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REAL GROSS DOMESTIC INCOME, RELATIVE PRICES, AND ECONOMIC PERFORMANCE ACROSS THE OECD

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This paper uses OECD data to examine changes in labor productivity, real gross domestic product (GDP) and real gross domestic income (GDI), economic aggregates, and relative economic growth over time. Real GDI combines changes in production (real GDP) with a trading gain derived from relative price changes. The paper considers two sources of trading gains: the terms of trade, and the real exchange rate. For OECD countries, the terms of trade is the more important price ratio, making a contribution to real income growth that is, on average, an order of magnitude larger than the real exchange rate. Over long time periods, the most important source of real income growth is changes in production. Over shorter time horizons, however, the trading gain can make noteworthy contributions. Changes in aggregates like real private consumption, or the relative economic performance of nations, are shown to be particularly dependent on the trading gain during the large swings in resource prices that occurred post-2002.

1. Introduction

Economists examine real income differences across countries and over time in an effort to understand differences in living standards. Real gross domestic product (GDP), which is an income measure that assumes all real income change comes from changes in production, and labor productivity, which is a measure of output per hour worked, are frequently employed measures for this purpose. New processes, technological breakthroughs, or higher labor and capital inputs lead to increases in real GDP. Technological advances and increases in the capital labor ratio raise labor productivity. Through examining the production process, or the real income it generates, real GDP and labor productivity are used as a base for productivity analysis (see, e.g. Hulten, 2001), real income analysis (see, e.g. Rodgers, 2003), or to model economic aggregates such as consumption.

However, relative prices also affect real income growth. Depending on how the relative prices of exports and imports change, the volume of goods and services that an economy can purchase can differ from its production. An economy may improve its labor productivity, raising the efficiency with which it produces goods and services, but if it produces goods for export whose prices are falling relative to the imported goods it purchases, it may not see much of an increase in its standard of living as measured by the purchasing power of its income. The importance of taking these factors into account for understanding the outcomes of international income comparisons, or changes in economic aggregates such as consumption or imports, increased greatly after 2002.

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The years 2003–07 cover a period of global expansion when emerging nations, particularly China, emerged as important economic centers. Prices rose sharply for most commodities while, at the same time, relative prices for many manufactured products fell (Francis, 2007). This confluence of events led to the largest relative price shifts experienced by OECD nations since the second oil shock. The years 2003–07, therefore, provide a unique period when the influence of relative price change stands out.

This paper uses a real income measure referred to as real gross domestic income (GDI) to examine the role of relative price changes for real income growth. Using real GDI breaks the fixed relationship between real income and production that arises when real GDP is used. Real GDI is interpreted as a measure of purchasing power, or absorption, rather than a measure of production or productivity. Growth in real GDI captures changes in the volume of goods and services available to a domestic economy, and is associated with changes in utility (Kohli, 2004).

Moving from real GDP to real GDI involves accounting for relative price changes related to traded products. Two relative prices are considered here: the terms of trade, and the real exchange rate. The terms of trade is defined as the ratio of export to import prices, while the real exchange rate is defined as the ratio of traded to non-traded prices.

Data for 29 OECD countries are used to examine sources of real income growth, to demonstrate the importance of commodity prices for terms of trade and real exchange rate changes, the importance of relative price adjustment for understanding movements in economic aggregates like consumption, and to examine changes in economic performance over time. The paper focuses on the 2003–07 period because rapid increases in commodity prices post-2002 create dramatic changes for relative prices during these years. However, the historical record is employed to provide a long-term perspective, and to provide comparisons between the 2003–07 resource boom and previous resource price cycles.

The remainder of the paper is organized as follows. Section 2 discusses real GDP, labor productivity, and real GDI, while Section 3 discusses data and methodology. Section 4 examines labor productivity, real GDI, and real GDP across OECD countries during the 2003–07 period. It pays particular attention to relative price changes which reflect commodity price cycles. Section 5 looks at how much cross sectional variation in real aggregates can be explained using real GDI. Section 6 contains a long-run comparison of economic performance relative to the United States for Australia, Canada, and the United Kingdom. Section 7 concludes.

2. Real Gross Domestic Product and Real Gross Domestic Income

Following Diewert and Morrison (1986) and Fox *et al*. (2002), suppose there are $N = N_D + N_X + N_M$ netputs that can be divided into domestic outputs, exported outputs, and imported inputs (negative netputs) that can be represented by the following netput vector, $\underline{y} \equiv (\underline{y}_D, \underline{y}_X, \underline{y}_M)'$ with price vector $\underline{p} \equiv (\underline{p}_D, \underline{p}_X, \underline{p}_M)' > 0$. Suppose also that there is a one by M vector of primary inputs (labor and capital)

$\underline{v} \equiv (v_1, \ldots, v_M)' \geq 0$ with price vector $\underline{w} \equiv (w_1, \ldots, w_M)' > 0$. It is then possible to calculate nominal GDP as the sum of final expenditures or the sum of payments to primary factors of production: $GDP = \underline{y} \bullet \underline{p}$

By assuming that $\underline{y}$ and $\underline{p}$ can be represented by indices, and letting $\underline{v} \bullet \underline{w} = Q$, it is possible to write the relationship between nominal GDP and nominal income as:

$$GDP = y \times p = Q. \tag{1}$$

Real GDP is calculated by removing price effects from production. This is equivalent to assuming the GDP deflator is the relevant price index for calculating real income, and leads to the interpretation of real GDP as a real income measure:

$$real\ GDP = y = \frac{Q}{p}. \tag{2}$$

Real income measured in this fashion associates changes in income with changes in the volume of production. Because it uses the GDP deflator to do so, real income is measured in terms of the netputs produced, and is therefore associated with movements relating to the economy's production function. As a result, changes in productivity, capacity utilization, and inputs will change real income, but movements in prices have no volume effect. This will only be the case if all prices progress at the same rate, or if the economy is closed. In an open economy where export, import, and domestic prices change at different rates, changes in production do not necessarily result in commensurate changes in real income.

The relationship between GDP and nominal income can be used to form productivity measures that reflect the efficiency of production. One such measure is labor productivity which tracks the volume of output per unit of labor input. Growth in labor productivity is associated with movements in real wages, making it an attractive metric for analyzing changes in economic performance over time. When the cost of labor and capital can be represented by indices, it is possible to decompose real GDP into three volume components: labor input, capital services, and multifactor productivity. The labor index, h, is typically measured as the number of hours worked. Labor productivity is measured by factoring h out of the production function and using it to scale real GDP:

$$\text{Labor Productivity} = \frac{y}{h}. \tag{3}$$

Real GDP and labor productivity are associated with changes in an economy's production possibilities. However, it is possible to move to move to a real income concept more closely associated with a society's utility curve by using a price index other than the GDP deflator. One choice for an alternative price index is the final domestic expenditure price index. It includes private consumption, gross fixed capital formation, government consumption, and inventory prices. The final domestic expenditure price index is the broadest price index available that captures the final goods and services purchased by domestic economic agents.

When final domestic expenditure prices are used to deflate nominal income, the resulting measure is real gross domestic income:

$$real\ GDI = y\frac{p}{p_D} = \frac{Q}{p_D}. \tag{4}$$

Real income measured using the final domestic expenditure deflator associates changes in real income with changes in the volume of production as well as relative price shifts. Changes in relative prices can behave in an analogous manner to productivity growth (Diewert and Morrison, 1986), and lead to real changes in the volume of goods and services available to an economy.

