade implies that there is no net foreign borrowing and that all income is used for current consumption, where for purposes of analyzing terms of trade effects GDFE is an appropriate measure of consumption.[3]

Suppose that trade is indeed balanced in period t and period t+1, but that the deflators for exports and imports have different values. In this case, real GDP does not equal real GDFE even though GDP does equal GDFE in nominal terms. Yet with no borrowing and income entirely used for current consumption, the purchasing power of income is measured by real current consumption, so our measure of real GDI must be real GDFE.

The requirement that real GDI equal real GDFE when trade is balanced implies that a common deflator is needed for exports and imports. Therefore, in a Laspeyres framework, the index for real GDI must have the form:

$$V_{GDI}^{Lasp} = \frac{\mathbf{p}_{D_{t+1}} \cdot \mathbf{q}_{D_{t+1}} / P_D^{Paasche} + \mathbf{p}_{X_{t+1}} \cdot \mathbf{q}_{X_{t+1}} / P^* - \mathbf{p}_{M_{t+1}} \cdot \mathbf{q}_{M_{t+1}} / P^*}{\mathbf{p}_{D_t} \cdot \mathbf{q}_{D_t} + \mathbf{p}_{X_t} \cdot \mathbf{q}_{X_t} - \mathbf{p}_{M_t} \cdot \mathbf{q}_{M_t}}$$

$$= \frac{\mathbf{p}_{D_{t+1}} \cdot \mathbf{q}_{D_{t+1}} / P_D^{Paasche} + (\mathbf{p}_{X_{t+1}} \cdot \mathbf{q}_{X_{t+1}} - \mathbf{p}_{M_{t+1}} \cdot \mathbf{q}_{M_{t+1}}) / P^*}{\mathbf{p}_{D_t} \cdot \mathbf{q}_{D_t} + \mathbf{p}_{X_t} \cdot \mathbf{q}_{X_t} - \mathbf{p}_{M_t} \cdot \mathbf{q}_{M_t}} . \qquad (2)$$

The difference between the numerators of equations (2) and (1) is a measure of trading gains, and the ratio of real GDI to real GDP is the *trading gains index*. Multiplying real GDP by the trading gains index yields real GDI.

---

[2] Extending the results on real GDI to real GNI is a trivial matter: the same deflator may be used for GNI as the one that is used below to deflate GDI (Macdonald, 2007, p. 20.)

[3] We ignore the distinction between the investment and current consumption goods included in GDFE because the problem of how to treat purchases of fixed investment goods in converting nominal income to real income is tangential to our problem of how to account for terms of trade effects. A rationale for treating investment goods like consumption goods in a measure of real income is offered by Weitzman (1976).

2.2 Use of the Imports Price Index to Deflate Trade

GDI differs from GDFE when the trade balance is in surplus and income used for foreign lending, or when the trade balance is in deficit and consumption is financed by foreign borrowing. How to measure real GDI in these cases has long been a matter of controversy, with different authors advocating different definitions for P* in equation (2) (or for its counterpart in expressions for GDI based on Paasche or Törnqvist indexes.) Just two of these proposed definitions for P* are regularly used, however. An import price index was selected by Denison (1981) to measure real GNI in the US national accounts, and an import index is also used by Kehoe and Ruhl (2008) to be consistent with the method used in the US national accounts. The GDFE price index is used by Fox and Kohli (1998), Kohli (2004, 2006, and 2008) and Macdonald (2007, 2008). Both the imports index and the GDFE index are identified as acceptable definitions for P* in the 2008 System of National Accounts.

An approach that views the aim of trade as obtaining imports implies that P_M is the right definition for P*. Assume that a trade deficit would be closed by curtailing imports, and a trade surplus would be used to purchase additional imports, as in Nicholson (1960). Real income is measured by the real consumption that is afforded by nominal income. In the case of net lending, the weights for determining this level of real consumption depend on how the income used for lending would have been spent had it been used for consumption. In the case of net borrowing, these weights depend on how the composition of consumption would adjust if expenditures were reduced to match income.

If all imports are final goods, then $\mathbf{p}_{D_{t+1}} \cdot \mathbf{q}_{D_{t+1}} = \mathbf{p}_{D_{t+1}} \cdot (\mathbf{q}_{DD_{t+1}} + \mathbf{q}_{M_{t+1}})$, where $\mathbf{q}_{DD}$ is the vector of final goods that are produced domestically, and goods simultaneously supplied by domestic and foreign sources have a single price given by the appropriate element of $\mathbf{p}_D$. If net borrowing is used to purchase extra imports and net lending is funded by foregoing imports, the value of the imports

that would be purchased with current income just equals the value of exports. This implies an import vector of $(\mathbf{p}_{X_{t+1}} \cdot \mathbf{q}_{X_{t+1}} / \mathbf{p}_{M_{t+1}} \cdot \mathbf{q}_{M_{t+1}}) \mathbf{q}_{M_{t+1}}$ and a domestic final consumption vector of:

$$\tilde{\mathbf{q}}_{D_{t+1}} = \mathbf{q}_{DD_{t+1}} + (\mathbf{p}_{X_{t+1}} \cdot \mathbf{q}_{X_{t+1}} / \mathbf{p}_{M_{t+1}} \cdot \mathbf{q}_{M_{t+1}}) \mathbf{q}_{M_{t+1}}. \tag{3}$$

Valuing $\tilde{\mathbf{q}}_{D_{t+1}}$ at the period *t* prices used by the Laspeyres volume index, we obtain a measure of real GDI that specifies P* as $P_M^{Paasche}$:

$$\begin{aligned} \mathbf{p}_{D_t} \cdot \tilde{\mathbf{q}}_{D_{t+1}} &= \mathbf{p}_{D_t} \cdot \mathbf{q}_{DD_{t+1}} + \mathbf{p}_{M_t} \cdot \mathbf{q}_{M_{t+1}} (\mathbf{p}_{X_{t+1}} \cdot \mathbf{q}_{X_{t+1}} / \mathbf{p}_{M_{t+1}} \cdot \mathbf{q}_{M_{t+1}}) \\ &= \mathbf{p}_{D_{t+1}} \cdot \mathbf{q}_{D_{t+1}} / P_D^{Paasche} + \mathbf{p}_{X_{t+1}} \cdot \mathbf{q}_{X_{t+1}} / P_M^{Paasche} - \mathbf{p}_{M_{t+1}} \cdot \mathbf{q}_{M_{t+1}} / P_M^{Paasche}. \end{aligned} \tag{4}$$

A drawback of using equation (4) to measure real GDI is its asymmetric treatment of exports and imports. Taking the numerator of V_{GDI}^{Lasp} from equation (4), we find that $V_{GDI}^{Lasp} - V_{GDP}^{Lasp} = (s_{X_{t+1}} / P_X^{Paasche})(ToT^{Paasche} - 1)$, where $s_{X_{t+1}}$ is the share of exports in GDP and $ToT^{Paasche} = P_X^{Paasche} / P_M^{Paasche}$. Therefore, the growth rate of the trading gains index equals the price-adjusted exports share times the growth rate of the terms of trade index. Even the changes in terms of trade that arise from import prices are weighted by exports to measure real GDI.

The assumption used to derive equation (4) is also questionable. Assuming that marginal income is spent entirely on imports ignores the substitution possibilities between domestic consumption and exports. The adjustments made to close a trade deficit, for example, may involve an increase in exports and a contraction in domestic absorption that is broader in scope than just imported final products. What is more, economic theory does not predict the kind of links between sources and uses of income that would justify using weights that reflect the *sources* of income in a deflator for measuring the real *uses* (or purchasing power) of income.[4] Indeed, having one deflator for income originating from domestic final sales and another for income originating from net exports

[4] Deflating different sources of income with different deflators is appropriate for some other purposes, such as the estimation of real labor and capital inputs in a calculation of productivity growth.

makes the measure of real GDI depend, paradoxically, on the national saving rate. For example, many newly industrialized countries that have enjoyed strong productivity gains have had strong export growth and high national saving rates, so a relatively large share of their income will be adjusted by the import price index if this index is used to measure their real income from net exports. Conversely, the effect of import prices on real income will be *understated* in countries with negative national saving. For example, the effect on US real GDI of the improvement in terms of trade in the recession year of 2001 is found to be 0.2 percentage points when net exports are deflated by the imports index, compared to an estimate of 0.4 percentage points if the GDFE index is used instead.

2.3 Deflating Trade by the Index for GDFE

In the absence of direct evidence on the specific uses of marginal real income arising from trading gains, a reasonable assumption is that marginal income is spent in the same way as average income. This assumption—which is analogous to homotheticity in microeconomic models—is particularly appropriate in national accounts given the general range of purposes for which they are used. It means that GDFE adjusts to eliminate a trade imbalance. The appropriate specification for P* in equation (2) is then P_D, and the Laspeyres volume index for GDI should be:

$$V_{GDI}^{Lasp} = \frac{(\mathbf{p}_{D_{t+1}} \cdot \mathbf{q}_{D_{t+1}} + \mathbf{p}_{X_{t+1}} \cdot \mathbf{q}_{X_{t+1}} - \mathbf{p}_{M_{t+1}} \cdot \mathbf{q}_{M_{t+1}})/P_D^{Paasche}}{\mathbf{p}_{D_t} \cdot \mathbf{q}_{D_t} + \mathbf{p}_{X_t} \cdot \mathbf{q}_{X_t} - \mathbf{p}_{M_t} \cdot \mathbf{q}_{M_t}} . \tag{5}$$

A uniform proportional increase (decrease) in all components of domestic absorption that changes the value of GDFE by an amount equal to the trade surplus (deficit) results in adjustments to imports and exports that eliminate the trade imbalance under the assumptions that output prices are proportional to marginal costs of production and that input prices are equal to marginal revenue products. In the case of a trade deficit, for example, a uniform decrease in consumption will cause a

fall in imports of final and intermediate goods and a shift in production from domestic consumption to exports. The resulting rise in net exports will be equal in value to the fall of GDFE.

With real GDI defined as the level of real GDFE that could be purchased with current income, the definition of the trading gains index as the ratio of the Laspeyres volume indexes for GDI and GDP implies that it equals the ratio of Paasche price indexes of GDP and GDFE. $P_{GDP}^{Paasche}$ can be expressed as a harmonic mean with weights equal to the shares $s_{D_{t+1}}$, $s_{X_{t+1}}$, and $s_{M_{t+1}}$, so this ratio can be simplified as shown in equation (6):

$$\mathrm{TGI}^{\mathrm{PPI}} = \frac{(\mathbf{p}_{\mathrm{D}t+1}\cdot\mathbf{q}_{\mathrm{D}t+1} + \mathbf{p}_{\mathrm{X}t+1}\cdot\mathbf{q}_{\mathrm{X}t+1} - \mathbf{p}_{\mathrm{M}t+1}\cdot\mathbf{q}_{\mathrm{M}t+1})/\mathrm{P_D}^{\mathrm{Paasche}}}{\mathbf{p}_{\mathrm{D}t+1}\cdot\mathbf{q}_{\mathrm{D}t+1}/\mathrm{P_D}^{\mathrm{Paasche}} + \mathbf{p}_{\mathrm{X}t+1}\cdot\mathbf{q}_{\mathrm{X}t+1}/\mathrm{P_X}^{\mathrm{Paasche}} - \mathbf{p}_{\mathrm{M}t+1}\cdot\mathbf{q}_{\mathrm{M}t+1}/\mathrm{P_M}^{\mathrm{Paasche}}}.$$

$$= \frac{\mathrm{P_{GDP}}^{\mathrm{Paasche}}}{\mathrm{P_D}^{\mathrm{Paasche}}}$$

$$= \left[s_{D_{t+1}} + s_{X_{t+1}}(\mathrm{P_D}^{\mathrm{Paasche}}/\mathrm{P_X}^{\mathrm{Paasche}}) - s_{M_{t+1}}(\mathrm{P_D}^{\mathrm{Paasche}}/\mathrm{P_M}^{\mathrm{Paasche}})\right]^{-1}. \qquad (6)$$

