The Impact of Emerging Asia on Commodity Prices*

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Abstract

Over the past 5 years, real energy and non-energy commodity prices have trended sharply higher, and these relative price movements have had important implications for both inflation and economic activity in Canada and the rest of the world. China has accounted for the bulk of incremental demand for oil and many base metals over this period. As rapid economic growth in China has raised the level of world demand, this has placed upward pressure on commodity prices. This effect has been further amplified by rising resource intensities in China's production in recent years. This paper assesses the impact of emerging Asia on the real prices of oil and base metals in the Bank of Canada Commodity Price Index (BCPI). Two separate single-equation models are estimated for oil and the base metals price index. We employ a structural break approach for oil prices, while metals prices are modelled with an error correction model (ECM). In both cases, we find strong evidence that oil and metals prices have historically moved with the business cycle in the developed world, but that this relationship has broken down since mid-1997. Thereafter, industrial activity in emerging Asia appears to have become a more dominant driver of oil price movements. While metals price fluctuations have become increasingly aligned with the emerging Asia business cycle, rising metals intensities of production may have been a more important factor behind the acceleration in prices since 2002.

JEL classification: E3, F4, O19, Q11
Keywords: commodity price, emerging Asia, China

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1. Introduction

Over the past 5 years, real energy and non-energy commodity prices have trended sharply higher. These relative price movements have had important implications for both inflation and economic activity in Canada and the rest of the world.[1] Dramatic increases have been observed primarily in oil and base metals prices, and can be justified in part by strengthening demand conditions in the industrialized world, the depreciation of the U.S. dollar, and slow supply responses. However, China has accounted for the bulk of incremental demand for oil and many base metals during this period. As rapid economic growth in China has raised the level of world demand, this has placed upward pressure on commodity prices. This effect has been further amplified by increasing resource intensities of China's production in recent years.

This paper uses an empirical approach to assess from the data the impact of emerging Asia on the real prices of oil and base metals in the Bank of Canada Commodity Price Index (BCPI).[2] Given emerging Asia's growing prominence in the world economy, it is important to understand its impact on commodities markets and its role in driving recent price movements. An enhanced understanding of these aspects would allow us to better assess the implications for commodity prices going forward, and improve the accuracy of Bank of Canada projection models for policy analysis. Analysis of emerging Asia's impact on commodity prices has been limited to date, given that its upsurge in demand has been relatively recent. While Lalonde and Muir (2006) are able to simulate the recent rise in commodity prices within a DSGE framework through combining a permanent productivity increase in emerging Asia with a shock to energy intensity, the literature has provided little empirical support for this.

Given the heterogeneity across diferent commodity markets, two separate single-equation models are estimated for oil and metals prices. We employ a structural break approach for oil prices, based on previous findings of structural shifts by Lalonde, Zhu, and Demers (2003). For the base metals price index, an error correction model (ECM) is estimated. We find strong evidence that while oil and metals prices have historically moved with the business cycle in developed economies, this relationship has broken down since mid-1997. Thereafter, industrial activity in emerging Asia appears to have become a more dominant driver of oil price movements. While metals price fluctuations have become increasingly aligned with the emerging Asia business cycle, rising metals intensities of production may have been a more important factor behind the acceleration in prices since 2002.

This paper is organized as follows. Section 2 summarizes recent developments in commodity price behaviour and Section 3 discusses the sources of emerging Asia's demand for commodities. A brief literature review is provided in Section 4, followed by a description of the theoretical framework and data in Section 5. The model specifications and results are discussed in Section 6, with concluding remarks in Section 7.

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[1] Since Canada is a net exporter for most commodities, a sustained increase in commodity prices would incur a shift in productive resources towards commodity-producing sectors, while driving an appreciation in the exchange rate. The improved terms of trade would create wealth effects and raise consumption.

[2] Examination of agricultural and forestry product prices is left for future research, since little real price increase has materialized thus far.

2. Recent Behaviour in Real Commodity Prices

While real commodity prices had been on a downward trend for much of the past 25 years, they have moved persistently higher since the end of 2001.[3] This is illustrated in Figure 1, which plots the Bank of Canada Non-Energy Commodity Price Index in real terms and the real West Texas Intermediate (WTI) benchmark crude oil price. Figure 2 illustrates the evolution of prices of the major non-energy commodity groups over history.[4] The BCPI is constructed from the U.S. dollar spot or transaction prices of 23 key Canadian commodities produced in Canada and sold in world markets. A list of the commodities and their weights is provided in Table A1 in the Appendix.

Fig. 1: Bank of Canada Commodity Price Index

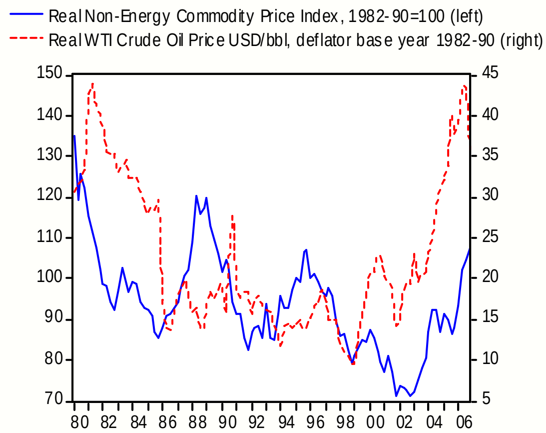
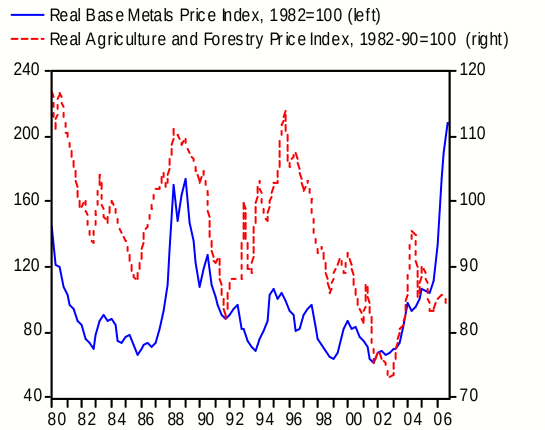