To empirically analyze price and volume changes, an index number formula must be chosen. The Tornqvist (1936) index is used here. It has the attractive property of being log-additive, making it possible to interpret factors as contributions to growth. In addition to the ease of interpretation, the Tornqvist and Fisher ideal index are equivalent to a second order approximation (Diewert, 1978), which as Fox *et al*. (2002) point out, makes them equivalent to at least two decimal points.

Define the logged Tornqvist final domestic expenditure price index between periods t and s as:

$$\ln\left(p_{D,t}/p_{D,s}\right) \equiv \sum_{j=1}^{N} \bar{v}_{j,t} \ln\left(\frac{p_{j,t}}{p_{j,s}}\right) \tag{5}$$

where, $j = 1, \ldots, N_D$ netputs, $\bar{v}_{j,t} = \left(\frac{\varpi_{j,t} + \varpi_{j,s}}{2}\right)$ and $\varpi_{j,t} = y_j p_j / \underline{y} \bullet \underline{p}$.

Using the final domestic expenditure price index, changes in real income are the sum of changes in real GDP (production) and relative price changes:

$$\underbrace{\ln(Q_t/Q_s) - \ln\left(p_{D,t}/p_{D,s}\right)}_{\text{Real Income Change}} = \underbrace{\ln(y_t/y_s)}_{\text{Change in Real GDP}} + \underbrace{\ln(p_t/p_s) - \ln\left(p_{D,t}/p_{D,s}\right)}_{\substack{\text{Change in Relative Prices} \\ \text{(Trading Gain)}}}. \tag{6}$$

The relative price changes are referred to as a trading gain and represent the benefit/loss that an open economy receives from changes in price structures related to traded items.[1]

[1]In the literature surrounding the System of National Accounts (SNA) the trading gain is derived from deflating net exports directly rather than using an implicit price deflator. The SNA presents several options for deflating net exports, including import prices, export prices, an average of import and export prices, or a final domestic expenditure price index. No consensus has been reached about which method is most satisfactory (see Stuvel, 1956; Nicholson, 1960; Geary, 1961; Courbis, 1969; Kurabayashi, 1971; Denison, 1981; Silver and Mahdavy, 1989; SNA, 1993; Kohli, 2006a).

Currently the Bureau of Economic Analysis in the United States calculates a command basis GDP that is equivalent to the real GDI discussed in the SNA using an import price deflator. A command GDP measure is also available from the Penn World Tables annually up to 2004.

$$\underbrace{\ln(T_t/T_s)}_{\text{Change in Trading Gain}} = \underbrace{\ln(p_t/p_s) - \ln(p_{D,t}/p_{D,s})}_{\text{Change in Relative Prices}}. \tag{7}$$

Kohli (2006a) shows that the trading gain based on a final domestic expenditure deflator can be decomposed into a terms of trade contribution and a real exchange rate contribution:

$$\underbrace{\ln(T_t/T_s)}_{\text{Change in Trading Gain}} = \underbrace{\left(\frac{\overline{v}_{X,t} + \overline{v}_{M,t}}{2}\right)}_{\text{Average Share of Trade in GDP}} \underbrace{\ln(ToT_t/ToT_s)}_{\text{Terms of Trade Changes}} + \underbrace{\left(\overline{v}_{X,t} - \overline{v}_{M,t}\right)}_{\text{Share of Net Exports in GDP}} \underbrace{\ln(RER_t/RER_s)}_{\text{Real Exchange Rate Changes}}. \tag{8}$$

Where changes in the terms of trade are calculated as the difference between export and import price changes:

$$\underbrace{\ln(ToT_t/ToT_s)}_{\text{Terms of Trade Changes}} = \underbrace{\ln(p_{X,t}/p_{X,s})}_{\text{Export Price Index Changes}} - \underbrace{\ln(p_{M,t}/P_{M,s})}_{\text{Import Price Index Changes}}. \tag{9}$$

And, changes in the real exchange rate are calculated as the difference between the average change in traded goods prices and domestic prices.

$$\underbrace{\ln(RER_t/RER_s)}_{\text{Real Exchange Rate Changes}} = \frac{1}{2}\left[\underbrace{\ln(p_{X,t}/p_{X,s})}_{\text{Export Price Index Changes}} + \underbrace{\ln(p_{M,t}/P_{M,s})}_{\text{Import Price Index Changes}}\right] - \underbrace{\ln(p_{D,t}/P_{D,s})}_{\text{Final Domestic Expenditure Price Index Changes}}. \tag{10}$$

The real exchange rate defined here is not the usual measure of the real exchange rate used in the macroeconomic literature. The more commonly employed real exchange rate adjusts a nations nominal exchange rate for domestic price differences. The real exchange rate defined here, as Kohli (2006a) notes, is consistent with the real exchange rate defined in what has become known as the Australian model (see Salter, 1959; Corden, 1960; Swan, 1960). It is also consistent with balance of payments theory since, as Corden (1992) notes, the Australian model was used by Dornbusch (1974, 1980) to integrate money into balance of payments theory, and with the booming sector, or Dutch disease, model of Corden and Neary (1982) and Corden (1984). The real GDI measure defined using the final domestic expenditure deflator is, therefore, a general equilibrium real income concept.

3. Data and Methods

Calculations use national accounts data collected by the OECD. For each country the most recent data vintage is employed. This limits the span of the data for many countries. As a result, long-run calculations are reported only for

Australia, Canada, the United Kingdom, and the United States. Calculations covering the 2003–07 resource boom employ the widest sample of countries possible. The national accounts data contains information on private consumption, gross fixed capital formation, public consumption, and exports and imports. The domestic expenditure deflator is not provided by the OECD. It is calculated from the published data by removing the influence of export and import prices from the GDP deflator.

Labor productivity measures by country are taken from the OECD. These data extend back, at most, to 1970 and in many cases cover a shorter time span. For Australia, Canada, the United Kingdom, and the United States, the data starting in 1970 are employed. For all other nations except Turkey, data for the period 2003–07 are available. The OECD does not provide a labor productivity measure for Turkey. Where it appears in analysis, only real GDP and real GDI are employed.

Population data from the OECD are used to scale estimates of real GDP and real GDI when international comparisons are made, or where labor productivity is compared with real income statistics. Per capita measures are reported because growth in per capita terms provides a more accurate reflection of changes in living standards across countries. Per capita measures are also more appropriate for comparing with labor productivity.

Trade data used to construct a measure of resource sensitivity are taken from the OECD trade database. Trade data contain information about nominal expenditures on different types of goods only.

Data on resource prices are taken from the Bank of Canada's commodity price index. The index is comprised of US$ prices for a wide range of commodities (see Hirsch, 2003 for details). Because the trading gain is comprised of relative price ratios, the U.S. durable goods CPI from the Bureau of Labor Statistics is used to scale commodity prices.

4. Real GDP and Labor Productivity vs. Real GDI 2003–07

The 2003–07 years are particularly important for examining real GDI per capita changes because they cover the largest commodity boom since the end of the Second World War. The influence of commodity price changes is larger and more apparent post-2002 than at almost any time in the previous 45 years. As a consequence, real GDP per capita and labor productivity are less than ideal for understanding how the standard of living was adjusting during this period.

Between 2003 and 2007, differences between real GDP per capita, labor productivity, and real GDI per capita growth arise in many OECD nations (Table 1). Real GDI per capita in resource rich, commodity exporting countries like Australia or Norway outpaces growth in real GDP per capita and labor productivity growth. In manufacturing centered, commodity importing nations like Japan or the United States, real GDP per capita and labor productivity rise faster than real GDI per capita.