The change in the bracketed term above can be expressed as the sum of a contribution from the change in the terms of trade and a contribution from the change in the relative price of tradables. The latter is measured as $\mathrm{RPT}^{\mathrm{Paasche}} = \mathrm{h}(\mathrm{P_X}^{\mathrm{Paasche}},\mathrm{P_M}^{\mathrm{Paasche}})/\mathrm{P_D}^{\mathrm{Paasche}}$, where $\mathrm{h}(\cdot,\cdot)$ denotes a harmonic mean. (RPT, which is also known as "the real exchange rate", is not a strict comparison of tradables and non-tradables because prices of final goods that are traded and also consumed domestically are included in both its numerator and its denominator.) Rearranging equation (6), we have:

$$\mathrm{TGI}^{\mathrm{PPI}} = \left[s_{D_{t+1}} + 0.5(s_{X_{t+1}} + s_{M_{t+1}})(\mathrm{P_D}^{\mathrm{Paasche}}/\mathrm{P_X}^{\mathrm{Paasche}})(1 - \mathrm{ToT}^{\mathrm{Paasche}}) + 0.5(s_{X_{t+1}} - s_{M_{t+1}})\mathrm{P_D}^{\mathrm{Paasche}}(1/\mathrm{P_X}^{\mathrm{Paasche}} + 1/\mathrm{P_M}^{\mathrm{Paasche}})\right]^{-1}$$

$$= \left[1 - 0.5(s_{X_{t+1}} + s_{M_{t+1}})(\mathrm{P_D}^{\mathrm{Paasche}}/\mathrm{P_X}^{\mathrm{Paasche}})(\mathrm{ToT}^{\mathrm{Paasche}} - 1) - (1 - s_{D_{t+1}})(1 - \mathrm{P_D}^{\mathrm{Paasche}}/\mathrm{h}(\mathrm{P_X}^{\mathrm{Paasche}},\mathrm{P_M}^{\mathrm{Paasche}}))\right]^{-1}.$$

$$= \left[1 - 0.5(s_{X_{t+1}} + s_{M_{t+1}})(\mathrm{P_D}^{\mathrm{Paasche}}/\mathrm{P_X}^{\mathrm{Paasche}})(\mathrm{ToT}^{\mathrm{Paasche}} - 1) - (s_{X_{t+1}} - s_{M_{t+1}})((\mathrm{RPT}^{\mathrm{Paasche}} - 1)/\mathrm{RPT}^{\mathrm{Paasche}})\right]^{-1}. \quad (7)$$

A first-order Taylor series for equation (7) implies a lower bound approximation to the change in the trading gains as the sum of the change in terms of trade times the average share of trade in GDP and the change in the relative price of tradables times the trade balance's share of GDP:

$$\mathrm{TGI}^{\mathrm{PPI}} - 1 \approx 0.5(s_{X_{t+1}} + s_{M_{t+1}})(\mathrm{P_D}^{\mathrm{Paasche}}/\mathrm{P_X}^{\mathrm{Paasche}})(\mathrm{ToT}^{\mathrm{Paasche}} - 1) + (s_{X_{t+1}} - s_{M_{t+1}})(\mathrm{RPT}^{\mathrm{Paasche}} - 1)/\mathrm{RPT}^{\mathrm{Paasche}}. \quad (8)$$

For example, if the improvement in the terms of trade is 10 percent and the average share of trade in GDP is 10 percent, the change in the trading gains index would be about +1 percent. An increase of 1 percent would also occur in real GDI, assuming that real GDP is constant. Suppose further that the trade deficit equals 5 percent of GDP and the relative price of tradables falls by 2 percent. Then real GDI would rise by 0.1 percent.[5]

The expression for the change in trading gains in a Laspeyres price index framework is similar but simpler. It compares Paasche volume indexes for GDI and GDP, where the index for GDI is:

$$\mathrm{V_{GDI}}^{\mathrm{Paasche}} = \frac{\mathbf{p}_{\mathrm{D}t+1}\cdot\mathbf{q}_{\mathrm{D}t+1} + \mathbf{p}_{\mathrm{X}t+1}\cdot\mathbf{q}_{\mathrm{X}t+1} - \mathbf{p}_{\mathrm{M}t+1}\cdot\mathbf{q}_{\mathrm{M}t+1}}{(\mathbf{p}_{\mathrm{D}t}\cdot\mathbf{q}_{\mathrm{D}t} + \mathbf{p}_{\mathrm{X}t}\cdot\mathbf{q}_{\mathrm{X}t} - \mathbf{p}_{\mathrm{M}t}\cdot\mathbf{q}_{\mathrm{M}t})\mathrm{P_D}^{\mathrm{Lasp}}}. \quad (9)$$

After canceling out the identical numerators in the ratio of the Paasche volume indexes for GDI and GDP, we obtain a trading gains index that compares Laspeyres price indexes of GDP and GDFE:

$$\mathrm{TGI}^{\mathrm{LPI}} = \frac{(\mathbf{p}_{\mathrm{D}t}\cdot\mathbf{q}_{\mathrm{D}t})\mathrm{P_D}^{\mathrm{Lasp}} + (\mathbf{p}_{\mathrm{X}t}\cdot\mathbf{q}_{\mathrm{X}t})\mathrm{P_X}^{\mathrm{Lasp}} - (\mathbf{p}_{\mathrm{M}t}\cdot\mathbf{q}_{\mathrm{M}t})\mathrm{P_M}^{\mathrm{Lasp}}}{(\mathbf{p}_{\mathrm{D}t}\cdot\mathbf{q}_{\mathrm{D}t} + \mathbf{p}_{\mathrm{X}t}\cdot\mathbf{q}_{\mathrm{X}t} - \mathbf{p}_{\mathrm{M}t}\cdot\mathbf{q}_{\mathrm{M}t})\mathrm{P_D}^{\mathrm{Lasp}}}$$

[5] A parallel expression using Törnqvist indexes is derived by Kohli (2006 and 2008), though he uses the term "real exchange rate" for RPT.

$$= s_{D_t} + s_{X_t}(P_X^{Lasp}/P_D^{Lasp}) - s_{M_t}(P_M^{Lasp}/P_D^{Lasp})$$

$$= 1 + s_{X_t}(P_X^{Lasp}/P_D^{Lasp} - 1) - s_{M_t}(P_M^{Lasp}/P_D^{Lasp} - 1). \quad (10)$$

Subtracting 1 from both sides of equation (10) provides the formula for contributions to change in the trading gains index of export prices and import prices. This formula can also be rearranged to decompose the change in trading gains into a contribution from the change in terms of trade and a contribution from the change in the relative price of tradables. If $ToT^{Lasp} = P_X^{Lasp}/P_M^{Lasp}$ and RPT^{Lasp} is the ratio of a simple average of P_X^{Lasp} and P_M^{Lasp} to P_D^{Lasp}, equation (10) implies that:

$$TGI^{LPI} - 1 = 0.5(s_{X_t} + s_{M_t})(P_X^{Lasp}/P_D^{Lasp} - P_M^{Lasp}/P_D^{Lasp}) + (s_{X_t} - s_{M_t})[(P_X^{Lasp} + P_M^{Lasp})/2P_D^{Lasp} - 1]$$

$$= 0.5(s_{X_t} + s_{M_t})(P_M^{Lasp}/P_D^{Lasp})(ToT^{Lasp} - 1) + (s_{X_t} - s_{M_t})(RPT^{Lasp} - 1). \quad (11)$$

As in equation (8), the change in the terms of trade is weighted by the average share of trade in GDP, and the change in the relative price of tradables is weighted by the trade balance's share of GDP.

3. Laspeyres and Paasche Bounds for the Theoretical Index of Trading Gains

3.1 Laspeyres and Paasche Bounds in the Theories of Consumption and Output Indexes

A well-defined conceptual goal of estimation is needed to guide the design of an estimator and to elucidate its properties and limitations. For the indexes of the terms of trade and trading gains, the economic approach to index number theory may be used to derive the underlying measurement objective and to clarify the economic meaning of their Laspeyres and Paasche index versions. In particular, Laspeyres and Paasche indexes bound underlying economic concepts of terms of trade indexes, trading gains indexes and real GDI from opposite sides. Fisher index averages of these bounds therefore provide better measures of the relevant economic concepts than either Laspeyres or Paasche indexes on their own.

The economic approach to index numbers assumes that consumption and production decisions are solutions to constrained optimization problems. In the production case, the observed mix of outputs maximizes revenue (or value added) over a convex set of outputs (and intermediate inputs in the value added case) that is attainable given the inputs at the disposal of the producer. In the consumption case, the observed consumption vector maximizes utility subject to a budget constraint, so it represents the cost-minimizing point in the convex set of consumption vectors that yield a utility greater than or equal to the utility level that was actually attained.

The bounding properties for the Laspeyres and Paasche indexes implied by these assumptions have been the topic of a large literature in the context of the consumption measurement problem, so we will consider this problem first, then turn to the production measurement problem. Economic price and volume indexes of consumption track the change in the expenditure function $e(\mathbf{p},u)$, which gives the minimum cost of achieving utility or welfare level u at the vector of prices $\mathbf{p}$. (The properties of the utility function linking u to the vector of quantities $\mathbf{q}$ allow u to play the role of a summary statistic for $\mathbf{q}$ in these indexes.) The Laspeyres-perspective volume index holds prices and preferences constant at their initial value, so it may be written as $e_t(\mathbf{p}_t,u_{t+1})/e_t(\mathbf{p}_t,u_t)$, where $e_t(\cdot)$ denotes the expenditure function reflecting the structure of preferences in period t. The minimum cost of achieving the utility of period t at the prices of period t equals $\mathbf{p}_t\cdot\mathbf{q}_t$, but the minimum cost of achieving the utility level of period t+1 at those prices might be less than $\mathbf{p}_t\cdot\mathbf{q}_{t+1}$. Consequently, $e_t(\mathbf{p}_t,u_{t+1})/e_t(\mathbf{p}_t,u_t) \leq \mathbf{p}_t\cdot\mathbf{q}_{t+1}/\mathbf{p}_t\cdot\mathbf{q}_t$, which shows that the Laspeyres-perspective economic index is bounded from above by the ordinary Laspeyres index. Similarly, the possibility that its denominator might be too high makes the Paasche index a *lower* bound on a Paasche-perspective economic index of consumption. In the volume index case, some other consumption bundle besides $\mathbf{q}_t$ might achieve u_t at lower cost at the prices of the final period, so $\mathbf{p}_{t+1}\cdot\mathbf{q}_{t+1}/\mathbf{p}_{t+1}\cdot\mathbf{q}_t \leq e_{t+1}(\mathbf{p}_{t+1},u_{t+1})/e_{t+1}(\mathbf{p}_{t+1},u_t)$.

Under the usual assumption of stable preferences, prices are needed to value a change in welfare, but not to know its sign. Consequently, given constant preferences, a Laspeyres or Paasche volume index that equals 1 has a bounding property that is independent of whether the Laspeyres or Paasche perspective is selected. According to the Weak Axiom of Revealed Preference (WARP), $\mathbf{q}_{t+1}$ cannot be strictly preferred to a consumption bundle that was chosen when $\mathbf{q}_{t+1}$ would have cost the same or less. In other words, an opportunity set that contains a consumption bundle that was actually chosen cannot be inferior to the opportunity set that existed when that bundle was chosen.

If the Laspeyres volume index is *less than* or equal to 1, then $\mathbf{q}_{t+1}$ was in the opportunity set when $\mathbf{q}_t$ was chosen, so WARP tells us that the opportunity set of period t represents at least as high a level of welfare as that of period t+1. Conversely, a Paasche volume index *greater than* 1 implies that the change in welfare is non-negative, as $\mathbf{q}_t$ remains in the opportunity set in period t+1.

The output measurement problem is analogous to the consumption measurement problem, except the positions of the Laspeyres and Paasche indexes are reversed (see the parallel expositions of consumption and production index theory in Varian, 1982 and 1984.) This reversal occurs because the objective function used to gauge the position of the production possibility frontier tracks maximized revenue, not minimized costs. The Laspeyres volume index is a *lower* bound on the Laspeyres-perspective economic index of output volume because at prices $\mathbf{p}_t$ some other point besides $\mathbf{q}_{t+1}$ on the production possibility frontier passing through $\mathbf{q}_{t+1}$ might give the producer more revenue than $\mathbf{p}_t \cdot \mathbf{q}_{t+1}$. Similarly, the Paasche volume index is an *upper* bound on the Paasche-perspective economic output volume index because at prices $\mathbf{p}_{t+1}$ some other point on production possibility frontier passing through $\mathbf{q}_t$ might yield higher revenue than $\mathbf{p}_{t+1} \cdot \mathbf{q}_t$.[6]

[6] In practical applications of this theory, the Laspeyres index is often found to be *above* the Paasche index. This pattern is not consistent with constant technology, so it suggests the presence of supply shocks that cause the Paasche-perspective production index to reflect a different technology from the Laspeyres-perspective index.

Similar logic can be applied to an objective function of maximizing value added rather than revenue as long as the Laspeyres and Paasche indexes of value added remain positive. GDP equals the consolidated value added of all the producers in the economy, so indexes of GDP are examples of value added indexes. This is made clear by Diewert and Morrison's (1986) economic volume index for GDP, which treats imports as intermediate inputs.