Fig. 2: Bank of Canada Non-Energy Commodity Price Index



The real price increases since the end of 2001 have been concentrated primarily in crude oil and base metals, which are now above or close to historical peaks of the last 25 years. The upward trend has been broadly based across different metals, suggesting that common factors have been responsible. As macroeconomic demand conditions in industrialized countries have traditionally been main determinants of commodity prices, some of the recent price increases can be explained by robust global economic growth (see Fig. A1) and a significant depreciation of the US dollar (see Fig. A2). However, the expanding share of commodities consumption attributable to emerging Asia suggests that the region has contributed importantly to demand pressures in recent years. Due to declining investment in energy and metals industries since the late 1990s (see Fig. A3), production capacity has been slow to respond. As a result, spare oil production capacity has fallen to historic lows (see Fig. A4), along with many base metals inventories.

3. A Decomposition of Asia's Demand for Commodities

Over the past 5 years, China has roughly doubled its share of world trade, while accounting for the majority of incremental demand for copper, nickel, and zinc, as well as a substantial portion of oil demand growth. The first two columns of Table 1 depict

[3] The downward trend in real metals prices over history may be largely attributed to productivity gains in this sector and declining metals intensities in major industrialized countries. Meanwhile, advances in technology and agro-science, appear to have played a key role in driving down real agricultural prices. Rising agricultural subsidies in Europe and United States during the 1980s have also participated in the downward movements of these prices.

[4] In Figures 1 and 2, all non-energy commodity price indexes are deflated using the U.S. producer price index for finished goods. The crude oil price is deflated by the U.S. GDP deflator.

China's expanding share of world demand growth for oil and the four base metals contained in the BCPI. Because China has a low domestic endowment of natural resources relative to its needs, it has become a net importer of most commodities (see Fig. A5).[5] One major exception is aluminium: while China has become one of the largest consumers of aluminium in the world, it has also recently emerged as a top producer and net exporter of this metal. Aluminium prices have more than doubled in the last 5 years, but this increase is considerably dwarfed by the gains observed in other base metals prices.

The expansion of China's international trade has been an important factor behind China's escalating demand for industrial materials. Regional integration has been elemental to China's trade growth, as a large portion of its exports originate from Japanese and other Asian firms, for final destination in U.S. and European markets. It is estimated that over 40% of China's imports are processed for re-export. Li and Song (2006) suggest that increasing bilateral trade and similar export structures between China and ASEAN countries reflects the operation of multinational corporations in the region seeking economies of scale through cross-border fragmentation of production. Consequently, while China has fostered a swelling trade surplus with the West, it has also built trade deficits with Japan, Korea, and the ASEAN-4 countries (see Fig. A14). It is thus important to also examine the role of other Asian countries in boosting commodities demand.

Table 1 compares the shares of commodities demand growth of China with those of India, Japan, the Asian NIEs, and ASEAN-4 countries. Although the contributions of ASEAN-4 to demand growth in oil and base metals have increased significantly in recent years, they remain modest compared to China. India and Japan have seen little increase in their shares of world demand growth for these commodities, while the portion attributable to Asian NIE countries has diminished for all commodities examined. Although this suggests little role for the NIEs in driving recent commodity price increases, South Korea's contribution to world nickel demand growth over 2001-2005 more than doubled to 33%, from 15% in the preceding 5 years. This increase has been more than offset by a significant decline in Taiwan's share.

Table 1. Shares of World Demand Growth[¥]

	China		Asian NIEs*		Japan		ASEAN-4**		India	
	1996-2000	2001-2005	1996-2000	2001-2005	1996-2000	2001-2005	1996-2000	2001-2005	1996-2000	2001-2005
Oil	23%	35%	6%	5%	0%	0%	3%	5%	12%	3%
Aluminium	32%	46%	7%	6%	0%	3%	0%	3%	0%	4%
Copper	26%	62%	12%	5%	0%	4%	8%	13%	4%	5%
Nickel	4%	63%	37%	28%	2%	0%	0%	4%	2%	0%
Zinc	32%	88%	13%	4%	0%	0%	2%	4%	2%	5%

[¥] Source: BP Statistical Review 2006, World Bureau of Metal Statistics. Demand growth is calculated as the change in units consumed over the stated period.
* Asian NIEs include Hong Kong, Singapore, South Korea, and Taiwan.
** ASEAN-4 countries include Indonesia, Malaysia, Philippines, and Thailand.

China's expanding appetite for industrial materials can be decomposed into two main sources: i) its rapid industrialization and infrastructure investment to meet the needs

[5] While China is the sixth largest crude oil producer in the world, it has been a net importer of oil since 1993.

of an expanding urban population, and ii) its growing industrial integration with other East Asian countries to become a major world exporter of manufactured goods. Of course, these two factors are highly interrelated, since China's thriving export industry has been a major catalyst for rising domestic investment and urban migration in recent years. Nevertheless, it is worth distinguishing between these two sources of demand for commodities. This is because the first channel is driven by final domestic demand in China and is expected to be a persistent source of commodities demand going forward, whereas the second is more dependent on external demand conditions, and is expected to eventually diminish in importance. Henceforth, we refer to the first source as the *domestic demand channel*, and the second as the *export channel*. Emerging Asia's demand for commodities can be represented simplistically as follows:

$$D_{ASIA} = \eta DOM_{ASIA} + \zeta PROD_{ASIA} \qquad (3.1)$$

where demand is dependent on the level of domestic activity DOM_{ASIA} (the domestic demand channel) and the production of manufactured goods for export $PROD_{ASIA}$ (the export channel), combined with their respective intensities of resource use (η and z). While expanding domestic infrastructure investment and exports of manufactured goods have raised the respective levels of DOM_{ASIA} and $PROD_{ASIA}$, an increase in resource intensities over recent years has also boosted emerging Asia's demand for commodities.