The different performances between measures stems in large part from terms of trade changes. The trading gain decomposition in equation (8) illustrates why. The impact of terms of trade changes on real income is proportional to the average

TABLE 1
AVERAGE ANNUAL REAL GDP, REAL GDI, AND LABOR PRODUCTIVITY GROWTH, 2003–07

	Labor Productivity	Real GDP Per Capita	Real GDI Per Capita
Australia	1.2%	2.0%	3.4%
Austria	1.8%	1.9%	1.8%
Belgium	1.4%	1.7%	1.5%
Canada	0.9%	1.7%	2.9%
Czech Republic	4.6%	5.2%	5.1%
Denmark	1.5%	1.8%	2.0%
Finland	2.5%	3.1%	2.2%
France	1.4%	1.3%	1.2%
Germany	1.2%	1.5%	1.3%
Greece	2.3%	3.9%	4.2%
Hungary	3.7%	3.8%	3.4%
Iceland	2.6%	3.6%	3.6%
Ireland	2.4%	3.3%	1.8%
Italy	0.0%	0.6%	0.5%
Japan	2.0%	2.0%	1.4%
Korea	4.5%	4.0%	2.8%
Luxembourg	2.7%	3.2%	4.9%
Netherlands	0.8%	2.0%	1.9%
New Zealand	1.0%	1.9%	2.7%
Norway	1.2%	2.0%	4.8%
Poland	3.0%	5.1%	5.5%
Portugal	1.5%	0.5%	0.6%
Slovak Republic	5.1%	6.8%	6.3%
Spain	1.0%	1.8%	1.9%
Sweden	2.3%	2.7%	2.5%
Switzerland	1.0%	1.6%	1.2%
Turkey	NA	6.3%	6.5%
United Kingdom	2.1%	2.1%	2.2%
United States	1.8%	1.8%	1.6%

share of imports and exports in GDP while the impact of the real exchange rate is proportional to the share of net exports in GDP. Consequently, the more open a country is to trade, the more susceptible it is to terms of trade changes, while the larger a country's trade imbalance, the more susceptible it is to real exchange rate movements. On average across the OECD, the share of exports and imports in GDP between 2003 and 2007 is 44.5 percent, while the average absolute trade balance in GDP is 5.5 percent (Table 2). This roughly translates into terms of trade shifts being an order of magnitude more important for real income growth than real exchange rate changes, but about half as important as changes in production (real GDP), which has a unitary weight in the real GDI decomposition in equation (6).

Most nations have an average share of imports and exports in GDP between 25 and 50 percent. However, there are some nations where real income will be more sensitive terms of trade changes, particularly Luxembourg (143.7 percent), Belgium (83.1 percent), the Slovak Republic (79.6), and the Czech Republic (69.5 percent). There are also nations where real income will be less sensitive to terms of trade shifts, notably the United States (13.0 percent) and Japan (13.3 percent). The share of net exports in GDP tends to be between 5 and 15 percent, but there are some exceptions, like Luxembourg (26.2 percent) or Italy (0.1 percent).

TABLE 2

Relative Price Change Weights and Contributions to Real GDI Per Capita Growth, 2003–07

	Weights in GDP		Contributions to Real GDI Per Capita		
	$(\bar{v}_{X,t} + \bar{v}_{M,t})/2$	$(\bar{v}_{X,t} - \bar{v}_{M,t})$	Real GDP Per Capita	Terms of Trade	Real Exchange Rate
Australia	20.2%	–1.9%	2.0%	1.4%	0.0%
Austria	50.9%	4.3%	1.9%	–0.1%	0.0%
Belgium	83.1%	3.9%	1.7%	–0.2%	0.0%
Canada	36.0%	3.5%	1.7%	1.2%	–0.1%
Czech Republic	69.5%	1.2%	5.2%	0.0%	0.0%
Denmark	46.1%	4.5%	1.8%	0.2%	0.0%
Finland	38.6%	6.1%	3.1%	–0.9%	0.0%
France	26.3%	–0.2%	1.3%	–0.1%	0.0%
Germany	37.8%	5.2%	1.5%	–0.1%	0.0%
Greece	27.6%	–12.3%	3.9%	0.2%	0.1%
Hungary	68.6%	–1.4%	3.8%	–0.4%	0.1%
Iceland	38.0%	–8.7%	3.6%	0.0%	0.0%
Ireland	76.4%	13.6%	3.3%	–1.0%	–0.5%
Italy	26.2%	0.1%	0.6%	–0.1%	0.0%
Japan	13.3%	1.5%	2.0%	–0.7%	0.1%
Korea	40.4%	2.2%	4.0%	–1.1%	–0.1%
Luxembourg	143.7%	26.2%	3.2%	0.8%	0.9%
Netherlands	64.5%	7.6%	2.0%	–0.1%	0.0%
New Zealand	29.6%	–0.7%	1.9%	0.8%	0.0%
Norway	35.8%	15.1%	2.0%	2.3%	0.6%
Poland	37.7%	–2.1%	5.1%	0.4%	0.0%
Portugal	33.2%	–7.9%	0.5%	0.0%	0.1%
Slovak Republic	79.6%	–3.4%	6.8%	0.6%	0.1%
Spain	28.5%	–4.5%	1.8%	0.1%	0.1%
Sweden	43.9%	7.6%	2.7%	–0.1%	0.0%
Switzerland	44.8%	7.1%	1.6%	–0.4%	0.0%
Turkey	24.3%	–2.8%	6.3%	0.1%	0.1%
United Kingdom	27.8%	–2.9%	2.1%	0.0%	0.0%
United States	13.0%	–5.2%	1.8%	–0.2%	0.0%

The preeminence of the terms of trade changes for real income growth behoves an examination of what drives terms of trade adjustments. Movements in the terms of trade for OECD countries over the 2003–07 period come from relative price movements between resources and manufactured products. For nations that are relatively resource rich, the terms of trade represent the opportunity cost of manufactured goods relative to resources, while for countries that are relatively resource poor, the terms of trade capture the opportunity cost of resources in terms of manufactured products. When resource booms occur, changes in the terms of trade redistribute purchasing power across countries. The size of the redistribution depends on a country's endowments, comparative advantages, and trade openness.

Plotting the terms of trade adjustments that countries experienced between 2003 and 2007 from largest to smallest illustrates the nature of the redistribution that can occur as commodity prices rise (Figure 1). Resource exporting countries like Australia, Norway, Canada, and New Zealand experienced the largest terms of trade improvements, while resource importing nations like Japan, Korea, Finland, or the United States experienced terms of trade deteriorations.

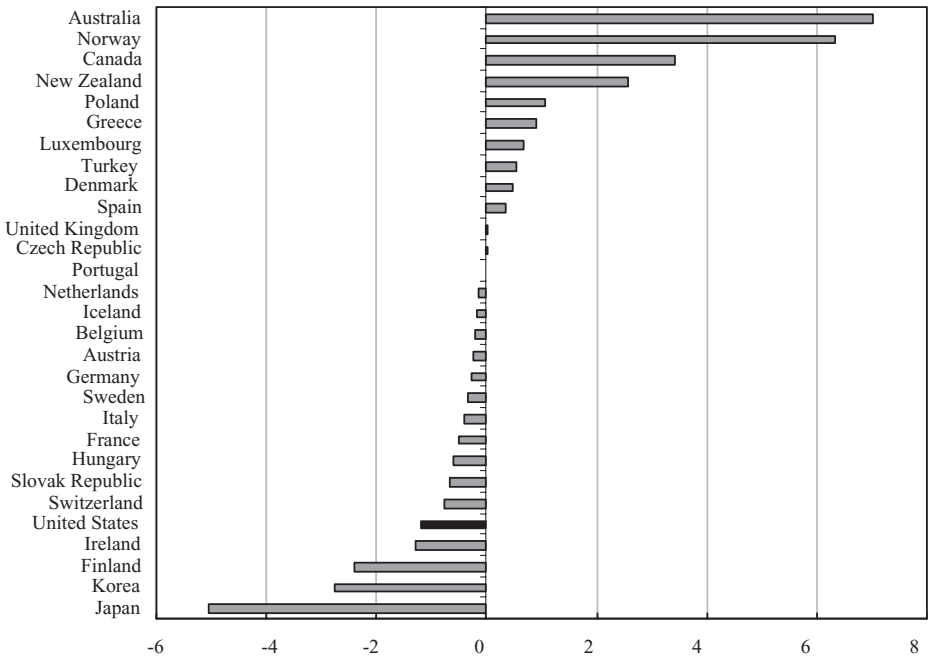

Figure 1. Terms of Trade Changes Across Countries

A more formal way to illustrate the relationship between resources and terms of trade shifts is to construct a measure of how important resources are to trade flows, and then compare it with changes in the terms of trade. A resource sensitivity indicator, based on 1-digit Standard International Trade Classification Codes, is constructed here.