Figure 1 illustrates GDP and GDFE for a simple economy that exports one final good and uses the proceeds to pay for imports of another final good. The balanced trade constraint implies a budget line for this economy whose slope equals minus the ratio of the export good price to the import good price. The production possibility frontier—whose position is measured by real GDP—reflects the inputs and technology at the disposal of the economy's producers. In a competitive equilibrium, production is at point A, which is the point on the production possibility frontier that maximizes revenue given the slope of the budget line. GDFE is given by point B, which is on the highest indifference curve attainable by trade. Gains from trade make this indifference curve superior to any indifference curve that intersects the production possibility frontier.

The effect of a deterioration in terms of trade is shown in figure 2. Production shifts along the production possibility frontier to point A′, and consumption falls to the lower indifference that passes through point B′. The Laspeyres volume index for GDP uses the original slope of the budget line to evaluate the change in production to point A′, so it implies that output has fallen even though the true change in output is zero. In contrast to the downward bias of the Laspeyres volume index of GDP, the Laspeyres volume index of GDFE will *understate* the fall in consumption (that is, have an upward bias) because the budget line with the original slope will have a point of tangency on the indifference curve passing through point B′ that is below point B′. The biases of the Paasche indexes are in the opposite direction. For example, the Paasche volume index for GDP uses the final slope of the budget line so it incorrectly implies that point A′ represents a higher level of output.

3.2 Economic Concepts of Trading Gains and Real GDI

3.2.1. Assumptions

We make a number of assumptions to simplify our investigation of the effects of export and import price changes. First, we assume a budget constraint that requires balanced trade. A budget constraint with a lower limit on the trade surplus or an upper limit on the deficit, though more realistic, would imply similar upper and lower bound characteristics for the Laspeyres and Paasche indexes to those derived below. Only the results showing when the direction of change in the economic measure of real GDI can be inferred from the direction of change in the terms of trade would change in a significant way, as they would have to include an extra condition concerning the change in the relative price of tradables.

Second, as discussed in footnote 3, in applying the definition of real GDI as the level of consumption that can be purchased with nominal GDI, we take consumption to mean GDFE despite the presence of an investment component in GDFE that provides for future consumption. Also, our theoretical exposition focuses on *gross* income, even though the amount of investment that is needed to offset consumption of fixed capital is not part of the concept of income as sustainable consumption recommended by Diewert (2008.) Real *net* domestic income calculated as net domestic product deflated by the index for net DFE is included in our empirical results, however.

We also make three assumptions concerning prices. Price changes are not so extreme that a numerator or denominator of any Laspeyres or Paasche index ceases to be positive, prices of traded goods are exogenous world prices (which means that the country does not attempt to exercise monopoly or monopsony power in its production or purchase decisions), and purchasers' prices and producers' prices are the same because tariffs or other taxes on products are absent. Tariffs cause GDP to exceed gross value added at basic prices because GDP measures imports at tariff-free prices. The effect of extending our model to include the tariffs and other taxes on products would be to make

the volume index of gross value added at basic prices the measure of output growth arising from growth in inputs and productivity change. The difference between this index and the volume index of GDP would then measure the change in the deadweight losses due to tax-induced misallocations.[7]

In the older literature on terms of trade effects, trade is generally assumed to involve final goods, while in the recent literature imports are treated as intermediate inputs in recognition of the fact that most trade is in products that require further processing, or at least wholesale and retail distribution services.[8] Nevertheless significant amounts of imports do not even require distribution services, such as finished investment goods and services for final consumption. Therefore, we assume that $\mathbf{p}_{M_t}\cdot\mathbf{q}_{M_t} = \mathbf{p}_{DM_t}\cdot\mathbf{q}_{DM_t} + \mathbf{p}_{MM_t}\cdot\mathbf{q}_{MM_t}$, where $\mathbf{q}_{DM}$ is the quantity vector of final commodity imports and $\mathbf{q}_{MM_t}$ is the quantity vector of imported intermediate inputs. The presence of imports of final goods as a component of domestic final expenditures implies that domestic final expenditures in period t are $\mathbf{p}_{D_t}\cdot\mathbf{q}_{D_t} = \mathbf{p}_{D_t}\cdot(\mathbf{q}_{DD_t} + \mathbf{q}_{DM_t})$, so the expression for GDP as $\mathbf{p}_{\mathrm{D}t}\cdot\mathbf{q}_{\mathrm{D}t} + \mathbf{p}_{\mathrm{X}t}\cdot\mathbf{q}_{\mathrm{X}t} - \mathbf{p}_{\mathrm{M}t}\cdot\mathbf{q}_{\mathrm{M}t}$ can be simplified to: $\mathrm{GDP}_t = \mathbf{p}_{D_t}\cdot\mathbf{q}_{DD_t} + \mathbf{p}_{X_t}\cdot\mathbf{q}_{X_t} - \mathbf{p}_{MM_t}\cdot\mathbf{q}_{MM_t}$.

We also assume a full-employment equilibrium where producers are price-taking profit maximizers, and consumers utility maximizers, so that price ratios are equal to marginal rates of transformation for producers and marginal rates of substitution for consumers. As shown by Diewert and Morrison (1986), this allows us to define the GDP function as a maximum of value added given the endowment of primary inputs and technology and configuration of world prices for traded goods. Let $S_t(\mathbf{L}_t)$ be the set of feasible combinations of final domestic absorption product outputs $\mathbf{q}_{DD}$, export product outputs $\mathbf{q}_X$, and imported intermediate inputs $\mathbf{q}_{MM}$ given the technology of time t and the

[7] Feenstra, Reinsdorf and Slaughter (2009) show that in a neo-classical model, an elimination of tariffs increases GDP by inducing an expansion in trade. Aulin-Ahmavaara and Pakarinen (2007) investigate how taxes on products used as intermediate inputs affect productivity measurement.

[8] Krueger and Sonnenschein (1967) derive some key results on terms of trade effects using the older approach. Their Proposition 2, which implies that real GDI rises whenever the Laspeyres terms of trade index rises and real GDP is constant, resembles Corollary 1.2 below. Some papers that treat imports as intermediate goods are: Diewert and Morrison (1986), Diewert (2005, 2008), Diewert and Lawrence (2006) and Kohli (2004, 2005, 2006, 2008.)

endowment of primary inputs $\mathbf{L}_t$. The production technology is such that $S_t(\mathbf{L}_t)$ is strictly convex. Then, the GDP function $G_t(\mathbf{p}_{D_t}, \mathbf{p}_{X_t}, \mathbf{p}_{MM_t}, \mathbf{L}_t)$ for the technology of time t is defined by:

$$\begin{aligned} \mathrm{GDP}_t &= G_t(\mathbf{p}_{D_t}, \mathbf{p}_{X_t}, \mathbf{p}_{MM_t}, \mathbf{L}_t) \\ &= \underset{(\mathbf{q}_{DD},\mathbf{q}_X,\mathbf{q}_{MM})\in S_t(\mathbf{L}_t)}{\text{maximum}} \mathbf{p}_{D_t}\cdot\mathbf{q}_{DD} + \mathbf{p}_{X_t}\cdot\mathbf{q}_X - \mathbf{p}_{MM_t}\cdot\mathbf{q}_{MM}. \end{aligned} \tag{12}$$

Last, we assume stable preferences. Then the Laspeyres-perspective and Paasche-perspective economic volume indexes for GDFE have the form of Allen indexes:

$$\mathrm{Q_D}^{\mathrm{Lasp}} = e(\mathbf{p}_{D_t}, U(\mathbf{q}_{D_{t+1}})) \,/\, e(\mathbf{p}_{D_t}, U(\mathbf{q}_{D_t})) \tag{13}$$

and

$$\mathrm{Q_D}^{\mathrm{Paasche}} = e(\mathbf{p}_{D_{t+1}}, U(\mathbf{q}_{D_{t+1}})) \,/\, e(\mathbf{p}_{D_{t+1}}, U(\mathbf{q}_{D_t})). \tag{14}$$

3.2.2 Inferring the Direction of Change in Real GDI from the Change in Terms of Trade

Under certain conditions, WARP can be used to show that a rise in the Laspeyres terms of trade index implies a rise in real GDI and that a fall in the Paasche terms of trade index implies a fall in real GDI. However, a fall in the Laspeyres terms of trade index or a rise in the Paasche terms of trade index is not indicative of the direction of change in real GDI.

Consider first the Laspeyres terms of trade index. Under an assumption of balanced trade, equation (11) can be simplified to:

$$\mathrm{TGI}^{\mathrm{LPI}} - 1 = \hat{s}_{M_{t+1}}[\mathrm{ToT}^{\mathrm{Lasp}} - 1], \tag{15}$$

where $\hat{s}_{M_{t+1}} = s_{M_t}(\mathrm{P_M}^{\mathrm{Lasp}} / \mathrm{P_D}^{\mathrm{Lasp}})$, the predicted share of imports in GDP given Leontief behavior and unchanged terms of trade. Balanced trade also implies that the Paasche volume index of GDFE equals the Paasche volume index of GDP times $\mathrm{TGI}^{\mathrm{LPI}}$. Therefore, given constant real GDP, if the

change in ToT^{Lasp} is positive, so is the change in the Paasche volume index GDFE. By WARP, a positive change in the Paasche volume index of GDFE implies a positive change in welfare, or real GDI. This is stated formally in the following proposition:

PROPOSITION 1: *Given balanced trade and a Paasche volume index of GDP ≥ 1, a rise in the Laspeyres terms of trade index implies a rise in real GDI.*

Proposition 1 is surprising in one respect. Non-negativity of the Paasche index for GDP is a weaker condition than non-negativity of the economic index of GDP because substitution effects can make the Paasche volume index of GDP exceed the Paasche-perspective economic index of GDP. Thus, a small improvement in trade prices can be accompanied by a negative productivity shock, yet we can be sure that real GDI has risen! The explanation for this paradox is that the downward substitution bias of TGI^{LPI} documented in Proposition 4 below offsets the effects of upward substitution bias of the Paasche index of GDP.

To derive an analogous result to Proposition 1 using Paasche price indexes, let $\hat{s}_{X_t} = s_{X_{t+1}}(\text{P}_\text{D}^{\text{Paasche}}/\text{P}_\text{X}^{\text{Paasche}})$, the share of exports in GDP in period t that would be predicted from the observed share in period t+1 given unchanged terms of trade. Then, under the assumption of balanced trade, we can simplify the final expression in equation (7) and subtract 1 from both sides of the equation to obtain:

$$\begin{aligned}\text{TGI}^{\text{PPI}} - 1 &= \left[1 - \hat{s}_{X_t}(\text{ToT}^{\text{Paasche}} - 1)\right]^{-1} - 1 \\ &= \hat{s}_{X_t}(\text{ToT}^{\text{Paasche}} - 1) + \left[\hat{s}_{X_t}(\text{ToT}^{\text{Paasche}} - 1)\right]^2 + \left[\hat{s}_{X_t}(\text{ToT}^{\text{Paasche}} - 1)\right]^3 + \ldots \qquad (16)\end{aligned}$$

Because $|\hat{s}_{X_t}(\text{ToT}^{\text{Paasche}} - 1)| < 1$ by assumption, the sign of $\hat{s}_{X_t}(\text{ToT}^{\text{Paasche}} - 1)$ determines the sign of the sum on the right side of equation (16). Also, with balanced trade, the Laspeyres volume index of GDFE equals the Paasche volume index of GDP times TGI^{LPI}. Thus if $\text{ToT}^{\text{Paasche}}$ falls with

GDP held constant, then so does the Laspeyres volume index of GDFE. But by WARP, if the change in the Laspeyres volume index of GDFE is negative, then so is the change in real GDI. We therefore have Proposition 2:

PROPOSITION 2. *Given balanced trade and a Laspeyres volume index of GDP ≤ 1, a decline in the Paasche terms of trade index implies a fall in real GDI.*

3.2.3 Upper and Lower Bounds for Economic Indexes of Terms of Trade and Trading Gains

Bounding properties for the Laspeyres and Paasche trading gains indexes can be derived from the properties of the volume indexes for GDFE and GDP. The following proposition shows that the Laspeyres volume index of GDP in the denominator of TGI^{PPI} is a lower bound on the Laspeyres-perspective economic index of GDP, while the Paasche volume index of GDP in the denominator of TGI^{LPI} is an upper bound on the Paasche-perspective economic index of GDP.