3.1. Domestic Demand Channel:

Although China has continuously developed its urban infrastructure and domestic industry for quite some time, its energy and metals intensities have only advanced noticeably in recent years. As Figures A6 to A10 show, China's per GDP consumption has accelerated since 2003 for energy and zinc, and since the late 1990s for aluminium, copper and nickel.[6] As discussed in Rosen and Houser (2007), much of this is attributable to the substantive growth in energy-intensive and capital-intensive industries - such as steel, aluminium, cement, and glass – used for road and building construction.

Studies show that resource demands in developing countries typically begin to climb during the early phase of industrialization, and eventually stabilize and then decline as income levels advance, creating an inverted U-curve.[7] For example, Figure A11 plots the per capita consumption of zinc against real GDP per capita (2000 U.S. dollar terms) for China, Japan, South Korea, Malaysia, and Thailand. Similar graphs for energy and other base metals show comparable patterns, and are thus not shown. Based on the experiences of Japan in the 1960s and Korea in the 1980s, emerging Asia's energy and metals intensities could be expected to gain momentum at income levels between $5000-$10,000 per capita, and continue to grow rapidly before slowing at income levels of about $15,000-$20,000 per capita.[8] Indeed, for countries whose per capita income levels range

[6] China's energy intensities began a long descent in the late 1970s until very recently, as energy efficiencies were gained and market reforms encouraged structural shifts away from heavy industry (e.g. steel and cement) towards labour-intensive light manufacturing (e.g. textiles). This trend has reversed in recent years, as economic incentives have favoured energy-intensive industries.

[7] For example, see Cleveland and Ruth (1999), Park and Zhai (2006), and Garnaut and Song (2006).

[8] A slowing in China's resource intensities would be dependent on its industry moving away from manufacturing towards a service sector orientation.

between \$5000-\$10,000 (China, Thailand, and Malaysia), resource intensities have accelerated in recent years. In contrast, little change has been observed thus far in India, Indonesia, and the Philippines, where per capita income levels remain below \$5000.

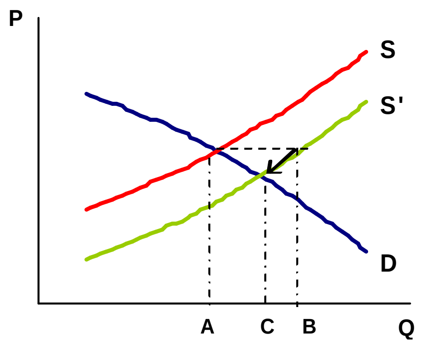
Garnaut and Song (2006) propose three key variables that drive a country's energy and metals use: investment share of output, export share of production, and rate of urbanization (defined as the fraction of population that is urban). So far, China's resource intensities have been bolstered primarily by advancing investment and export shares of output in recent years (see Fig. A12).[9] Looking ahead, consumption is expected to become the leading driver of energy and metals demand, as rising incomes of urban workers generates growing automobile ownership and consumption of household durables. The proportion of China's population living in cities - currently at 40%, compared with Japan at 66% and Korea at 81% (see Fig. A13) - should also continue to progress for some time. Together, these factors suggest that the domestic demand channel should be a persistent source of demand for commodities going forward.

3.1.2 Export Channel:

China's abundant labour force has given it a strong competitive advantage in the relatively labour-intensive manufacturing sector, allowing it to integrate into the global processing chain as a low-cost final assembler of manufactured goods. Adopting this role has generated a surge in China's exports of manufactured goods and increased raw material needs. Figure A15 illustrates that emerging Asian countries have accumulated larger shares of world manufacturing activity since 2000.[10]

To the extent that emerging Asia is boosting the global supply of manufactured goods, higher production levels would generate a higher level of world demand for raw materials. As illustrated in Figure 3 below, the increased availability of cheap manufactured goods on world markets would shift the supply curve out from S to S'. The increase in emerging Asia's production of manufactured goods would thus be *AB*. Some

Fig. 3: World Market for Manufactured Goods



of this increase could also reflect manufacturing activity that has migrated from higher-cost countries to Asia. The decreases observed in Japanese and U.S. shares of world manufacturing activity since 2000 (shown in Fig. A15) suggest that mounting exports

[9] The transportation sector has also become increasingly important. The number of motor vehicles on the road has doubled in the last 5 years, and transportation has accounted for 42% of China's growth in oil consumption since 1995.

[10] In particular, China's shares of global production have more than doubled since 2000 to 28% for aluminium, 35% for steel, and 48% for cement.

from emerging Asia may be displacing production in the rest of the world.[11] If we assume that firms in the rest of the world outsource a fraction α of their production to emerging Asia, then the increase in the region's production of manufactures could be represented as:

$$\Delta PROD_{ASIA} = \delta + \alpha PROD_{ROW} = AB$$

where δ is the portion of growth that does not come from outsourcing. Holding everything else constant, from equation (3.1), emerging Asia's demand for commodities would increase by $\zeta AB = \zeta(\delta + \alpha PROD_{ROW})$.

As the emergence of a low-cost producer on world markets pushes down the global price of manufactured goods, production in the rest of the world would also decline as relatively inefficient firms shut down. Assuming this reduces production outside of Asia by the fraction β,

$$\Delta PROD_{ROW} = -(\alpha + \beta) PROD_{ROW}$$

From Figure 3, the resulting growth in total world production of manufactured goods would thus be the amount $AC < AB$.

$$\Delta PROD_{WORLD} = \delta - \beta PROD_{ROW} = AC$$

Everything else constant, the rise in emerging Asia's demand for commodities would thus exceed the global demand increase, by an amount proportional to $\Delta PROD_{ROW}$.