The indicator is the difference between the share of resources in exports and the share of resources in imports:

$$\text{Resource Sensitivity} = 1 \geq \frac{X_{resources}}{X_{total}} - \frac{M_{resources}}{M_{total}} \geq -1. \tag{11}$$

Resource activities are defined as imports or exports of food and live animals; crude materials, inedible, except fuels; and mineral fuels, lubricants, and related materials. Data are drawn from the OECD trade database.

A country that exports only resources and imports only manufactured products will have a score of 1, while a country that exports only manufactured products and imports only resources will have a score of –1. A country that does not trade in resources, or has an equal share of resources in imports and exports, will have a score of 0.

When nations' average resource sensitivity post-2002 is compared with their average terms of trade changes, a statistically significant, positive relationship emerges (Figure 2). Approximately two-thirds of the cross sectional variation in average terms of trade changes can be explained by the resource sensitivity

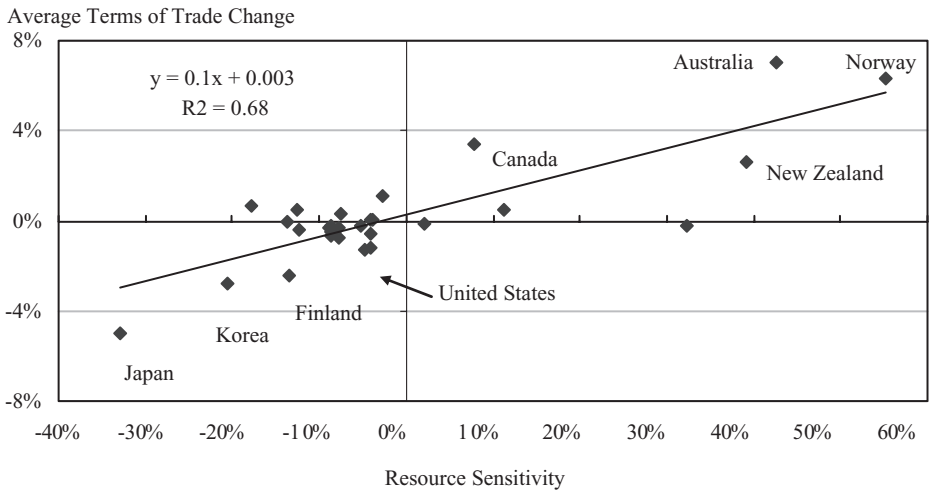

Figure 2. Resource Sensitivity vs. Terms of Trade Changes, 2003–07

measure. The nations that experience the largest terms of trade improvements are resource rich countries like Norway or Australia. Net importers of commodities, like Japan and Korea, experience the largest terms of trade deteriorations.

5. Real Income and Economic Aggregates 2003–07

In the short-run, changes in real income should translate into changes in economic aggregates. As production rises, and relative prices change, the volume of goods and services available to the domestic economy changes. Increasing real GDP and trading gain growth both signal that the volume of goods and services that may be consumed or invested is rising. Real consumption and real gross fixed capital formation (GFCF) can rise faster than real GDP as a result. If the trading gain works against real GDP, then real consumption and real GFCF rise less than real GDP.

The importance of the trading gain for real income growth post-2002 should make it difficult to understand changes in real private consumption, real GFCF, or real government expenditures across OECD countries without including the trading gain. The relationship between economic aggregates and the trading gain can be illustrated using linear regressions. The average changes in real production (real GDP) and the trading gain are regressed on changes in real private consumption, real GFCF, and real government consumption. If the trading does contribute to changes in domestic expenditures, then it should have a statistically significant, positive, coefficient.

Table 3 presents cross section regression results for OECD countries.[2] Variation in economic aggregate growth across OECD countries is related to changes in real GDP and changes in the trading gain. For real private consumption, the

[2]An examination of residual values suggested that Luxembourg is an aberrant observation. It is removed from the dataset used for regressions.

TABLE 3
REGRESSION RESULTS FOR ANNUAL AVERAGES OF OECD COUNTRIES, 2003–07

	Real Private Consumption	Real GFCF*	Real Government Consumption*
Intercept	0.02	–0.43	0.1
P-value	(0.95)	(0.67)	(0.93)
Real GDP Growth	0.95	1.66	1.16
P-value	(0.00)	(0.00)	(0.00)
Trading Gain	0.72	1.70	1.53
P-value	(0.00)	(0)	(0.01)
R-squared	0.77	0.66	0.48
Observations	28	28	28

Notes: *OECD databases do not have entries for real GFCF and real Government Consumption for Greece. An unreported dummy variable is used to account for the impact of the missing data.

combination of real GDP growth and changes in the trading gain explains about three-quarters of variation across the OECD countries; about two-thirds of changes in real GFCF; and about half of the changes in real government consumption. For all of the real aggregates, the coefficient on the trading gain is positive and statistically significant at the 5 percent nominal level.[3]

The results can be interpreted as follows. During the years 2003–07, real GDP increased in all OECD countries. At the same time, the price of commodities rose sharply, affecting terms of trade. The purchasing power of output was redistributed across nations based on their endowments. Real consumption and real gross fixed capital formation advanced more than real production in resource rich nations. In resource net importers, rising commodity prices, particularly for energy, led to lower increases in real consumption and real gross fixed capital formation than changes in the volume of production.

5.1. *Relative to the United States*

Changes in GDP per capita or labor productivity over time are often interpreted as being synonymous with changes in the living standards of an economy. Cross country comparisons are made by examining changes in one country relative to another. While this is instructive, only in the event that domestic and trade prices progress at the same rate, or that both economies are closed, will the real GDP per capita measures necessarily reflect relative real income changes. Similarly, cross country comparisons made using productivity measures to examine the relative changes in efficiency only reflect changes related to production. These

[3]The elasticity estimates for government consumption suggest that governments benefit from trading gains. However, the model here is a reduced form equation, and the route through which this occurs is not explained in detail. Relative price changes are expected to affect government revenues through two main channels. In those nations where governments collect resource royalties, or where rising resource prices lead to higher profits, and hence higher income tax revenue, there will be a direct effect. A second channel arises because governments levy value added taxes on consumption. As relative prices adjust, the volume of consumption adjusts, leading to two, possibly offsetting movements. First the volume of consumption changes, which, ceteris paribus changes taxable expenditures. However, taxes are levied on nominal expenditures, so it is the combination of the price and volume that matter. These movements can be reinforcing or offsetting.