PROPOSITION 3: *The Paasche volume index of GDP is an upper bound for the Paasche-perspective economic index of GDP, and the Laspeyres volume index of GDP is a lower bound for the Laspeyres-perspective economic index of GDP.*

PROOF: The Paasche volume index for GDP is:

$$V_{GDP}^{\text{Paasche}} = \frac{\mathbf{p}_{D_{t+1}} \cdot \mathbf{q}_{DD_{t+1}} + \mathbf{p}_{X_{t+1}} \cdot \mathbf{q}_{X_{t+1}} - \mathbf{p}_{MM_{t+1}} \cdot \mathbf{q}_{MM_{t+1}}}{\mathbf{p}_{D_{t+1}} \cdot \mathbf{q}_{DD_t} + \mathbf{p}_{X_{t+1}} \cdot \mathbf{q}_{X_t} - \mathbf{p}_{MM_{t+1}} \cdot \mathbf{q}_{MM_t}} . \tag{17}$$

The Paasche-perspective economic index of GDP uses the prices of period t+1 to compare the level of output that is possible with the technology and primary inputs of period t+1 to the level of output that is possible with the technology and primary inputs of period t. It does this by comparing optimal points in the production possibility sets $S_{t+1}(\mathbf{L}_{t+1})$ and $S_t(\mathbf{L}_t)$:

$$Q_{GDP}^{\text{Paasche}} = \frac{G_{t+1}(\mathbf{p}_{Dt+1}, \mathbf{p}_{Xt+1}, \mathbf{p}_{MMt+1}, \mathbf{L}_{t+1})}{G_t(\mathbf{p}_{Dt+1}, \mathbf{p}_{Xt+1}, \mathbf{p}_{MMt+1}, \mathbf{L}_t)} . \tag{18}$$

The numerator of the Paasche-perspective economic index of GDP equals the numerator of the Paasche index, but its denominator is the maximum over the set $S_t(\mathbf{L}_t)$. The quantities in the denominator of the Paasche volume index are also a point in $S_t(\mathbf{L}_t)$, so $Q_{GDP}^{\text{Paasche}} \leq V_{GDP}^{\text{Paasche}}$.

The proof of the lower bound property of the Laspeyres volume index of GDP is analogous. ■

The Laspeyres volume index of GDFE in the numerator of TGI^{PPI} is an upper bound on the Laspeyres-perspective economic index, while the Paasche volume index of GDFE in the numerator of TGI^{LPI} is a lower bound on the Paasche-perspective economic index. (The proof of the bounds for the economic volume indexes of consumption, or Allen indexes, is analogous to the proof of Proposition 3, but with the roles of the Laspeyres and Paasche indexes reversed.) The bounds for the trading gains indexes thus resemble the bounds for the volume indexes of GDFE in their numerator:

PROPOSITION 4: *Let the Laspeyres-perspective economic index of trading gains be defined as the ratio of the Laspeyres-perspective volume index of GDI to the Laspeyres-perspective volume index of GDP, with the Paasche-perspective economic index of trading gains defined analogously. The trading gains index calculated from Paasche price indexes,* TGI^{PPI}, *is an upper bound for a Laspeyres-perspective economic index of trading gains. The trading gains index calculated from Laspeyres price indexes*, TGI^{LPI}, *is a lower bound for a Paasche-perspective economic index of trading gains.*

4. Contributions to Change in Trading Gains in a Fisher Index Framework

The bounding results derived in section 3 arise because price changes generate substitution effects that make Laspeyres and Paasche indexes diverge from their economic index counterparts in opposite directions. Fisher price and volume indexes for GDFE account for these effects because the

substitution biases that give the Laspeyres and Paasche indexes their character as upper and lower bounds offset one another when they are averaged. Similarly, Fisher indexes of GDP properly account for substitution in production between outputs and between types of intermediate inputs.[9] Furthermore, although other superlative indexes are able to account for substitution effects in a satisfactory way under many circumstances, the Fisher index is the only superlative index that is always within the Laspeyres-Paasche bounds (Hill, 2006.) An index formula that can be outside the Laspeyres-Paasche bounds is likely to get the sign of the welfare change wrong under some circumstances, since it will violate WARP if it is too far below a slowly rising Paasche volume index, or too far above a slowly falling Laspeyres volume index.

Another advantage of Fisher indexes for national accounts purposes is that deflating by a Fisher price index yields a Fisher volume index (a property known as "factor reversal" in the literature on the axiomatic approach to indexes.) The Fisher trading gains index defined as $[GDP_{t+1} / P_D^{Fisher}] / [GDP_{t+1} / P_{GDP}^{Fisher}]$ can therefore be calculated from Fisher price indexes as $TGI^{Fisher} = P_{GDP}^{Fisher}/P_D^{Fisher}$. Expressions for Fisher price indexes are precisely analogous to expressions for Fisher volume indexes, with prices and quantities exchanging roles.

The disadvantage of Fisher indexes in national accounts is that they are not additive. The solution to this problem is express the top-level Fisher index as a weighted average of lower level aggregates that are not themselves Fisher indexes except in special cases. A formula for these additive contributions based on a decomposition due to Dikhanov (1997) and van IJzeren (1951) is an excellent approximation to the contributions to change in an economic objective function (Reinsdorf, Diewert and Ehemann, 2002.)

[9] Fisher indexes also permit reliable measurement of both price change and volume change *at the same time*. With a Laspeyres volume index based in period, the change in the implied Paasche price index between year t+1 and year t+2 will fail to hold the weights constant, making it an unreliable measure of price change. This problem can be avoided by chaining, but then the Laspeyres and Paasche indexes will be more susceptible to chain drift than Fisher indexes.

The additive form of the Fisher volume index holds prices fixed at a weighted average of their initial value and their deflated final value. Let the price for any detailed item i be measured by $p_i^* = (p_{it} + p_{i,t+1}/\mathrm{P_{GDP}}^{\mathrm{Fisher}})/2$. Then the contribution of item i to the change in $\mathrm{V_{GDP}}^{\mathrm{Fisher}}$ is $c_i = s_i^*[(q_{i,t+1}/q_{it}) - 1]$, where $s_i^* = s_{it}[1 + (p_{i,t+1}/p_{it})(1/\mathrm{P_{GDP}}^{\mathrm{Fisher}})]/\sum_j s_{jt}[1 + (p_{j,t+1}/p_{jt})(1/\mathrm{P_{GDP}}^{\mathrm{Fisher}})]$.

The contribution to change in $\mathrm{V_{GDP}}^{\mathrm{Fisher}}$ of any mid-level aggregate, such as GDFE, exports and imports, equals the sum of the contributions for the detailed items inside the aggregate. For example, the total of the s_i^* within exports, denoted s_X^*, is proportional to $s_{X_t}(1 + \mathrm{P_X}^{\mathrm{Lasp}}/\mathrm{P_{GDP}}^{\mathrm{Fisher}})$. The corresponding volume index is $\mathrm{V_X}^* = [\mathrm{V_X}^{\mathrm{Lasp}} + (\mathrm{P_X}^{\mathrm{Lasp}}/\mathrm{P_{GDP}}^{\mathrm{Fisher}})\mathrm{V_X}^{\mathrm{Paasche}}]/[1 + \mathrm{P_X}^{\mathrm{Lasp}}/\mathrm{P_{GDP}}^{\mathrm{Fisher}}] \approx \mathrm{V_X}^{\mathrm{Fisher}}$, where the approximation is exact if $\mathrm{P_{GDP}}^{\mathrm{Fisher}} = \mathrm{P_X}^{\mathrm{Fisher}}$.

The additive representation for the Fisher price index has the same form, with the roles of the price and volume indexes reversed. Define $\mathrm{P_X}^{**}$ analogously to $\mathrm{V_X}^*$, with the roles of the volume and price indexes interchanged. Fisher price indexes provide a close approximation to $\mathrm{P_X}^{**}$ and its counterparts for GDFE and imports, so the Fisher price index for GDP can be expressed as:

$$\mathrm{P_{GDP}}^{\mathrm{Fisher}} = \frac{s_{D_t}(1+\mathrm{V_D}^{\mathrm{Lasp}}/\mathrm{V_{GDP}}^{\mathrm{Fisher}})\mathrm{P_D}^{**} + s_{X_t}(1+\mathrm{V_X}^{\mathrm{Lasp}}/\mathrm{V_{GDP}}^{\mathrm{Fisher}})\mathrm{P_X}^{**} - s_{M_t}(1+\mathrm{V_M}^{\mathrm{Lasp}}/\mathrm{V_{GDP}}^{\mathrm{Fisher}})\mathrm{P_M}^{**}}{s_{D_t}(1+\mathrm{V_D}^{\mathrm{Lasp}}/\mathrm{V_{GDP}}^{\mathrm{Fisher}}) + s_{X_t}(1+\mathrm{V_X}^{\mathrm{Lasp}}/\mathrm{V_{GDP}}^{\mathrm{Fisher}}) - s_{M_t}(1+\mathrm{V_M}^{\mathrm{Lasp}}/\mathrm{V_{GDP}}^{\mathrm{Fisher}})}$$

$$\approx \frac{s_{D_t}(1+\mathrm{V_D}^{\mathrm{Lasp}}/\mathrm{V_{GDP}}^{\mathrm{Fisher}})\mathrm{P_D}^{\mathrm{Fisher}} + s_{X_t}(1+\mathrm{V_X}^{\mathrm{Lasp}}/\mathrm{V_{GDP}}^{\mathrm{Fisher}})\mathrm{P_X}^{\mathrm{Fisher}} - s_{M_t}(1+\mathrm{V_M}^{\mathrm{Lasp}}/\mathrm{V_{GDP}}^{\mathrm{Fisher}})\mathrm{P_M}^{\mathrm{Fisher}}}{s_{D_t}(1+\mathrm{V_D}^{\mathrm{Lasp}}/\mathrm{V_{GDP}}^{\mathrm{Fisher}}) + s_{X_t}(1+\mathrm{V_X}^{\mathrm{Lasp}}/\mathrm{V_{GDP}}^{\mathrm{Fisher}}) - s_{M_t}(1+\mathrm{V_M}^{\mathrm{Lasp}}/\mathrm{V_{GDP}}^{\mathrm{Fisher}})}$$

$$\approx \frac{s_{D_t}(1+\mathrm{V_D}^{\mathrm{Fisher}}/\mathrm{V_{GDP}}^{\mathrm{Fisher}})\mathrm{P_D}^{\mathrm{Fisher}} + s_{X_t}(1+\mathrm{V_X}^{\mathrm{Fisher}}/\mathrm{V_{GDP}}^{\mathrm{Fisher}})\mathrm{P_X}^{\mathrm{Fisher}} - s_{M_t}(1+\mathrm{V_M}^{\mathrm{Fisher}}/\mathrm{V_{GDP}}^{\mathrm{Fisher}})\mathrm{P_M}^{\mathrm{Fisher}}}{s_{D_t}(1+\mathrm{V_D}^{\mathrm{Fisher}}/\mathrm{V_{GDP}}^{\mathrm{Fisher}}) + s_{X_t}(1+\mathrm{V_X}^{\mathrm{Fisher}}/\mathrm{V_{GDP}}^{\mathrm{Fisher}}) - s_{M_t}(1+\mathrm{V_M}^{\mathrm{Fisher}}/\mathrm{V_{GDP}}^{\mathrm{Fisher}})}$$

$$= \tilde{s}_{D_t}\mathrm{P_D}^{\mathrm{Fisher}} + \tilde{s}_{X_t}\mathrm{P_X}^{\mathrm{Fisher}} - \tilde{s}_{M_t}\mathrm{P_M}^{\mathrm{Fisher}}. \tag{19}$$

The additive contributions to the change in the Fisher price index are therefore: $\tilde{s}_{D_t}(\mathrm{P_D}^{\mathrm{Fisher}} - 1)$, $\tilde{s}_{X_t}(\mathrm{P_X}^{\mathrm{Fisher}} - 1)$ and $-\tilde{s}_{M_t}(\mathrm{P_M}^{\mathrm{Fisher}} - 1)$. Writing equation (19) as $\mathrm{P_{GDP}}^{\mathrm{Fisher}} = 1 + \tilde{s}_{X_t}(\mathrm{P_X}^{\mathrm{Fisher}} - \mathrm{P_D}^{\mathrm{Fisher}}) - \tilde{s}_{M_t}(\mathrm{P_M}^{\mathrm{Fisher}} - \mathrm{P_D}^{\mathrm{Fisher}})$ and dividing by $\mathrm{P_D}^{\mathrm{Fisher}}$ yields the Fisher index version of equation (10):

$$\mathrm{TGI}^{\mathrm{Fisher}} = 1 + \tilde{s}_{X_t}(\mathrm{P_X}^{\mathrm{Fisher}}/\mathrm{P_D}^{\mathrm{Fisher}} - 1) - \tilde{s}_{M_t}(\mathrm{P_M}^{\mathrm{Fisher}}/\mathrm{P_D}^{\mathrm{Fisher}} - 1). \tag{20}$$

Equation (20) can be rearranged to obtain an expression parallel to equation (11). It gives the contributions of the change in the terms of trade and the change in the relative price of tradables to the change in the Fisher trading gains index:

$$\mathrm{TGI}^{\mathrm{Fisher}} - 1 \approx 0.5(\tilde{s}_{X_t} + \tilde{s}_{M_t})(\mathrm{P_M}^{\mathrm{Fisher}}/\mathrm{P_D}^{\mathrm{Fisher}})(\mathrm{ToT}^{\mathrm{Fisher}} - 1) + (\tilde{s}_{X_t} - \tilde{s}_{M_t})(\mathrm{RPT}^{\mathrm{Fisher}} - 1) \tag{21}$$

5. Estimates of Terms of Trade and Real GDI for the US

5.1 GDP Volume Index, Trading Gains and Real GDI

Although Fisher volume measures are not additive, their Laspeyres and Paasche constituents are. Table 1 therefore shows the derivation of the index of real GDI by removing the exports and imports components of constant-price GDP, then adding back their purchasing power equivalents, where purchasing power is calculated by deflating by $\mathrm{P_D}^{\mathrm{Fisher}}$. It then compares US real GDI and US real GDP via an index of trading gains. The price spike for petroleum imports of 1973-74 is reflected in a drop of 1.3 percentage points in the trading gains index, the petroleum price spike of 1979-80 is associated with a two-year drop of 1.7 percentage points in the trading gains index, and a series of price increases for petroleum from 2003 to mid-2008 coincided with a cumulative decline of 1.8 percentage points in the terms of trade. On the other hand, after recessions begin, declines in import prices caused by falling demand often raise the trading gains index, helping to stabilize US real GDI. Rises in trading gains in the range of 0.2 to 0.4 percent occur in the recession years of 1982, 1991 and 2001, and the 1998 recession in countries affected by the Asian currency crisis brought a rise of 0.5 percent. Rising trading gains also added to US real GDI improvements in the years following the 1982 recession because of a rising dollar, a process that ended abruptly in late 1985 after a multilateral agreement calling for a devaluation of the dollar (the Plaza Accord.)