While it is the *incremental* world demand attributable to emerging Asia - AC - that moves commodity prices, this amount is generally difficult to isolate from the amount $\Delta PROD_{ASIA} = AB$. Therefore, any inferences made from observations of $\Delta PROD_{ASIA}$ could lead to an overstatement of the region's true impact on prices.

A second reason emerging Asia's influence on commodity prices may be difficult to identify is that a significant portion of the region's manufactured goods are exported to the Americas and Europe. Consequently, one could arguably attribute the related raw materials demand to external demand conditions. As concluded in a study by the Asian Development Bank (2007) on Asian intra-industry trade, growth in manufactures exports from emerging Asia remains heavily reliant on final demand outside the region. Accordingly, the region's demand for commodities for its production of manufactures exports is arguably more driven by the business cycle in the industrialized world than in emerging Asia itself.

[11] The observed declines in net exports to the U.S. from Japan, Singapore, and Hong Kong since 2000 (shown in Fig. A18) may also indicate that some of the expanding Chinese exports to the U.S. have simply displaced Japanese and Asian NIE exports. The decline in the U.S. manufacturing sector relative to real GDP since 2000 (shown in Fig. A16) may partly reflect some production being outsourced to Asia (although there has been some recovery since mid-2005). This seems to be corroborated by decreases in some of the metals intensities of consumption in the U.S. since 2000, in particular copper and aluminium (see Figs. A7 and A8). However, this is also difficult to conclude with certainty, as the relative declines in industrial production and metals intensities in the U.S. since 2000 may be a result of other factors, such as recession or the correction in the information technology sector.

In the above scenario, it is assumed that the manufacturing activity outsourced to Asia generates no net gains in commodities demand. This would not apply if the resource intensities of emerging Asia were substantially higher than those in the rest of the world. In the case of oil, migrating production to emerging Asia would likely produce net increases to world oil demand. This is because emerging Asia industry is much more inefficient in its energy use than the developed economies. According to some estimates (see Rosen and Houser, 2007), Chinese firms consume 20 to 40% more energy for the same level of output compared to their OECD counterparts.

4. Review of Literature

Research on structural models for commodity prices have traditionally found the main price drivers to be world industrial activity and the U.S. real exchange rate. Hua (1998) finds that the long-run equilibrium level of real non-oil commodity prices is a function of industrial production in developed countries, the real effective U.S. exchange rate, and real oil prices. Lalonde, Zhu, and Demers (2003) use a SVAR to model the Bank of Canada's total real non-energy commodity price series, and a separate multiple structural break equation for real crude oil prices. The authors find that a 1 percent positive shock to world economic activity (as measured by the G7 output gap) leads to a peak response of 12 percent in real oil prices and 6 percent in real non-energy commodity prices. Studies also show that cycles tend to be correlated across commodities, suggesting a role for common macroeconomic factors. In particular, Borensztein and Reinhart (1994) and Hua (1998) find that oil price shocks play an important role in driving non-oil prices.

Specific analysis of emerging Asia's impact on commodity prices has been limited to date, given that its upsurge in demand has been relatively recent. Within a DSGE framework, Lalonde and Muir (2006) are able to explain the recent rise in oil prices through simulating a permanent increase in productivity in emerging Asia, combined with a further shock to energy intensity. However, empirical support for this has been limited thus far in the literature.

A recent empirical study by Pain, Koske, and Sollie (2006) from the OECD attempts to isolate the commodity price response to growth in emerging economies, as measured by non-OECD shares of world output and trade. The authors estimate reduced form equations using an error-correction framework for 5 major commodity groups. Results indicate that relative strength in emerging market economies exhibited significant and permanent effects on real oil prices, while only temporary effects on the level of real metals prices, and no effect on agricultural prices. The authors attribute these differences to more elastic supply responses for non-oil commodities than for oil.

Borensztein and Reinhart (1994) argue that traditional "demand-driven" structural models that ignore supply have tended to persistently over-predict real commodity prices by wide margins from the latter half of the 1980s into the early 1990s.[12] While the OECD study uses deterministic time trends to capture long-term productivity increases, this variable has no explanatory power for oil or metals prices.

[12] The authors suggest that this was due to the sharp increase in commodities exports from economies in transition in the Former Soviet Union, which were not accounted for in most models.

In practice, world commodity supply is unobservable and difficult to measure, with any constructed proxy likely to face measurement error problems[13]. Furthermore, even if reliable production data can be obtained for a given commodity, it is arguably productive *capacity* which drives longer-term price behaviour. While supply capacity can be estimated from indicators such as reserves and investment in mining and resource sectors, such data remains difficult to obtain globally. Yet more difficult to capture are *expected* supply shortages, which can be important in influencing prices even in the absence of actual disruptions. As a result, lack of data availability is a standard assumption in much of the commodity price literature, and price predictions are commonly derived from statistical inference made solely from the observed prices.