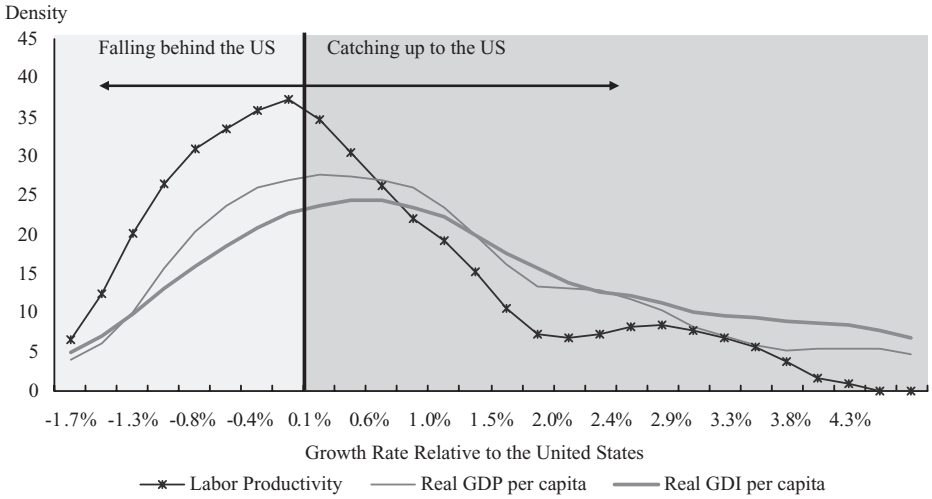

Figure 3. Distributions of Relative Growth for Labor Productivity, Real GDP Per Capita, and Real GDI Per Capita

types of comparisons are unable to incorporate the role of relative price changes on purchasing power and are, therefore, less comprehensive than comparisons made using real GDI per capita. Its ability to incorporate purchasing power changes into international comparisons makes real GDI per capita a more appropriate real income statistic for international comparisons between open economies.

Here, all nations are examined relative to the United States for the period 2003–07. The United States is often viewed as the technological frontier, and a country's performance is measured against whether or not it is catching up to or falling behind the United States.

Conclusions about the relative performance of the OECD nations varies depending on whether labor productivity, real GDP per capita, or real GDI per capita is used (Figure 3 and Table 4).[4] In resource exporting nations, labor productivity and real GDI provide different outcomes relative to the United States. Australia, Canada, New Zealand, and Norway all exhibit a pattern of declining relative labor productivity but rising relative real GDI per capita. In Japan the opposite pattern exists: relative labor productivity increased, but relative real GDI per capita declined.

When the nations are treated as a statistical sample, the distribution of relative performance based on labor productivity is bunched around zero. Just under half of all OECD countries saw a gain in labor productivity relative to the United States during the years 2003–07. The distributions of GDP per capita and GDI per capita are flatter, and skewed to the right with more countries gaining ground on the United States. When labor productivity is used as the metric for comparison, 48 percent of countries progress more rapidly than the United States. When

[4]Kohli (2006b) illustrates the effect of going from real GDP to real GDI for Hong Kong. His results show that growth in real income outpaces real GDP growth on average by 0.9 percentage points per year.

TABLE 4
AVERAGE ANNUAL GROWTH RELATIVE TO THE UNITED STATES, 2003–07

	Labor Productivity	GDP Per Capita	GDI Per Capita
Australia	**–0.6%**	0.2%	1.8%
Austria	0.0%	0.1%	0.2%
Belgium	**–0.4%**	**–0.1%**	**–0.1%**
Canada	**–0.9%**	**–0.1%**	1.2%
Czech Republic	2.7%	3.4%	3.6%
Denmark	**–0.3%**	0.0%	0.4%
Finland	0.7%	1.3%	0.6%
France	**–0.4%**	**–0.5%**	**–0.4%**
Germany	**–0.6%**	**–0.3%**	**–0.3%**
Greece	0.5%	2.1%	2.6%
Hungary	1.9%	2.0%	1.8%
Iceland	0.8%	1.8%	2.0%
Ireland	0.6%	1.5%	0.2%
Italy	**–1.7%**	**–1.2%**	**–1.1%**
Japan	0.2%	0.2%	**–0.2%**
Korea	2.6%	2.2%	1.2%
Luxembourg	0.8%	1.4%	3.4%
Netherlands	**–1.0%**	0.2%	0.3%
New Zealand	**–0.8%**	0.1%	1.1%
Norway	**–0.6%**	0.2%	3.3%
Poland	1.2%	3.3%	3.9%
Portugal	**–0.3%**	**–1.2%**	**–1.0%**
Slovak Republic	3.2%	5.1%	4.8%
Spain	**–0.8%**	0.0%	0.3%
Sweden	0.5%	0.9%	0.9%
Switzerland	**–0.8%**	**–0.2%**	**–0.4%**
Turkey	NA	4.6%	5.0%
United Kingdom	0.3%	0.3%	0.5%

Note: Bold values indicate a decline relative to the United States.

relative real GDP per capita is used, 71 percent of countries advance more rapidly, while when GDI per capita is used, three-quarters of countries in the sample grow faster than the United States.

The speed with which nations gain or lose ground in the short run depends on the metric used for comparison. The smallest relative gains and losses occur when labor productivity is used. Moving to real GDP per capita and real GDI per capita increases the relative changes. On average, gainers go from a relative increase of 1.2 percent per year for labor productivity to 1.6 percent and 1.9 percent for real GDP per capita and real GDI per capita, respectively. Those losing ground go from an average relative decline of –0.7 percent per year for labor productivity to –0.5 percent for real GDP per capita and real GDI per capita.

For the years 2003–07, moving from relative labor productivity to relative GDP per capita or real GDI per capita changes the relative performance of roughly 20 percent of OECD countries in the sample. Australia, Canada, New Zealand, Norway, and Spain go from losing ground to gaining ground, while Japan goes from gaining ground to losing ground. The metric employed alters perceptions of how a nation is performing, as well as how quickly it is catching up or falling behind.

6. Real GDP and Labor Productivity vs. Real GDI in the Long Run

Between 2003 and 2007, the trading gain was an unprecedented source of real income growth that accelerated or decelerated changes in real GDI per capita relative to labor productivity and real GDP per capita. While resource prices led to significant relative price shocks in the past, notably during the oil shocks of the 1970s, their influence during the years 2003–07 is anomalous, as is the divergence that occurred between metrics used to compare economic performance across nations. When labor productivity, real GDP per capita, and real GDI per capita are viewed over longer time spans, the unusual nature of the years 2003–07 becomes apparent.

The performance of Australia, Canada, and the United Kingdom relative to the United States for the 1961–2007 period is used to illustrate the historically large impact of the trading gain post-2002. These are the four counties in the OECD database where the latest data vintage extends back to 1961.

For all four countries the average annual growth rates of real GDP and real GDI are virtually identical over long time spans and do not differ greatly form long-run labor productivity growth (Table 5). Over shorter time spans differences emerge as the trading gain accelerates or decelerates real GDI growth. During the 1970s and post-2002 the trading gain is a particularly important source of real income growth. During the 1970s, real GDI growth accelerated relative to real GDP in Canada, and decelerated to real GDP in Australia, the United Kingdom, and the United States.

During the 1980s and 1990s, real GDI growth fluctuates around real GDP growth. Over a period of several years real GDI will rise faster than real GDP only to fall back later. The pattern of more rapid and slower relative growth is repeated across decades for all four countries. After 2002, the largest divergence on record occurs. In Australia and Canada, real GDI growth outpaces real GDP growth, while in the United States real GDI growth does not keep pace with real GDP growth. In the United Kingdom there was little difference in real GDP and real GDI growth rates.