Since *net* domestic income is a measure of sustainable consumption that takes into account the need to replace obsolete and worn out capital stock, table 1 also shows real net domestic product and real net domestic income. The deflator real net domestic income is the price index for **net** domestic final expenditures; use of the index for GDFE would effectively result in double adjustment for price changes of the investment needed to offset CFC. On average, real net income rises more slightly slowly than real gross income. Expenses for consumption of fixed capital (CFC) have grown faster than GDP because of growth in stocks of fast-depreciating equipment like computers.

5.2 Contributions of Exports and Imports to Changes in Real GDI

Contributions of trading gains to the change in real GDI from equation (23) provide a gauge of the importance of export and import price movements for the US economy. In 1974, for example, the fall in real GDI of 1.6 percent reflected a contribution of –1.1 percentage points from the change in trading gains, which consisted of a contribution of rising petroleum prices of –1.2 percentage points that was partially offset by a positive net contribution of export and nonpetroleum import prices. The contribution of changing trading gains to real GDI was –1.25 percentage points at the time of the petroleum price spike of 1980, but in this case non-petroleum imports amplified a contribution of petroleum prices of –1 percent. Petroleum prices again played a key role in a string of negative contributions of trading gains to real GDI from 2003 to the first half of 2008 that were cumulatively quite large. On the other hand, non-petroleum imports had declines in prices that increased trading gains in the strong dollar years of 1982-85 and again in 1996-2002, and that offset much of the negative impact of rising oil prices in 2003-2006. Indeed, if petroleum products are excluded, trading gains for goods have a remarkable string of positive contributions to real GDI starting in 1996, which average about 0.17 percent per year.

The contribution to real GDP of net exports volume is a benchmark for gauging the size of the trading gain contribution to real GDI (bottom panel of table 2.) Yet despite the similarity of this

volume change contribution to the trading gains (price change) contribution in an accounting sense, its economic interpretation is quite different. The contribution of net exports volume change to real GDI is zero in an economic sense (at least to the first order), because the contribution of GGDFE volume change to real GDP partly reflects domestic consumption that is supplied by imports or items that could have been exported. In an economic sense, the contribution of net imports that is implicitly included in the GGDFE contribution cancels out the explicit contribution of net exports to real GDP.[10] Instead, net exports result in net national lending, which is a component of national saving. Thus in an economic sense, the large negative contributions of volume of net exports seen in 1996 to 2005 represent negative effects on the rate of saving of GDI, not real GDI itself.

Not surprisingly, net export volumes tend to be inversely related to trading gains. Years with large positive contributions from trading gains, like 1983-84 and 1998, generally have large negative contributions from trade volume changes, while in 2007 and early 2008, negative trading gain contributions coincide with positive trade volume contributions. The net export volume changes generally play the dominant role in the evolution of the trade balance: their median absolute value is 0.6 percentage points, compared with 0.2 percentage points for trading gains.

5.3 The Terms of Trade and in the Relative Price of Tradables

The overall pattern of US export and import prices is summarized by the terms of trade index and by the relative price of tradables, as shown in table 3. The long run trend for US terms of trade is down, because occasional sharp drops caused by jumps in oil prices are never fully reversed. Excluding petroleum changes the picture, however. The nonpetroleum terms of trade deteriorate sharply in the last half of the 1980s, but after 1995 import prices consistently fall relative to export

[10] But if frictions prevent the assumption of full employment from holding, changes in net exports may lead to short run changes in domestic output until a full employment equilibrium is re-established. For example, in the first half of 2008 the growth in US real GDP of 1.8 percent per year came entirely from the contribution of net exports volume change. Although a fall in GDFE growth could possibly have reduced imports sufficiently to account for the entire jump in net exports, it is also plausible that the growth in net exports helped to stabilize the fall in US employment.

prices. Furthermore, following the rise in the relative price of tradables brought about by the Plaza Accord devaluation, the relative price of non-petroleum tradables begins a steady decline that results in significant trading gains in the years when the US has a substantial trade deficit. Indeed, in 1998-2002, the average contribution to the annual growth rate of US real GDI from the falling relative price of nonpetroleum tradables of 0.08 percentage points exceeds the 0.07 percentage point average contribution of the nonpetroleum terms of trade.

The nonpetroleum trading gains that began in the mid-1990s reflect the emergence of China and other newly industrialized countries as major trading partners of the US. In effect, some of the benefits of rising productivity in these countries have been enjoyed by the US, as prices for its manufactured imports fell and new markets opened up for its exports. These gains leave the nonpetroleum terms of trade index just slightly lower in 2007 than in 1973. Their contributions to US real GDI over the years since 1995 are substantial: excluding petroleum, the cumulative effect of the contributions of changes in terms of trade and changes in the relative price of tradables is to raise real GDI almost two percentage points over the period from 1995 to 2007 (figure 4.) (On the other hand, rising demand for petroleum from newly industrialized countries contributed to rises in petroleum prices gains that pushed overall US terms of trade down after 2003.)

With petroleum included, the contributions of trading gains to the change in real GDI from 1974 to 2007 (table 4) imply a subtraction of at least 0.21 percentage points from real GDI a quarter of the time, and an addition at least 0.18 percentage points a quarter of the time Trade price effects of 0.2 percent or more on real gross income occur about half the time in annual data. These effects come mainly from terms of trade movements rather than changes in the relative price of tradables. The contributions to the change in real GDI also show that the terms of trade shocks of 1974 and 1980 were quite large, as they each subtracted over a percentage point from income growth. The

terms of trade shock from the spike in prices of petroleum and other imported crude commodities in the first half of 2008 was almost as large, but it proved to be shorter lived.

6. Conclusion

The effect of prices of exports and imports on an economic measure of real GDI can be analyzed using Fisher indexes of the terms of trade, the relative price of tradables and trading gains and the formula for the contributions of terms of trade and the relative price of tradables to the change in the trading gains index. Applying these methods to data from the US national accounts from 1974 to 2007, we find that significant terms of trade effects are common even in annual frequency data and even though the US has a relatively closed economy compared with many other countries. Trading gains subtract at least 0.21 percentage points from real GDI a quarter of the time, and that they add at least 0.18 percentage points a quarter of the time. Occasionally, however, the shocks are much larger. The petroleum price shocks that occurred at the end of 1973, in 1980 subtracted more than a full percentage point from real GDI, and the one in the first half of 2008 in combination with rising prices of other imports subtracted almost 2 percentage points from the annualized growth rate of real GDI.

On the other hand, when petroleum prices are excluded, large effects of falling prices for imports from newly industrialized countries such as China are revealed. Excluding petroleum, US terms of trade improved steadily from 1996 to 2007. Combined with the contribution from a falling relative price of tradables, this terms of trade improvement added an average of 0.15 percentage points to the annual growth rate of real GDI, or 1.7 percent on a cumulative basis over 11 years.

References

Aulin-Ahmavaara, Pirkko and Perttu Pakarinen. 2007. "Integrated Industry and Economy-wide TFP-Measures with Different Prices in Different Uses." *Economic Systems Research*19 (no. 3, September): 253–276.

Denison, Edward F. 1981. "International Transactions in Measures of the Nation's Production," *Survey of Current Business* 61 (May): 17-28.

Diewert, W. Erwin 1984. "Group Cost of Living Index: Approximations and Axiomatics," *Methods of Operations Research* 48, 23-45.

Diewert, W.Erwin. 1992. "Fisher ideal output, input, and productivity indexes revisited," *Journal of Productivity Analysis* 3, 211-248.

Diewert, W. Erwin. 2005. "Welfare, Productivity and Changes in the Terms of Trade." Department of Economics, University of British Columbia, November.

Diewert, W. Erwin and Denis Lawrence. 2006. *Measuring the Contributions of Productivity and Terms of Trade to Australia's Economic Welfare*, report by Meyrick and Associates to the Productivity Commission, Canberra.

Diewert, W. Erwin. 2008. "Changes in the Terms of Trade and Canada's Productivity Performance." Available at http://www.indexmeasures.com/dc2008/finalprogram.htm .

Diewert, W. Erwin and Catherine J. Morrison. 1986. "Adjusting Outputs and Productivity Indexes for Changes in the Terms of Trade." *Economic Journal* 96, 659-679.

Dikhanov, Yuri. "The Sensitivity of PPP-Based Income Estimates to Choice of Aggregation Procedures." mimeo, The World Bank, Washington, DC, January 1997.

Fox, Kevin J. and Ulrich Kohli. 1998. "GDP Growth, Terms-of-trade Effects and Total Factor Productivity." *Journal of International Trade and Economic Development* 7, 87-110.

Geary, R.C. 1961. "Productivity Aspects of Accounts Deflation." *Studies in Social and Financial Accounting. Income and Wealth, Series IX*. 3-45.

Gutmann, Pierre. 1981. "The Measurement of Terms of Trade Effects," *Review of Income and Wealth* 27 (December): 433-453.

Hill, Robert J. 2006. "Superlative Index Numbers: Not All of Them are Super." *Journal of Econometrics* 130, 25-43.

Kohli, Ulrich. 2003. "Growth accounting in the open economy: international comparisons." *International Review of Economics and Finance* 12: 417–435.

Kohli, Ulrich. 2004. "Real GDP, real domestic income, and terms-of-trade changes." *Journal of International Economic*s 62, 83-106.

Kohli, Ulrich. 2006. "Real GDP, Real GDI, and Trading Gains: Canada, 1981-2005." *International Productivity Monitor* 13 (Fall): 46-56.

Kohli, Ulrich. 2008. "Globalization, Trade in Middle Products, and Relative Prices." Available at http://www.indexmeasures.com/dc2008/finalprogram.htm .

Kehoe, Timothy J. and Kim J. Ruhl. 2008. "Are Shocks to the Terms of Trade Shocks to Productivity?" *Review of Economic Dynamics* 11 (October): 804-819.

Krueger; Anne O. and Hugo Sonnenschein. 1976. "The Terms of Trade, the Gains from Trade and Price Divergence." *International Economic Review* 8, No. 1. (February): 121-127.

Kurabayashi, Yoshimasa. 1971. " The Impact of Changes in Terms of Trade on a System of National Accounts: An Attempted Synthesis." *Review of Income and Wealth* 17 (September): 285-297.

Macdonald, Ryan. 2007. "Canadian and U.S. Real Income Growth Pre and Post 2000: A Reversal of Fortunes." Economic Analysis Research Paper Series 11F0027MIE, no. 048 (November): Statistics Canada.

Macdonald, Ryan. 2008. "Real Income Measurement: The Canadian Experience" Presented to the BEA Advisory Committee, Nov. 7, 2008. Available at: http://www.bea.gov/about/pdf/Macdonald07November2008.pdf

Nicholson, J. L. 1960. "The Effects of International Trade on the Measurement of Real National Income." *The Economic Journal* 70, No. 279. (Sept.): 608-612.

Reinsdorf, Marshall B., W. Erwin Diewert and Christian Ehemann. 2002. "Additive Decompositions for Fisher, Törnqvist and Geometric Mean Indexes." *Journal of Economic and Social Measurement* 28, 51–61.