5. Theoretical Framework

The approach used to estimate the impact of emerging Asia on commodity prices begins with a simple partial equilibrium framework of price formation in a storable commodity market. The market comprises of consumption demand, inventory demand, and supply:

$$D_t = \mathrm{D}\{(L)P_t, (L)Y_t, (L)X_t\}$$
$$Q_t = \mathrm{Q}\{(L)P_t, P^e{}_t, (L)Z_t\}$$
$$I_t = \mathrm{I}\{(P^e{}_{t+1} - P_t), r_t\}$$

With *(L)* as acting as the lag operator, commodities demand (D_t) is a function of current and past levels of the price (P_t), income (Y_t), and other exogenous variables (X_t). Supply (Q_t) is also determined by current and past commodity prices, expected future prices, and some exogenous variables (Z_t). Inventory demand (I_t) is dependent on the cost of storage as defined by the interest rate (r_t), and the expected profit from holding the stock, as defined by the expected change in price. Because commodities are storable, expectations about future market conditions can have immediate impacts on the demand for storage, and thus affect current prices. Finally, the market clearing price is that which equates consumption demand and inventory demand with supply:

$$Q_t = D_t + \Delta I_t$$

Given the data difficulties mentioned with world commodities supply, demand, and inventories, the system of equations becomes very difficult to estimate and solve. Consequently, price is typically represented by a reduced form single-equation model, and is a function of income, lagged prices, price expectations, interest rates, and other exogenous variables:

$$P_t = P\{(L)Y_t, (L)P_{t-1}, (L)X_t, \Delta P^e_{t+1}, (L)r_t\} \qquad (5.1)$$

From this equation, it would not be possible to identify the parameters in the structural system, nor disentangle effects of supply and demand adjustments. For some of

[13] For most commodities, obtaining data on world production, consumption and inventories faces limitations in terms of low quality, timeliness, and prohibitive cost. Frequency and units of measure also varying markedly across different countries and different types of commodities, making aggregation difficult.

the variables it is even difficult to know the proper sign of the coefficient. Variables such as expected future prices are also unobservable.

The dependent and independent variables considered for equation (5.1) are described in the following section. To estimate the impact of emerging Asia on commodity prices, we consider a number of different emerging Asia variables to represent the growth in demand and intensity of resource use from this region. Emerging Asia is defined to include China, India, ASEAN-4, and the Asian NIEs. This differs from the OECD study, which captures the more general "emerging markets", as represented by non-OECD countries. Given that many major emerging markets actually lowered their shares of world demand growth in commodities over the 2002-2005 period (see IMF, 2006), such as Brazil, India, Mexico and Russia, this may lead to different results from the OECD study. We also attempt to identify and differentiate between the effects from both the domestic demand channel and the export channel described in Section 3.

Since our interest in commodity prices stems primarily from their importance for the Canadian economy, our analysis is centred on the commodities in the BCPI basket. Since the most pronounced increases have been observed in the real prices for oil and base metals over recent years, we focus on these commodities. Given the heterogeneity across different commodity markets, two separate equations are estimated for the real oil price and the real base metals index from the BCPI.[14] For global agriculture and forestry product prices, little increase has materialized in real terms in the past 5 years, and the bulk of gains over this interval are suspected to be more related to supply factors.[15] Although food and forestry prices are expected to be increasingly influenced by emerging Asia's rising housing demand and household wealth, this analysis is left for future research.

5.1. Data

All data series are quarterly and logged, with the exception of real world interest rates and variables in ratio form. More detailed sources and definitions of the data used are given in the Appendix. The commodity price series used are the benchmark WTI crude oil price and the base metals index of the BCPI. Both series are deflated to real terms using the U.S. producer price index for finished goods.

To represent demand from industrialized countries, the income variables considered are the OECD index of industrial production and the OECD output gap. These variables are expected to bear a positive relationship with prices, as increased production in major industrialized countries would raise input demand for commodities. Other important determinants of commodities demand are the U.S. real effective exchange rate and real world interest rates. Since most commodities are traded and priced in U.S. dollars, a depreciation of the U.S. dollar would allow other countries to purchase commodities more cheaply, and would thus be expected generate higher demand levels and higher prices. The exchange rate variable is represented as the price of foreign currency, with an increase signifying a real depreciation of the U.S. dollar. The relationship between

[14] For example, oil prices tend to be subject to idiosyncratic shocks related to geopolitical conflicts, because of the fact that the majority of world oil supplies are located in regions with political instability.

[15] For North American markets, forestry product supplies have been heavily influenced by changes in softwood lumber agreements as well as industry restructuring and capacity closures over recent years. In food markets, crop supplies have been highly dependent on weather conditions.

commodity prices and real interest rates, however, is less clear. An increase in interest rates could lower commodity demand by raising the costs of storage as well as slowing future aggregate demand, putting downward pressure on prices. Conversely, rising interest rates could discourage investment activity by producers, thus lowering expected future supplies and driving commodity prices higher. We also consider the Standard and Poors 500 stock index as a substitute good price, since commodities compete with other assets for investment demand.

On the supply side, variables considered for the oil equation include data on world oil production capacity. For metals, an investment indicator was constructed from data on OECD real investment in metals and mining industries. This data provides a fairly rough measure of investment since it is only available to 2003, it is missing data for many of the OECD countries, and it also excludes many major metals producing countries such as Mexico, Chile, and China. Real oil prices are also considered in the equation for metals prices to represent costs of extraction and production.

Various variables are considered to represent demand growth in emerging Asia and rising resource intensities in the region. A major limitation faced is the availability and reliability of Chinese data, with many of the desired series available only since the mid-1990s, or else only at annual frequencies, or in nominal or growth rate form. Given these constraints, we construct an emerging Asia industrial production index using time-varying GDP weights on the 10 individual country industrial production indexes of China, India, ASEAN-4, and the NIEs. While this measure overlaps somewhat with the OECD industrial production index, with South Korea included in both, the implications are expected to be small given that its weight in OECD output is relatively small.

Figure 4 shows the resulting de-trended emerging Asia industrial production index, compared with the similarly de-trended OECD industrial production index.[16] Two things are worth noting in this graph. The first is that the production cycle in emerging Asia has become more closely correlated with that in the OECD since about 1997.[17] This may be a reflection of either increasing globalization that has led to converging business cycles worldwide, or that emerging Asia's export-led growth has linked its economies with those in the developed world. The second notable item in Figure 4 is that the increase in emerging Asia's industrial production since 2001 looks fairly modest relative to evidence of strong demand growth in the region for commodities over the last 5 years, and relative to increases observed in the early 1990s. This could be a sign that the industrial production index does not convey the rising resource intensities of production associated with expanding urban infrastructure and recent shifts in Chinese manufacturing from labor-intensive goods towards more capital-intensive goods.