The cyclical nature of the trading gain leads to higher volatility for real GDI than production based measures. The standard deviation of real GDI growth is higher than the standard deviation of labor productivity or real GDP per capita for all nations (Table 6). Allowing for relative price induced purchasing power changes leads to a real income measure that implies greater uncertainty for economic agents.

Across countries, the starkest difference emerges for the resource exporting countries Australia and Canada. Over the long run, their real GDP per capita, real GDI per capita, and labor productivity progressed at similar rates, but with noteworthy differences in uncertainty across measures. Over the short run, real GDI per capita outpaces and then lags behind real GDP growth repeatedly, and in a predictable fashion. During periods when commodity prices rise, real GDI per capita tended to accelerate in Canada and Australia and decelerate in the United States. When commodity prices weakened, real GDI per capita performed well relative to real GDP per capita in the United States, and poorly relative to real GDP per capita in Australia and Canada. The 1970s oil shocks, the 1986 energy

TABLE 5

Real GDP Growth vs. Real GDI Growth, 1962–2005, for Australia, Canada, the United Kingdom, and the United States

		1962–2007	1971–2007	1962–72	1973–78	1979–86	1987–90	1991–97	1998–2002	2003–07
Australia	Real GDP	2.2%	1.8%	3.1%	1.3%	1.7%	2.0%	1.9%	2.6%	2.0%
	Real GDI	2.3%	1.9%	3.1%	1.1%	1.3%	2.7%	1.8%	2.8%	3.4%
	Labor Productivity	–	1.7%	–	1.8%	1.4%	0.4%	2.5%	2.1%	1.2%
Canada	Real GDP	2.3%	1.9%	3.3%	2.9%	1.7%	1.5%	1.0%	2.9%	1.7%
	Real GDI	2.4%	2.2%	3.3%	3.2%	1.6%	1.9%	0.9%	2.8%	3.0%
	Labor Productivity	–	1.4%	–	2.0%	1.0%	0.6%	1.6%	2.0%	0.9%
United Kingdom	Real GDP	2.2%	2.2%	2.3%	2.2%	1.8%	2.9%	1.8%	2.8%	2.1%
	Real GDI	2.2%	2.2%	2.4%	1.5%	2.0%	3.1%	1.9%	3.0%	2.1%
	Labor Productivity	–	2.3%	–	2.3%	2.3%	1.0%	2.4%	2.3%	2.1%
United States	Real GDP	2.2%	2.0%	3.1%	2.4%	1.9%	2.2%	1.6%	1.8%	1.8%
	Real GDI	2.1%	1.9%	3.1%	2.1%	1.8%	2.0%	1.7%	1.9%	1.5%
	Labor Productivity	–	1.6%	–	1.5%	1.4%	1.0%	1.4%	2.3%	1.8%

TABLE 6

PERCENTAGE POINT STANDARD DEVIATIONS OF GROWTH RATES, 1971–2007*

	Labor Productivity	Real GDP Per Capita	Real GDI Per Capita
Australia	1.9	1.8	2.3
Canada	1.1	2.0	2.5
United Kingdom	1.5	1.9	2.0
United States	1.1	1.9	2.0

Note: *Real GDP per capita and real GDI per capita over the entire sample period show a similar increase in volatility between production and purchasing power adjusted real income measures.

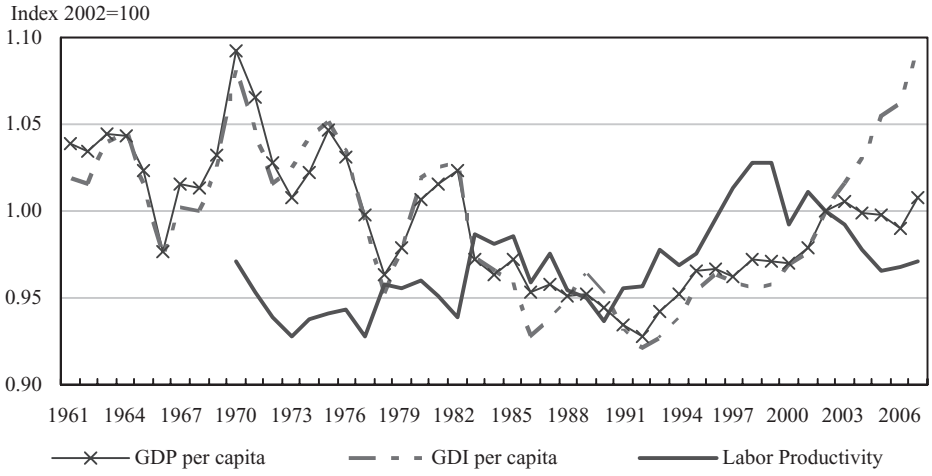

Figure 4. Long-Run Economic Performance: Australia Relative to United States

price collapse, and the post-2002 commodity boom are all periods when real GDI per capita and real GDP per capita growth rates diverged.

For Australia and Canada, the performance of their respective economies relative to the United States over long periods of time tended to be determined by movements associated with production from 1961 to 2001 (Figures 4 and 5). Movements in relative GDI per capita followed the same pattern as movements in relative real GDP per capita. While trading gains led to larger relative changes in GDI per capita, particularly during the first and second oil shocks, ultimately it was changes in inputs and productivity that drove differences in relative economic performance.

After 2001, terms of trade improvements for Australia and Canada, coupled with terms of trade deteriorations for the United States, led to a divergence between relative labor productivity, GDP per capita, and GDI per capita. Labor productivity in the resource rich nations failed to keep pace with labor productivity growth in the United States, but real GDP per capita kept pace. Real GDI per capita for Australia and Canada, on the other hand, shows gains relative to the United States between 2002 and 2007.

The long-run analysis implies that commodity price cycles have been an important source of real income fluctuations in developed countries for an

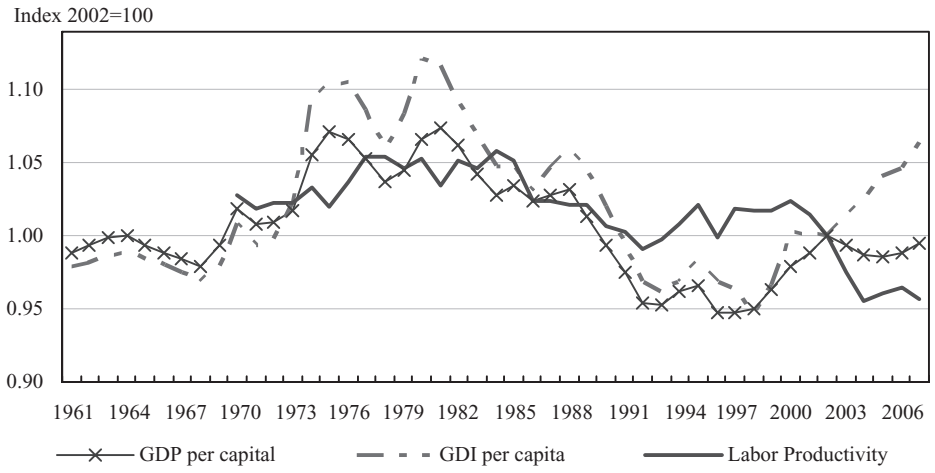

Figure 5. Long-Run Economic Performance: Canada Relative to United States

extended period of time. One way to illustrate the influence of resource cycles for terms of trade shifts is to examine the relationship between terms of trade and commodity prices for individual countries over time. Because the contention is that the terms of trade reflect the price of commodities relative to manufactured goods, a relative commodity price is employed.