Reinsdorf, Marshall B., Feenstra Robert C., and Slaughter Matthew J. 2007. "Effects of Terms of Trade Gains and Tariffs Changes on the Measurement of U.S. Productivity Growth." Available at http://www.indexmeasures.com/dc2008/finalprogram.htm.

Sanyal, Kalyan K. and Ronald W. Jones. 1982. "The Theory of Trade in Middle Products." *American Economic Review* 72, No. 1. (March), pp. 16-31.

Silver, Mick and Khashayar Mahdavy. 1989. The Measurement of a Nation's Terms of Trade Effect and Real National Disposable Income within a National Accounting Framework. *Journal of the Royal Statistical Society*, series A, 152, 87-107.

Stuvel G. 1958. "The Impact of Changes in the Terms of Trade on Western Europe's Balance of Payments." *Econometrica* 26, No. 1. (Jan.,), pp. 107-116.

Stuvel, G. 1959. "Asset Revaluation and Terms-of-Trade Effects in the Framework of the National Accounts." *The Economic Journal* 69, No. 274, (June): 275-292.

United Nations, Commission of the European Communities, IMF, OECD and World Bank. 1993. *System of National Accounts 1993*. New York, Brussels, Paris and Washington.

United Nations, Commission of the European Communities, IMF, OECD and World Bank. 2008. *System of National Accounts 2008*. New York, Brussels, Paris and Washington.

van IJzeren, Jan. 1952. Over de Plausibiliteit van Fisher's Ideale Indices, (On the Plausibility of Fisher's Ideal Indices), Statistische en Econometrische Onderzoekingen (Centraal Bureau voor de Statistiek), *Nieuwe Reeks* **7**(2), 104–115.

Varian, Hal. 1982. The non-parametric approach to demand analysis, *Econometrica* **50**, 945-974.

Varian, Hal. 1984. The non-parametric approach to production analysis, *Econometrica* **52**, 579-597.

Weitzman, Martin L. 1976. "On the Welfare Significance of National Product in a Dynamic Economy." *Quarterly Journal of Economics* 90(1): February: 156-162.

Figure 1: Gains from Trade in Final Goods

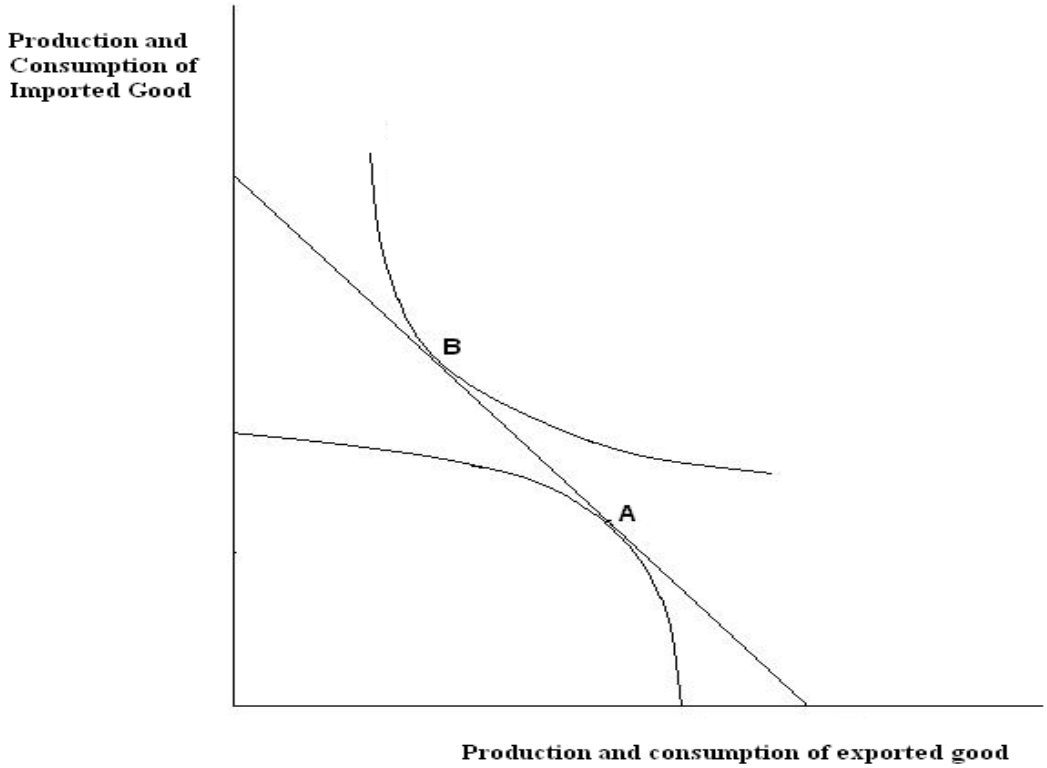
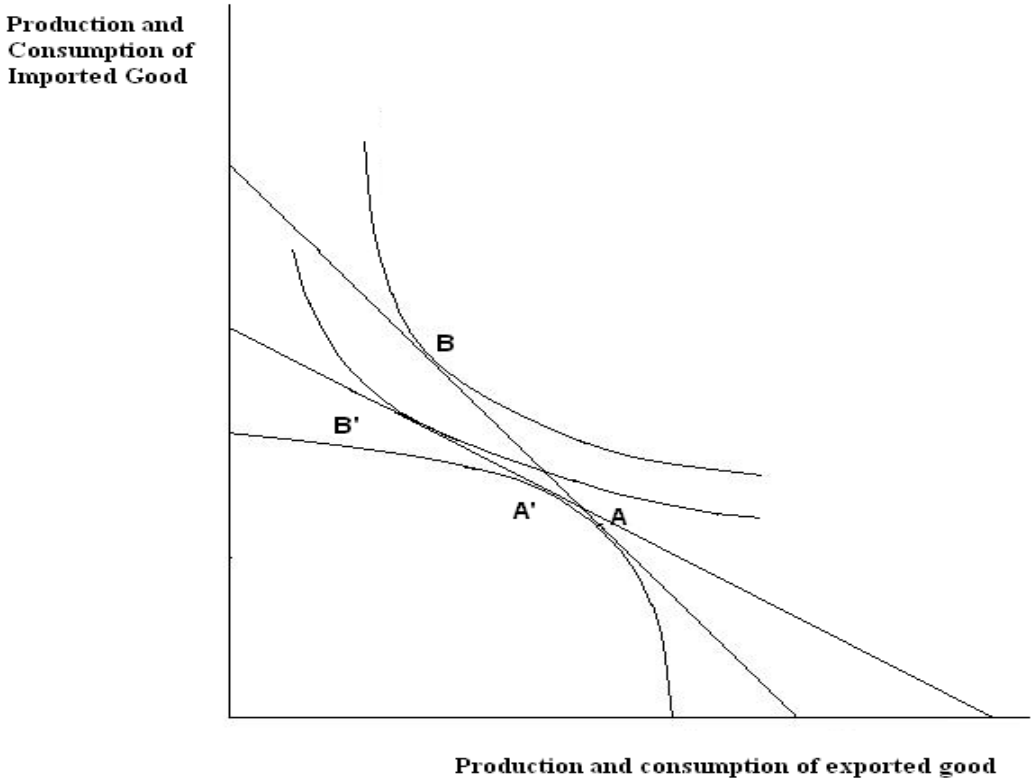


Figure 2: Fall in GDA after a Deterioration in Terms of Trade



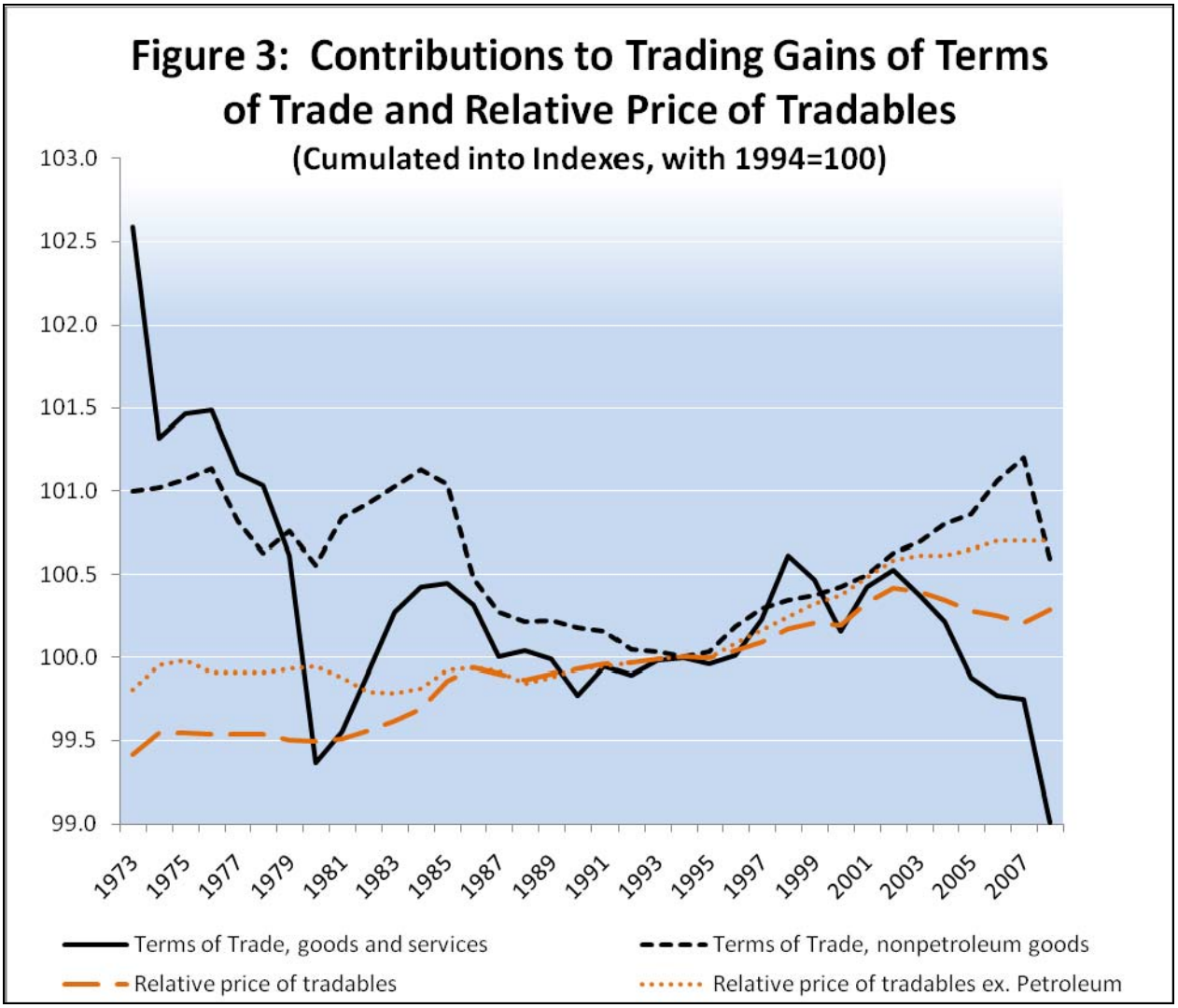


Figure 3: Contributions to Trading Gains of Terms of Trade and Relative Price of Tradables
(Cumulated into Indexes, with 1994=100)
103.0
102.5
102.0
101.5
101.0
100.5
100.0
99.5
99.0
1973
1975
1977
1979
1981
1983
1985
1987
1989
1991
1993
1995
1997
1999
2001
2003
2005
2007
Terms of Trade, goods and services
Terms of Trade, nonpetroleum goods
Relative price of tradables
Relative price of tradables ex. Petroleum

Table 1: Relation of Real Gross Domestic Income to Real GDP and Real GGDFE
(Percentage Changes in Volume from Preceding Year; 2008 H1 at annual rate)