Other variables are used to capture the increasing resource intensities in emerging Asia, including China's urbanization rate, China's investment share of output, as well as a constructed metals intensity index for emerging Asia (see Fig. 5). No energy intensity measure was constructed, since increases observed thus far have been modest (see Fig. A6) and likely too recent to be captured in any estimations. Several variables were also used to reflect rising intensities through the export channel, including emerging Asia's share of world trade, China's net exports of manufactured goods, China's exports of

[16] The series are de-trended using a Hodrick-Prescott filter.
[17] The correlation coefficient between the two series from 1997Q3-2006Q2 is 0.58, compared with 0.29 from 1982Q1-1997Q2.

manufactured goods as a share of the country's GDP, Chinese exports of manufactured goods to the US and Chinese exports of machinery and equipment to US.

Fig. 4. Industrial Production Cycles: OECD vs. Emerging Asia

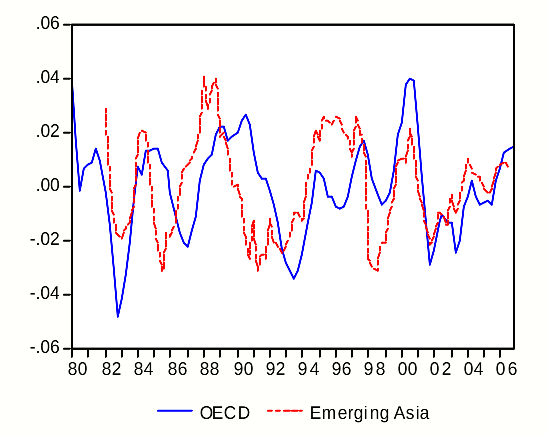
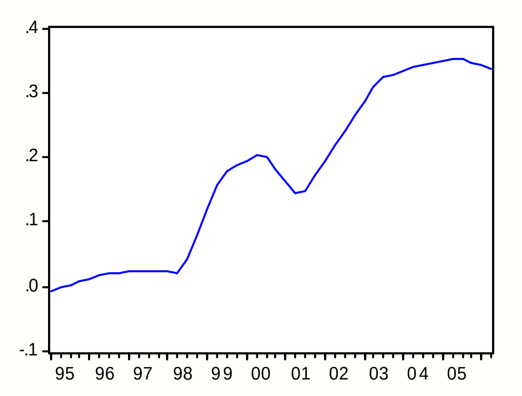


Fig. 5. Emerging Asia Logged Metals Intensity Index



6. Equation Specifications

The specification of the commodity price equation depends to a great extent on whether the series is stationary. While many commodity prices do not appear to be stationary over history, there is no clear consensus in the literature on whether this arises from deterministic trends, stochastic trends, or structural breaks. While earlier studies commonly assumed commodity prices to follow a random walk, much of the recent financial literature has argued in favour of modelling them as mean-reverting processes (see for example, Pindyck [2001], Schwartz and Smith [2000]). Intuitively, if a positive demand shock pushes the price of a commodity above its equilibrium level, producers would respond by increasing supply, thus pressuring prices down towards equilibrium. Non-stationarity can nonetheless arise because demand and supply adjustments are often slow, and shocks to commodity prices tend to be long-lasting, as shown by Cashin et al. (2000). The equilibrium price could also shift in response to changing expectations of the reserve base, political and regulatory climates, or production technologies.

Perron (1990) demonstrated that the existence of structural shifts in the mean of a series may also give rise to the appearance of an integrated process, when in fact the series may be stationary within each regime. Lalonde et al. (2003) find this behaviour is consistent with real oil prices between 1974 and 2001. Using the methodology of Bai and Perron (1998), the authors find evidence of two structural breaks over this sample period, each coinciding with a major exogenous shock that dramatically shifted supply expectations: the Iran-Iraq war in 1980 and the collapse of OPEC discipline in the mid-1980s. Upon accounting for these structural shifts, real oil prices are found to be stationary within each regime.

6.1. Real Oil Prices

Based on the findings of Lalonde et al. (2003), past movements in oil prices have been characterized by deterministic shifts that can be linked to specific events, which have rendered prices to be nonstationary over history, but stationary within each estimated regime. Upon examination of real oil prices since the authors' last estimated break point of 1985Q3, it can be seen that the series no longer appears stationary once the sample is extended to the end of 2006. Indeed, an ADF test on real oil prices over the 1985Q4-2006Q4 interval yields a t-statistic of -1.66, confirming a failure to reject the presence of a unit root. This suggests the influence of some factors that may have generated yet another structural change, or else a stochastic shift in oil prices. Since it is difficult to know the cause of such a change, we first test for the presence of a structural shift.