The commodity price index employed here covers a wide range of primary commodities priced in United States dollars (see Hirsch, 2003 for details). To generate a relative commodity price free from the influences of nominal exchange rate fluctuations, the United States CPI durable manufactured goods price index is used as a U.S. dollar measure of manufacturing prices to scale the commodity price index.

Canada and Australia export a variety of commodities, which makes their terms of trade sensitive to price changes in many different types of primary products, while the United States imports many commodities, but is particularly sensitive to energy prices.[5]

Between 1961 and 2007, the terms of trade for Australia and Canada followed regular commodity price cycles (Figure 6) and did not have a long-run effect on real income growth. The cyclical nature of commodity price changes led to alternating terms of trade improvements and deteriorations, which increased the volatility of real income but did not affect its trend.

Between 1961 and 2007, the terms of trade for the United States reflected changes in the relative price of energy. The two largest terms of trade shifts

[5]The Bank of Canada Commodity Price Index is used as a measure of resource prices. It captures movements in primary resource prices using weights appropriate for Canada. It is not the ideal measure of the commodity prices for Australia. Nevertheless, because Australia and Canada export a wide range of commodities, the index follows shifts in global commodity demand that are relevant for both countries.

Similarly, the energy price index used to illustrate the relationship between U.S. terms of trade and energy prices is a sub-index of the Bank of Canada Commodity Price Index. While not ideal, it does capture the relevant energy price changes affecting the United States.

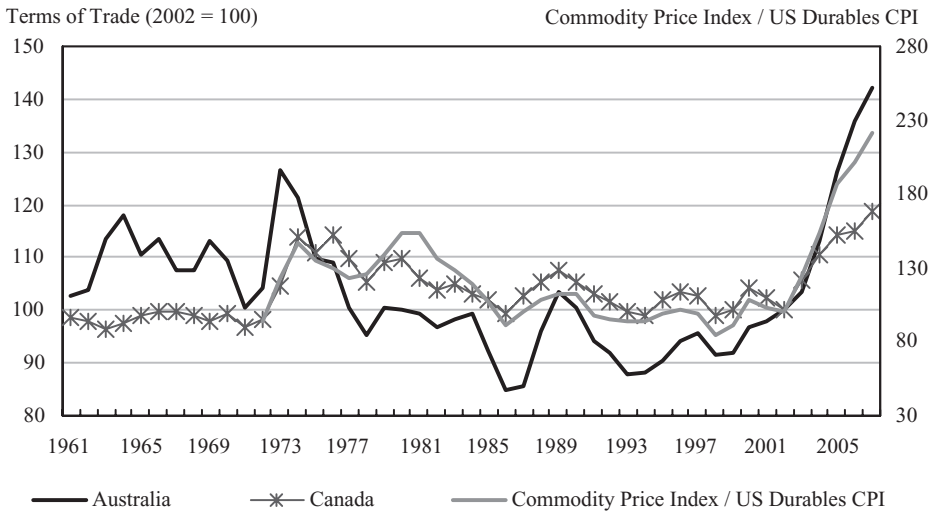

Figure 6. Commodity Prices/U.S. Durables CPI vs. Terms of Trade for Australia and Canada

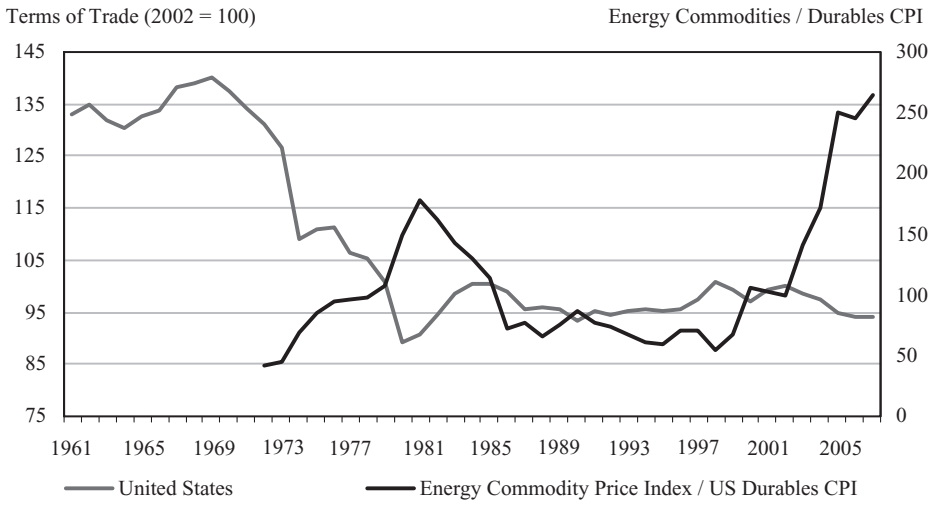

Figure 7. Energy Prices/U.S. Durables CPI vs. Terms of Trade for United States

occurred during the oil shocks (Figure 7). The cumulative effect of the supply disruptions was a 35.2 percent deterioration in the United States' terms of trade between 1970 and 1980. Unlike the cyclical movements in Australia and Canada, the majority of the deterioration in the United States was permanent.[6]

In addition to the oil shocks, energy prices also rose sharply during the resource boom. However, the increase in energy prices did not have as large an

[6]In the U.K., the first oil shock led to a 20.6 percent deterioration in the terms of trade between 1972 and 1974. The majority of the decline was unwound by the late 1970s, and the second oil shock did not generate a second due to energy exports from newly developed North Sea deposits.

impact on the United States' terms of trade which declined 5.8 percent between 2002 and 2007. One reason why a difference may appear is described in Reinsdorf (2008). He argues that prices of non-energy imports supported the terms of trade during the years 2003–07, partially offsetting the effect of rising energy prices. A second reason may be that energy prices did not rise by as much after 2002. From 1972 to 1981, the oil shocks led to a 720 percent rise in energy prices. From 2002 to 2007, energy prices rose 146 percent, less than a third of the increase during the oil shocks. If 1998, rather than 2002, is used as the low-point in energy price cycles, then the increase in energy prices rises to 328 percent, which is still less than half of the rise that the oil shocks of the 1970s generated.

The real exchange rate can also be influenced by commodity price fluctuations, and although its effects may be more muted due to its relatively low weight in the GDI decomposition, its long run impact behavior still entreats examination. Changes in the real exchange rate over long periods of time reflect differential changes between goods and services sectors. While there is trade in services, the majority of traded items are goods. As a result, the composition of domestic purchases is weighted more toward services than the composition of traded items. Because traded items include commodities whose prices are cyclical, but without a trend, and because manufactured goods prices fall relative to services over time, traded prices do not rise as quickly as domestic prices. The real exchange rate, therefore, tends to decline over long periods.

The profitability of traded and non-traded sectors changes as the real exchange rate changes. A declining real exchange rate acts to raise investment and employment in non-traded industries relative to traded industries (Corden and Neary, 1982). Shifts in the real exchange rate, in addition to their short-run influence on real income growth, influence changes in an economy's productive activity.

Over shorter periods of time, movements in commodity prices and currencies can eclipse the long-run determinants of real exchange rate change. Oil shocks, currency crises, and commodity booms all lead to real exchange rate changes in the short run. In many cases, periods of real exchange rate increase are accompanied by increased uncertainty and unemployment. In Australia, Canada, and the United States, the oil shocks lead to real exchange rate increases in 1973–74 and an increase in 1979–80 (Figure 8).[7]

7. Conclusion

In a world where international trade is an important activity, real income depends not only on the volume of production, but also on the volume of goods and services that production commands on world markets. A country may appear to better its income levels when a production based real income measure, like real GDP per capita, is used. However, if it produces items whose relative price is declining, it may not see much of an increase in the purchasing power of that income. Measures of real income that incorporate production and purchasing power changes can be formed from widely available national income statistics. Real GDI per capita is one such measure.