	1973	*1974*	1979	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990	1991	1992
Gross domestic product	***5.8***	***-0.5***	**3.2**	**-0.2**	**2.5**	**-1.9**	**4.5**	**7.2**	**4.1**	**3.5**	**3.4**	**4.1**	**3.5**	**1.9**	**-0.2**	**3.3**
Less: Exports of goods and services	*18.9*	*7.9*	9.9	10.8	1.2	-7.6	-2.6	8.2	3.0	7.7	10.8	16.0	11.5	9.0	6.6	6.9
Plus: Imports of goods and services	*4.6*	*-2.3*	1.7	-6.6	2.6	-1.3	12.6	24.3	6.5	8.6	5.9	3.9	4.4	3.6	-0.6	7.0
Equals: Gross dom. final expenditures	***4.9***	***-1.3***	**2.5**	**-1.9**	**2.7**	**-1.3**	**5.8**	**8.7**	**4.4**	**3.7**	**3.1**	**3.2**	**3.0**	**1.4**	**-0.8**	**3.3**
PLUS: Exports, real GDI basis[a]	*27.2*	*20.6*	13.2	10.5	-0.4	-12.2	-5.5	5.5	-2.9	3.8	10.2	18.0	9.2	5.5	4.6	4.0
LESS: Imports, real GDI basis	*16.2*	*26.8*	9.4	5.2	-0.9	-9.7	4.7	19.1	0.1	6.2	9.0	5.3	2.8	2.4	-4.1	4.6
EQUALS: Real gross domestic income	***5.5***	***-1.6***	**2.7**	**-1.5**	**2.7**	**-1.5**	**5.0**	**7.4**	**4.3**	**3.4**	**3.0**	**4.1**	**3.5**	**1.7**	**0.0**	**3.3**
Trading gains[b]	***-0.2***	***-1.1***	**-0.4**	**-1.3**	**0.2**	**0.4**	**0.4**	**0.2**	**0.2**	**0.0**	**-0.3**	**0.0**	**0.0**	**-0.2**	**0.2**	**0.0**
Net domestic product	*5.9*	*-1.1*	2.9	-0.8	2.4	-2.8	4.7	7.4	3.9	3.6	3.2	4.2	3.3	1.6	-0.8	3.3
Real net domestic income[c]	*5.6*	*-2.3*	2.4	-2.2	2.7	-2.3	5.2	7.7	4.1	3.5	2.8	4.2	3.3	1.4	-0.6	3.2

	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	H1 2008
Gross domestic product	**2.7**	**4.0**	**2.5**	**3.7**	**4.5**	**4.2**	**4.5**	**3.7**	**0.8**	**1.6**	**2.5**	**3.6**	**2.9**	**2.8**	**2.0**	**1.8**
Less: Exports of goods and services	3.2	8.7	10.1	8.4	11.9	2.4	4.3	8.7	-5.4	-2.3	1.3	9.7	7.0	9.1	8.4	8.6
Plus: Imports of goods and services	8.8	11.9	8.0	8.7	13.6	11.6	11.5	13.1	-2.7	3.4	4.1	11.3	5.9	6.0	2.2	-4.1
Equals: Gross dom. final expenditures	**3.2**	**4.4**	**2.4**	**3.8**	**4.8**	**5.3**	**5.3**	**4.4**	**0.9**	**2.2**	**2.8**	**4.1**	**3.0**	**2.6**	**1.4**	**0.0**
PLUS: Exports, real GDI basis	1.0	7.7	10.4	5.1	8.5	-0.6	2.1	7.9	-7.6	-4.1	1.1	10.2	7.0	9.2	9.3	15.0
LESS: Imports, real GDI basis	5.5	10.7	8.7	4.9	8.1	4.9	10.4	15.0	-7.0	0.6	5.3	13.2	8.6	6.9	3.1	11.3
EQUALS: Real gross domestic income	**2.8**	**4.1**	**2.5**	**3.8**	**4.8**	**4.7**	**4.3**	**3.3**	**1.2**	**1.8**	**2.3**	**3.4**	**2.5**	**2.6**	**2.0**	**-0.1**
Trading gains[b]	**0.1**	**0.0**	**0.0**	**0.1**	**0.3**	**0.5**	**-0.1**	**-0.3**	**0.4**	**0.2**	**-0.2**	**-0.2**	**-0.4**	**-0.1**	**-0.1**	**-1.9**
Net domestic product	2.8	3.8	2.3	3.6	4.3	3.9	4.1	3.3	-0.2	1.7	2.5	3.5	2.2	3.7	1.8	1.1
Real net domestic income	2.9	3.8	2.3	3.7	4.6	4.4	4.0	2.9	0.3	1.9	2.3	3.2	1.8	3.5	1.7	-0.5

a. Real GDI basis exports and imports are deflated by the price index for gross domestic final expenditures.

b. Trading gains index calculated as the ratio of real GDI to real GDP.

c. Defined as net domestic product deflated by the price index for net domestic final expenditures.

Table 2: Contributions to Change in Real Gross Domestic Income
(Percentage Changes from the Preceding Year; 2008 H1 at annual rate)

	1973	*1974*	1979	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990	1991	1992
Trading gains[a]	***-0.24***	***-1.10***	**-0.46**	**-1.25**	**0.21**	**0.40**	**0.45**	**0.24**	**0.19**	**-0.05**	**-0.35**	**0.00**	**-0.02**	**-0.19**	**0.20**	**-0.05**
Exports of goods and services	*0.45*	*0.84*	0.26	-0.03	-0.16	-0.46	-0.26	-0.21	-0.46	-0.28	-0.04	0.14	-0.19	-0.32	-0.19	-0.28
Goods	*0.46*	*0.82*	0.28	-0.06	-0.16	-0.47	-0.27	-0.16	-0.46	-0.30	-0.03	0.18	-0.17	-0.34	-0.23	-0.29
Services	*-0.02*	*0.02*	-0.02	0.03	-0.01	0.01	0.01	-0.05	0.00	0.02	-0.02	-0.03	-0.03	0.03	0.05	0.00
Imports of goods and services	*-0.69*	*-1.94*	-0.73	-1.22	0.37	0.85	0.71	0.46	0.65	0.23	-0.31	-0.15	0.17	0.13	0.38	0.24
Goods	*-0.56*	*-1.83*	-0.67	-1.14	0.30	0.77	0.62	0.36	0.59	0.39	-0.34	-0.12	0.09	0.20	0.39	0.24
Nonpetroleum goods	*-0.46*	*-0.65*	-0.12	-0.13	0.38	0.47	0.37	0.30	0.47	-0.27	-0.21	-0.31	0.21	0.35	0.23	0.19
Petroleum and petroleum products	*-0.10*	*-1.18*	-0.55	-1.01	-0.08	0.30	0.26	0.06	0.12	0.65	-0.13	0.19	-0.12	-0.15	0.16	0.05
Services	*-0.13*	*-0.11*	-0.06	-0.08	0.07	0.09	0.09	0.09	0.05	-0.16	0.03	-0.03	0.09	-0.07	-0.01	-0.01
PLUS: Gross domestic product	***5.76***	***-0.50***	**3.16**	**-0.23**	**2.52**	**-1.94**	**4.52**	**7.19**	**4.13**	**3.47**	**3.38**	**4.13**	**3.54**	**1.88**	**-0.17**	**3.33**
Gross dom. final expenditures	***4.94***	***-1.26***	**2.50**	**-1.91**	**2.67**	**-1.33**	**5.87**	**8.77**	**4.55**	**3.77**	**3.21**	**3.32**	**3.02**	**1.45**	**-0.85**	**3.36**
Net exports of goods and services	***0.82***	***0.75***	**0.66**	**1.68**	**-0.15**	**-0.60**	**-1.35**	**-1.58**	**-0.42**	**-0.30**	**0.17**	**0.82**	**0.52**	**0.43**	**0.69**	**-0.04**
Exports of goods and services	*1.12*	*0.58*	0.82	0.97	0.12	-0.73	-0.22	0.63	0.23	0.54	0.77	1.24	0.99	0.81	0.62	0.68
Goods	*1.01*	*0.46*	0.77	0.86	-0.09	-0.67	-0.19	0.46	0.20	0.26	0.56	1.04	0.75	0.55	0.46	0.52
Services	*0.11*	*0.12*	0.06	0.11	0.21	-0.06	-0.03	0.17	0.02	0.28	0.21	0.20	0.24	0.26	0.16	0.16
Imports of goods and services	*-0.30*	*0.17*	-0.16	0.71	-0.27	0.12	-1.13	-2.21	-0.65	-0.84	-0.61	-0.43	-0.47	-0.39	0.06	-0.72
Goods	*-0.34*	*0.17*	-0.14	0.67	-0.18	0.21	-1.00	-1.83	-0.52	-0.82	-0.39	-0.36	-0.38	-0.26	0.01	-0.77
Nonpetroleum goods	*-0.17*	*0.13*	-0.11	0.11	-0.54	-0.12	-1.02	-1.74	-0.60	-0.60	-0.36	-0.27	-0.31	-0.24	-0.04	-0.74
Petroleum and petroleum products	*-0.18*	*0.05*	-0.02	0.57	0.36	0.33	0.02	-0.09	0.09	-0.22	-0.04	-0.09	-0.07	-0.01	0.05	-0.03
Services	*0.05*	*0.00*	-0.02	0.04	-0.09	-0.08	-0.13	-0.39	-0.13	-0.02	-0.22	-0.07	-0.10	-0.13	0.05	0.05
EQUALS: Real gross domestic income	***5.52***	***-1.60***	**2.70**	**-1.48**	**2.73**	**-1.54**	**4.96**	**7.43**	**4.32**	**3.42**	**3.02**	**4.13**	**3.52**	**1.69**	**0.03**	**3.28**

See note at end of table.

Table 2, Continued
(Percentage Changes from the Preceding Year; 2008 H1 at annual rate)

	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	H1 2008
Trading gains[a]	**0.11**	**0.03**	**-0.05**	**0.10**	**0.29**	**0.48**	**-0.12**	**-0.33**	**0.40**	**0.19**	**-0.17**	**-0.22**	**-0.42**	**-0.14**	**-0.06**	**-1.97**
Exports of goods and services	-0.22	-0.10	0.02	-0.36	-0.37	-0.35	-0.24	-0.09	-0.25	-0.19	-0.01	0.04	-0.01	0.01	0.09	1.21
Goods	-0.20	-0.07	0.02	-0.36	-0.35	-0.32	-0.23	-0.11	-0.20	-0.16	-0.02	0.04	-0.04	0.00	0.06	0.94
Services	-0.02	-0.02	0.00	0.00	-0.01	-0.02	-0.01	0.02	-0.05	-0.04	0.01	0.00	0.04	0.02	0.03	0.27
Imports of goods and services	0.33	0.13	-0.07	0.45	0.65	0.83	0.13	-0.24	0.66	0.38	-0.16	-0.26	-0.41	-0.15	-0.15	-3.17
Goods	0.30	0.12	-0.06	0.46	0.62	0.76	0.16	-0.27	0.61	0.39	-0.07	-0.23	-0.36	-0.12	-0.13	-2.84
Nonpetroleum goods	0.20	0.06	0.01	0.60	0.55	0.45	0.35	0.22	0.38	0.40	0.12	0.07	0.14	0.26	0.07	-1.13
Petroleum and petroleum products	0.10	0.07	-0.07	-0.15	0.07	0.31	-0.18	-0.49	0.23	-0.01	-0.19	-0.30	-0.50	-0.38	-0.20	-1.71
Services	0.03	0.01	-0.01	-0.01	0.04	0.06	-0.04	0.03	0.04	0.00	-0.09	-0.03	-0.05	-0.04	-0.03	-0.33
PLUS: Gross domestic product	**2.67**	**4.02**	**2.50**	**3.70**	**4.50**	**4.17**	**4.45**	**3.66**	**0.75**	**1.60**	**2.51**	**3.64**	**2.94**	**2.78**	**2.03**	**1.84**
Gross dom. final expenditures	**3.26**	**4.45**	**2.40**	**3.84**	**4.83**	**5.33**	**5.44**	**4.52**	**0.95**	**2.29**	**2.95**	**4.32**	**3.15**	**2.79**	**1.45**	**-0.01**
Net exports of goods and services	**-0.59**	**-0.43**	**0.11**	**-0.14**	**-0.33**	**-1.16**	**-0.99**	**-0.86**	**-0.20**	**-0.69**	**-0.44**	**-0.68**	**-0.21**	**-0.02**	**0.58**	**1.84**
Exports of goods and services	0.32	0.85	1.03	0.91	1.30	0.27	0.47	0.93	-0.60	-0.23	0.12	0.93	0.71	0.96	0.95	1.12
Goods	0.23	0.67	0.85	0.68	1.11	0.18	0.29	0.84	-0.48	-0.28	0.12	0.60	0.54	0.73	0.59	0.92
Services	0.09	0.18	0.19	0.22	0.19	0.09	0.18	0.09	-0.12	0.06	0.00	0.33	0.17	0.23	0.36	0.20
Imports of goods and services	-0.91	-1.29	-0.93	-1.04	-1.63	-1.43	-1.46	-1.79	0.40	-0.46	-0.56	-1.61	-0.93	-0.98	-0.37	0.72
Goods	-0.85	-1.18	-0.86	-0.93	-1.45	-1.20	-1.31	-1.55	0.39	-0.41	-0.56	-1.34	-0.89	-0.82	-0.25	0.68
Nonpetroleum goods	-0.77	-1.13	-0.88	-0.87	-1.40	-1.15	-1.31	-1.49	0.43	-0.44	-0.49	-1.25	-0.85	-0.86	-0.30	0.16
Petroleum and petroleum products	-0.08	-0.05	0.01	-0.07	-0.04	-0.05	0.00	-0.06	-0.04	0.03	-0.07	-0.09	-0.04	0.04	0.05	0.52
Services	-0.06	-0.11	-0.06	-0.11	-0.19	-0.23	-0.15	-0.25	0.01	-0.05	0.00	-0.27	-0.04	-0.16	-0.12	0.04
EQUALS: Real gross domestic income	**2.78**	**4.05**	**2.46**	**3.80**	**4.79**	**4.65**	**4.33**	**3.33**	**1.15**	**1.79**	**2.34**	**3.42**	**2.52**	**2.64**	**1.97**	**-0.12**

a. Calculated from equation (22).