We begin by estimating the same equation as Lalonde et al. (2003) for the level of oil prices using the Bai-Perron (BP) methodology for the 1985Q4-2006Q2 sample. Given the relatively short sample size, we allow for a maximum of one unknown break point, with all parameters free to shift at the point. As described in Lalonde et al. (2003), real oil prices are characterized by the following equation in each regime i:[18]

$$RWTI_t = C_i + b_{1i}RWTI_{t-1} + b_{2i}RWTI_{t-2} + b_{3i}WLYGAP_{t-1} + b_{4i}\Delta USREER_{t-2} \qquad (6.1)$$

where *WLYGAP* is a world output gap (in logged form) and *USREER* is the logged U.S. real effective exchange rate.[19]

The test detects the presence of a structural break in 1997Q2 at a 1% significance level. The resulting parameter estimates over each regime are shown under the column labeled O1 of Table 2, which indicate that the *WLYGAP* variable is not statistically significant in either of the estimated regimes. Consequently, we modified equation (6.1) by replacing the world output gap variable with the OECD output gap, *OECD_GAP*. This moved the estimated break date slightly to 1997Q3, while improving the fit of the equation. The results from this estimation are shown in the column entitled O2 of Table 2. While the OECD output gap was found to bear a significant, positive impact on oil prices in the first regime of 1985Q4-1997Q3, it appears to have lost its statistical significance since mid-1997. Meanwhile, the U.S. exchange rate is only significant with the correct sign in the second regime. Alternative specifications were also tested with varying lag lengths and additional variables suspected to influence oil prices, such as the real world interest rate and oil production capacity. These variables were found either to be insignificant or to worsen the fit of the equation.

The estimated break date in mid-1997 coincides well with the Asian currency crisis, which had considerably reduced demand for commodities from this region over this period. The fact that the OECD output gap became insignificant in the period after 1997Q3 may suggest that oil prices became dominated by developments in emerging Asia demand around that time. To test this hypothesis, we included the emerging Asia industrial production index (*ASIA_IP)*, de-trended using a HP filter, into the modified equation (2) along with the OECD output gap.[20] As shown in column O3 of Table 2,

[18] This equation uses the first difference of the U.S. exchange rate, whereas Lalonde et al. (2003) had employed an exchange rate "gap" variable constructed using a HP filter. This does not affect the results materially.

[19] The world output gap is a production-weighted average of the gaps of the U.S., Canada, Mexico, the U.K., Europe, and Asia.

[20] Alternative variables were also considered to capture the effect of emerging Asia on oil prices through both domestic demand and export channels, including China's investment share of output, China's urbanization rate, emerging Asia's share of world trade, China's net exports of manufactured goods, China's exports of manufactured goods as a share of GDP, Chinese exports of manufactured goods to the U.S., and Chinese exports of machinery and

including the emerging Asia variable contemporaneously into the equation generated roughly the same break date (1997Q4) as specification O2, and improved the adjusted R^2. While the variable was found to be insignificant in the first regime, since 1998Q1 it has produced a significant, positive impact on oil prices. These results point to a larger influence from emerging Asia on oil prices since 1997. Of course, emerging Asia was also a key source of demand for commodities even over the early 1990s (see Novin and Stuber, 1999). However, it is likely that its importance became more apparent when oil prices dropped in the wake of the Asian crisis, without any major change in the OECD output gap.

Table 2. Real Oil Prices: Bai-Perron Estimation Results

	O1	**O2**	**O3**
Regime 1:	**1985Q4-1997Q2**	**1985Q4-1997Q3**	**1985Q4-1997Q4**
C	1.291 (6.53)	1.386 (7.18)	1.620 (3.13)
$RWTI_{t-1}$	0.715 (7.37)	0.698 (8.22)	0.678 (5.89)
$RWTI_{t-2}$	-0.168 (-1.86)	-0.186 (-2.45)	-0.246 (-2.03)
$WLYGAP_{t-1}$	4.796 (1.63)		
$OECD\_GAP_{t-1}$		0.033 (2.54)	0.034 (2.57)
$?USREER_{t-2}$	0.663 (1.15)	0.637 (1.22)	0.453 (0.75)
$ASIA\_IP_t$			-1.550 (-1.35)
Regime 2:	**1997Q3-2006Q2**	**1997Q4-2006Q2**	**1998Q1-2006Q2**
C	0.240 (1.70)	0.156 (1.13)	0.589 (3.67)
$RWTI_{t-1}$	1.199 (10.12)	1.200 (9.62)	0.825 (5.66)
$RWTI_{t-2}$	-0.271 (-2.22)	-0.245 (-1.86)	-0.005 (-0.04)
$WLYGAP_{t-1}$	-0.034 (-0.01)		
$OECD\_GAP_{t-1}$		0.010 (0.45)	-0.042 (-2.11)
$?USREER_{t-2}$	-2.449 (-3.13)	-2.662 (-3.04)	-1.257 (-1.74)
$ASIA\_IP_t$			7.855 (5.00)
Adj-R^2	0.850	0.856	0.874

In order to account for possible endogeneity between the contemporaneous emerging Asia variable and oil prices, we also estimated the equation over the second regime using generalized method of moments (GMM), with four lags of each regressor used as instruments and the standard errors adjusted using a five-lag Newey-West

equipment to US . These variables were found to either worsen the overall fit of the equation, or to be statistically insignificant.

correction. The resulting parameter estimates were not significantly different from those produced by the BP methodology.

While the OECD gap variable remains significant and positive in the earlier regime, Table 2 shows that the inclusion of the emerging Asia industrial production variable now produces a significantly negative coefficient on the OECD gap since 1998Q1. This may reflect some multicollinearity associated with increasing correlation that has emerged between the business cycles of the developed economies with emerging Asia since mid-1997, discussed in section 5.1. Nevertheless, given that the OECD output gap was found to be insignificant since 1997 in the absence of the emerging Asia variable (equation O2), it is desirable to remove it from the estimation when the emerging Asia variable is included. In order to do so, we estimate the oil equation using ordinary least squares (OLS) only over the latter 1998Q1-2006Q2 period, while removing the OECD output gap variable. The resulting estimates are (with t-statistics in parentheses):

$$\underset{}{RWTI_t} = \underset{(2.81)}{0.481} + \underset{(5.34)}{0.904}\, RWTI_{t-1} - \underset{(-0.28)}{0.045}\, RWTI_{t-2} - \underset{(-2.35)}{1.930}\, \Delta US\_REER_{t-2} + \underset{(3.18)}{5.807}\, ASIA\_IP_t$$

which shows a lower coefficient on the emerging Asia variable. The cumulative AR coefficient of 0.859 on the above equation implies less persistence in oil prices when we account for emerging Asia, compared to the O2 specification which does not. Ljung-Box Q-statistics also show no evidence of serial correlation in the residuals for up to 8 lags. These estimates imply a conditional mean price of oil that has increased in the 1998Q1-2006Q2 regime to US$30.31 per barrel in real terms, compared to US$17.32 per barrel over the 1985Q4-1997Q4 regime.