[7]The first oil shock led to an increase in the real exchange rate for the U.K. In Korea, the oil shocks and the 1997 Asian Financial Crises lead to increases of the real exchange rate.

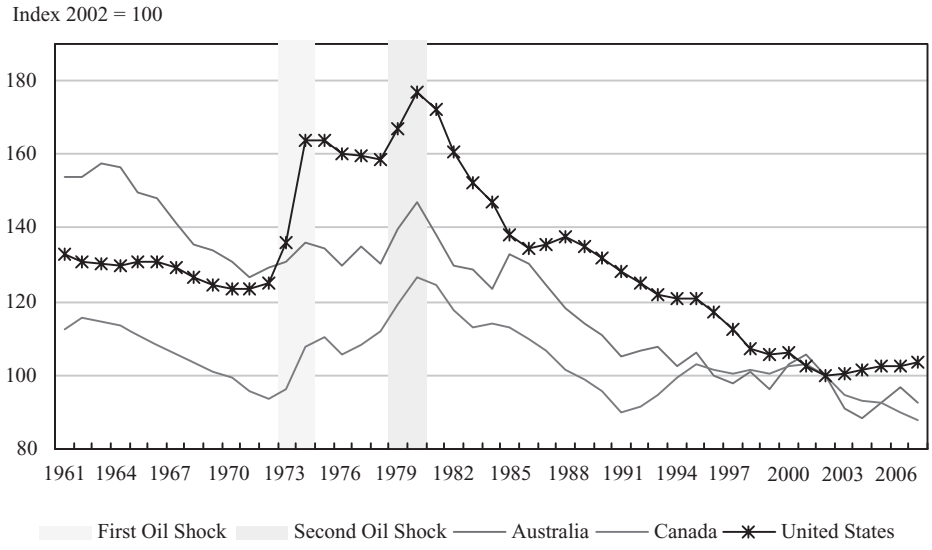

Figure 8. Real Exchange Rate Over Time: Select Countries

Purchasing power is measured through a trading gain, which is composed of two related relative prices: the terms of trade, and the real exchange rate. The terms of trade is the ratio of export to import prices, and the real exchange rate is the ratio of the geometric mean of export and import prices to an index of final domestic expenditures. The terms of trade are an order of magnitude more important for real income growth than the real exchange rate for most OECD countries.

The terms of trade are basically capturing a trade-off between resources and manufactured products. During the 2003–07 commodity boom, terms of trade changes redistributed purchasing power across the OECD: resource rich nations tended to experience increases in real consumption or real gross fixed capital formation that outpaced growth in real GDP, while resource net importers tended to experience increases in real consumption and real gross fixed capital formation that lagged behind real GDP growth.

The relationship between the terms of trade and resource prices, and the effect of relative price shifts on real income growth across the OECD from 2003 to 2007, produced a short-run boost in real income growth that was large by historical standards. During the commodity boom, being a resource rich, resource exporting nation was beneficial. However, during periods when resource prices decline relative to other prices, resource rich nations will face difficulties turning production into consumption and investment.

Moving to real GDI not only affects the interpretation of economic aggregates, and the role of resources in economic growth, but also influences the outcomes of international comparisons. Comparing measures of GDP per capita or labor productivity across countries over time can generate different results from trading gain adjusted real income measures during periods of rapid relative price change.

References

Corden, W. M., "The Geometric Representation of Policies to Attain Internal and External Balance," *Review of Economic Studies*, 28, 1–22, 1960.

———, "Booming Sector and Dutch Disease Economics: Survey and Consolidation," *Oxford Economics Papers*, 36, 359–80, 1984.

———, "Dependent Economy Model of the Balance of Payments," *New Palgrave Dictionary of Money and Finance*, Macmillan, London, 1992.

Corden, W. M. and J. P. Neary, "Booming Sector and De-Industrialization in a Small Open Economy," *Economic Journal*, 92, 825–48, 1982.

Courbis, R. W., "Compatabilitié nationale à prix constants et à la productivitié constant," *Review of Income and Wealth*, 15, 33–76, 1969.

Denison, Edward F., "International Transactions in Measures of the Nation's Production," *Survey of Current Business*, 61(5), 17–28, 1981.

Diewert, E. W., "Superlative Index Numbers and Consistency in Aggregation," *Econometrica*, 46, 883–900, 1978.

Diewert, E. W. and C. J. Morrison, "Adjusting Output and Productivity Indexes for Changes in the Terms of Trade," *Economic Journal*, 96, 659–79, 1986.

Dornbusch, R., "Real Monetary Aspects of the Effect of Exchange Rate Changes," in R. Z. Aliber (ed.), *National Monetary Policies and the International Financial System*, Chicago University Press, Chicago, 1974.

———, *Open Economy Macroeconomics*, Basic Books, New York, 1980.

Fox, K., U. Kohli, and R. Warren, "Accounting for Growth and Output Gaps: Evidence from New Zealand," *Economic Record*, 78, 312–26, 2002.

Francis, M., "The Effect of China on Global Prices," *Bank of Canada Review*, 13, 25, Autumn 2007.

Geary, R. C., "Problems in Deflation of National Accounts: Introduction," *Review of Income and Wealth*, 9, 3–8, 1961.

Hirsch, Todd, "Updating the Bank of Canada Commodity Price Index," *Bank of Canada Review*, 31–3, Spring 2003.

Hulten, C., "Total Factor Productivity: A Short Biography," in C. R. Hulten, E. R. Dean, and M. J. Harper (eds), *New Developments in Productivity Analysis*, University of Chicago Press, Chicago, 2001.

Kohli, U., "Real GDP, Real Domestic Income, and Terms of Trade Changes," *Journal of International Economics*, 62, 83–106, 2004.

———, "Real GDP, Real GDI, and Trading Gains: Canada, 1982–2005," *International Productivity Monitor*, No. 13, 46–56, Fall 2006a.

———, "Terms of Trade Changes, Real GDP and Real Value Added in the Open Economy: Reassessing Hong Kong's Growth Performance," Working Paper No. 5/2006, Hong Kong Institute for Monetary Research, 2006b.

Kurabayashi, Y., "The Impact of Terms of Trade on a System of National Accounts: An Attempted Synthesis," *Review of Income and Wealth*, 17, 285–97, 1971.

Nicholson, J. L., "The Effects of International Trade on the Measurement of Real National Income," *Economics Journal*, 70, 608–12, 1960.

Reinsdorf, M., "Measuring the Effects of Changes in the Terms of Trade on Incomes, Exports and Prices," Presentation to the BEA Advisory Committee, November 7, 2008.

Rodgers, M., "A Survey of Economic Growth," *Economic Record*, 29, 112–35, 2003.

Salter, W. E. G., "Internal and External Balance: The Role of Price and Expenditure Effects," *Economic Record*, 35, 226–38, 1959.

Silver, M. and K. Mahdavy, "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, 1989.

SNA, *System of National Accounts*, Commission of the European Communities/Eurostat, International Monetary Fund, Organisation for Economic Co-operation and Development, United Nations Secretariat, World Bank, 1993.

Stuvel, G., "A New Approach to Measurement of Terms of Trade Effects," *Review of Economic Statistics*, August, 294–307, 1956.

Swan, T. E., "Economic Control in a Dependent Economy," *Economic Record*, 36, 51–66, 1960.

Tornqvist, L., "The Bank of Finland's Consumption Price Index," *Bank of Finland Monthly Bulletin*, No. 10, 1–8, 1936.