Table 3: Prices of Exports and Imports
(Percentage Change from Preceding Year; 2008 H1 at Annual Rate)

	1973	*1974*	1979	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990	1991	1992
Exports of goods and services	***13.1***	***23.2***	**12.0**	**10.1**	**7.4**	**0.5**	**0.4**	**0.9**	**-3.1**	**-1.5**	**2.5**	**5.2**	**1.7**	**0.7**	**1.3**	**-0.4**
Goods	*16.1*	*26.6*	13.2	9.6	7.1	-1.1	-0.7	0.9	-5.0	-3.3	2.6	6.4	1.3	-1.0	-0.1	-1.6
Services	*4.7*	*11.6*	7.8	12.3	8.7	6.1	3.9	1.1	2.7	3.4	2.2	2.0	2.7	5.2	5.0	2.5
Imports of goods and services	***17.4***	***43.1***	**17.1**	**24.6**	**5.4**	**-3.4**	**-3.7**	**-0.9**	**-3.3**	**0.1**	**6.1**	**4.8**	**2.2**	**2.9**	**-0.4**	**0.1**
Goods	*17.9*	*49.6*	17.9	26.2	5.6	-4.0	-4.2	-0.7	-3.9	-2.2	7.1	4.8	2.8	1.8	-1.4	-0.5
Nonpetroleum goods	*16.9*	*26.1*	10.9	13.0	2.6	-2.5	-2.4	-0.8	-3.6	6.0	5.8	7.3	1.2	-0.4	0.2	-0.1
Petroleum and petroleum products	*27.4*	*228.4*	40.4	62.9	12.5	-8.1	-10.1	-0.2	-5.7	-46.0	19.9	-16.6	19.1	20.8	-12.6	-3.8
Services	*15.7*	*18.9*	12.9	16.1	4.3	0.1	-1.6	-1.7	-0.1	11.2	1.4	5.0	-0.6	7.6	3.7	2.7
Terms of Trade, Goods and Services[a]	***-3.6***	***-13.9***	**-4.3**	**-11.6**	**1.9**	**4.0**	**4.3**	**1.8**	**0.2**	**-1.5**	**-3.4**	**0.4**	**-0.5**	**-2.1**	**1.7**	**-0.5**
Terms of Trade, Goods	*-1.5*	*-15.4*	-4.0	-13.1	1.4	3.0	3.6	1.6	-1.1	-1.1	-4.2	1.6	-1.5	-2.7	1.3	-1.1
Terms of Trade, Nonpetroleum goods	*-0.7*	*0.4*	2.1	-3.0	4.3	1.4	1.7	1.7	-1.5	-8.7	-3.1	-0.8	0.1	-0.6	-0.3	-1.5
Relative price of tradables[b]	***8.9***	***20.5***	**5.3**	**6.0**	**-2.5**	**-6.8**	**-5.0**	**-3.4**	**-5.9**	**-2.9**	**1.1**	**1.5**	**-1.8**	**-2.2**	**-2.7**	**-2.4**
Relative price of tradables, Goods	*10.5*	*24.9*	6.2	6.4	-2.6	-7.8	-5.8	-3.3	-7.1	-4.9	1.7	2.1	-1.7	-3.5	-3.9	-3.3
Relative price of tradables, Nonpetroleum	*10.1*	*14.6*	3.0	0.7	-4.0	-7.1	-4.9	-3.4	-7.0	-1.0	1.1	3.3	-2.4	-4.6	-3.2	-3.1
Trading gains[c]	***-0.2***	***-1.1***	**-0.4**	**-1.3**	**0.2**	**0.4**	**0.4**	**0.2**	**0.2**	**0.0**	**-0.3**	**0.0**	**0.0**	**-0.2**	**0.2**	**0.0**
Gross domestic product price index	*5.6*	*9.0*	8.3	9.1	9.4	6.1	3.9	3.8	3.0	2.2	2.7	3.4	3.8	3.9	3.5	2.3
Gross dom. final expenditures prices	*5.8*	*10.2*	8.8	10.5	9.1	5.7	3.5	3.5	2.9	2.3	3.1	3.4	3.8	4.1	3.3	2.3

See footnotes at end of table.

Table 3, Continued
(Percentage Change from Preceding Year; 2008 H1 at Annual Rate)

	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	H1 2008
Exports of goods and services	**0.0**	**1.1**	**2.3**	**-1.3**	**-1.7**	**-2.3**	**-0.6**	**1.7**	**-0.4**	**-0.4**	**2.2**	**3.5**	**3.6**	**3.5**	**3.5**	**9.9**
Goods	-0.6	1.1	2.4	-2.6	-2.7	-3.2	-1.4	1.1	-0.7	-0.7	2.0	3.7	3.1	3.3	3.5	11.2
Services	1.4	1.3	2.1	1.9	1.0	-0.1	1.3	3.1	0.4	0.4	2.6	3.2	4.9	3.8	3.5	7.2
Imports of goods and services	**-0.9**	**0.9**	**2.7**	**-1.8**	**-3.6**	**-5.4**	**0.6**	**4.2**	**-2.5**	**-1.2**	**3.5**	**4.9**	**6.3**	**4.3**	**3.7**	**20.5**
Goods	-1.2	0.8	2.7	-2.5	-4.2	-6.0	0.1	4.8	-3.0	-1.8	2.9	4.9	6.5	4.2	3.6	22.2
Nonpetroleum goods	-0.3	1.4	2.0	-4.3	-4.0	-3.7	-1.7	0.6	-1.5	-2.2	1.2	2.4	2.5	1.2	2.1	9.6
Petroleum and petroleum products	-9.6	-6.2	11.2	20.3	-5.7	-33.7	33.1	67.5	-16.9	2.5	20.8	27.3	36.5	22.5	11.7	82.6
Services	0.7	1.7	2.8	2.1	-0.4	-2.2	3.2	1.4	0.1	1.7	6.3	4.4	5.7	4.8	3.7	12.2
Terms of Trade, Goods and Services[a]	**0.9**	**0.2**	**-0.4**	**0.4**	**1.9**	**3.3**	**-1.2**	**-2.4**	**2.2**	**0.8**	**-1.3**	**-1.3**	**-2.5**	**-0.8**	**-0.1**	**-8.8**
Terms of Trade, Goods	0.6	0.3	-0.3	-0.1	1.5	3.1	-1.5	-3.5	2.4	1.1	-0.9	-1.2	-3.2	-0.8	-0.1	-9.0
Terms of Trade, Nonpetroleum goods	-0.3	-0.3	0.4	1.8	1.3	0.5	0.3	0.6	0.8	1.5	0.8	1.2	0.6	2.1	1.4	1.5
Relative price of tradables[b]**:**	**-2.6**	**-1.0**	**0.4**	**-3.3**	**-4.0**	**-4.5**	**-1.5**	**0.4**	**-3.4**	**-2.3**	**0.5**	**1.1**	**1.2**	**0.5**	**0.8**	**10.8**
Relative price of tradables, Goods	-3.0	-1.1	0.4	-4.3	-4.8	-5.2	-2.1	0.4	-3.8	-2.7	0.2	1.2	1.0	0.4	0.8	12.2
Relative price of tradables, Nonpetroleum	-2.6	-0.8	0.1	-5.2	-4.7	-4.0	-3.0	-1.6	-3.0	-2.9	-0.7	0.0	-0.9	-1.1	0.1	6.3
Trading gains[c]	**0.1**	**0.0**	**0.0**	**0.1**	**0.3**	**0.5**	**-0.1**	**-0.3**	**0.4**	**0.2**	**-0.2**	**-0.2**	**-0.4**	**-0.1**	**-0.1**	**-1.9**
Gross domestic product price index	2.3	2.1	2.0	1.9	1.7	1.1	1.4	2.2	2.4	1.7	2.1	2.9	3.3	3.2	2.7	1.9
Gross dom. final expenditures price index	2.2	2.1	2.1	1.8	1.4	0.6	1.6	2.5	2.0	1.6	2.3	3.1	3.7	3.4	2.8	3.9

a. Ratio of the price index for exports to the price index for imports.

b. Ratio of the average of the price index for exports and the price index for imports to the price index for gross domestic final expenditures.

c. Ratio of the gross domestic product price index to the gross domestic final expenditures price index. .

Table 4: Contributions of the Terms of Trade and the Relative Price of Tradables to the Change in Trading Gains[a]
(percentage points; 2008 H1 expressed at annual rate)

	1973	*1974*	1979	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990	1991	1992
Terms of trade, goods and services	*-0.24*	*-1.24*	-0.41	-1.24	0.19	0.36	0.36	0.15	0.02	-0.13	-0.31	0.03	-0.05	-0.21	0.17	-0.05
o.w. Goods	*-0.08*	*-1.12*	-0.31	-1.17	0.12	0.22	0.24	0.11	-0.07	-0.07	-0.30	0.12	-0.11	-0.21	0.10	-0.09
o.w. Nonpetroleum goods	*-0.03*	*0.02*	0.13	-0.21	0.29	0.09	0.10	0.10	-0.09	-0.56	-0.20	-0.06	0.00	-0.04	-0.02	-0.11
PLUS: Relative price of tradables	*0.01*	*0.13*	-0.04	-0.01	0.01	0.05	0.06	0.07	0.16	0.08	-0.03	-0.04	0.03	0.03	0.03	0.01
o.w. Traded goods	*-0.01*	*0.11*	-0.07	-0.03	0.02	0.09	0.10	0.08	0.21	0.15	-0.05	-0.06	0.04	0.07	0.07	0.05
o.w. Traded nonpetroleum goods	*0.03*	*0.15*	0.02	0.01	-0.07	-0.08	-0.01	0.03	0.10	0.02	-0.03	-0.07	0.04	0.05	0.02	0.02
EQUALS: Trading Gains	*-0.23*	*-1.11*	-0.45	-1.25	0.20	0.41	0.43	0.23	0.18	-0.05	-0.34	0.00	-0.02	-0.18	0.20	-0.04
PLUS: Gross dom. final exp. prices	*5.81*	*10.11*	8.73	10.35	9.17	5.70	3.52	3.53	2.86	2.26	3.06	3.42	3.80	4.06	3.28	2.35
EQUALS: Gross domestic product prices	*5.58*	*9.00*	8.28	9.10	9.37	6.11	3.95	3.76	3.04	2.22	2.72	3.42	3.78	3.88	3.48	2.30

	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008 H1
Terms of trade, goods and services	0.09	0.02	-0.04	0.05	0.22	0.38	-0.15	-0.31	0.27	0.10	-0.15	-0.16	-0.34	-0.11	-0.02	-1.45
o.w. Goods	0.05	0.02	-0.02	-0.01	0.13	0.28	-0.14	-0.35	0.23	0.10	-0.08	-0.12	-0.33	-0.09	-0.01	-1.17
o.w. Nonpetroleum goods	-0.02	-0.03	0.03	0.15	0.11	0.05	0.03	0.05	0.07	0.13	0.07	0.11	0.06	0.20	0.14	0.15
PLUS: Relative price of tradables	0.02	0.01	0.00	0.04	0.05	0.08	0.03	-0.01	0.13	0.09	-0.02	-0.05	-0.07	-0.03	-0.04	-0.50
o.w. Traded goods	0.05	0.03	-0.01	0.10	0.12	0.15	0.07	-0.02	0.18	0.13	-0.01	-0.06	-0.06	-0.03	-0.05	-0.68
o.w. Traded nonpetroleum goods	0.03	0.01	0.00	0.09	0.08	0.08	0.08	0.05	0.10	0.11	0.03	0.00	0.04	0.05	0.00	-0.21
EQUALS: Trading Gains	0.11	0.03	-0.05	0.09	0.28	0.46	-0.11	-0.32	0.40	0.19	-0.17	-0.21	-0.40	-0.14	-0.06	-1.94
PLUS: Gross dom. final exp. prices	2.19	2.09	2.10	1.80	1.38	0.65	1.56	2.50	2.00	1.56	2.30	3.08	3.67	3.35	2.76	3.80
EQUALS: Gross domestic product prices	2.30	2.12	2.05	1.89	1.66	1.11	1.44	2.18	2.40	1.75	2.13	2.87	3.27	3.22	2.69	1.86

a. Calculated from equation (21).