The fact that the emerging Asia variable seems to have dominated the positive influence from OECD demand since 1997 may also indicate that the increasing share of world manufacturing activity that has migrated to emerging Asia in recent years has caused oil prices to be driven more by the business cycle in this region than in the developed economies. If this is the case, then the impact captured in the estimated parameter of the emerging Asia variable may partly reflect oil demand that has simply shifted from one part of the world to another (i.e. the export channel), in addition to any incremental demand that the region may have added to world demand. However, since emerging Asia industry remains relatively energy-inefficient, any production diverted from the developed world would likely generate substantive net gains in energy demanded.

The results point to two main findings. The first is the presence of a break detected in the equilibrium price for oil in the last half of 1997. The second is that the cyclical behaviour of oil prices since that break point appears to be linked to emerging Asia industrial activity. Although no conclusive evidence exists to explain the cause for the break, it appears to have possibly arisen from an increasing influence from emerging Asia. This would pose an additional challenge, as it would signify that the shift is more stochastic in nature, unlike previous breaks that were related to exogenous supply shocks or changes in OPEC behaviour.[21] However, the number of observations available is

[21] While there was a 10% increase in OPEC production quotas that took place in November 1997, no remarkable shifts in behaviour are visible from the production data around that time.

insufficient to capture such a stochastic equilibrium shift. In this context, the emerging Asia variable may be picking up the effects on oil prices that may be coming from any other trending factors not included in the equation, such as increased globalization, stronger U.S. productivity, or geopolitical factors. Such a case would create upward bias to the impact suggested by the estimated coefficient of emerging Asia. Since the oil production capacity variable was found to be insignificant over the sample, our estimated model for oil prices does not take into account developments in supply. As shown in Fig. A4, the sharp decline in OPEC spare production capacity since 2002 points to an insufficient supply response to recent demand pressures, which may have contributed in part to the recent acceleration in price. This would imply an additional upward bias on emerging Asia's estimated coefficient.

6.2. Real Base Metals Prices

The approach used to model real base metals prices is different from that for real oil prices. Unlike the case for oil, no specific events could be identified with metals prices to justify the presence of deterministic breaks. As ADF test results on the real metals price index were not able to reject the presence of a unit root, we employ a stochastic approach to model them. Consistent with the idea that real commodity prices should revert to some equilibrium level, we therefore test for the possibility that real metals prices possess a stable long-run cointegrating relationship with some other macroeconomic activity variable or combination of variables. This was conducted using Engle and Granger (1987) residual-based tests on the estimated cointegrating equation, using the dynamic least squares method of Saikkonen (1991) to correct for endogeneity and serial correlation:

$$RMTLS_t = \beta' x_t + \sum_{j=-k1}^{k2} b'_j \Delta x_{t-j} + v_t \qquad (6.2)$$

where x_t is a vector of I(1) variables cointegrated with the I(1) variable $RMTLS_t$, the logged real metals price index. The estimated long-run relationship between the variables is defined by the vector ß. Given evidence of a long-run equilibrium, a dynamic error correction equation (ECM) can be estimated using OLS, to model the short-term dynamics of metals prices:

$$\Delta RMTLS_t = \lambda(RMTLS_{t-1} - \beta' x_{t-1}) + \sum_{j=0}^{m} \delta_j Z_{t-j} + \mu_t \qquad (6.3)$$

where Z_t is a vector of I(0) exogenous variables, and λ is the estimated speed at which metals prices adjust back to their long-run level following a shock that pushes them away from equilibrium.

Given the commonly found relationship between commodity prices and macroeconomic activity in developed countries, cointegration was first tested between real metals prices and various combinations of the following variables: OECD industrial production, the U.S. real effective exchange rate, the real world interest rate, real oil prices, and real OECD investment in metals and mining industries.

Beginning from the earliest available data point in 1975Q3, results from the cointegration tests reveal the strongest support for a long-run relationship between metals prices and OECD industrial production (*OECD_IP)*, with allowance for a deterministic trend. However, this cointegration only exists for the sample up to 1997Q3.[22] Table 3 displays the estimated cointegrated system (labelled M1) over the period 1975Q3-1997Q3, along with the dynamic parameter estimates from the ECM. As shown by the ADF test statistic from the Engle-Granger test, the null hypothesis of no cointegration can be rejected at a 5% significance level for the sample up to 1997Q3. The statistically significant adjustment parameter also lends support to the existence of this equilibrium relationship between metals prices and OECD industrial production.[23] These results did not change significantly when the exchange rate, interest rate, oil price, or investment variables were included in the cointegrating equation. It was also found that including emerging Asia variables (such as industrial production or trade share) in the long-run equation for the sample to 1997Q3 actually weakened the support for cointegration, suggesting that this region did not have a large influence on long-run metals prices up to this point.

Table 3: Real Metals Prices: Estimated ECM (1975Q3-1997Q3)

	M1*
Long-Run Parameters	
C	-20.198 (-7.40)
Trend	-0.033 (-9.37)
OECD_IP	5.791 (9.09)
Equilibrium Adjustment Parameter (λ)	-0.202 (-3.91)
Dynamic Parameters	
C	-0.021 (-2.13)
Δ ***$RMTLS_{t-1}$***	0.194 (2.05)
Δ ***$RMTLS_{t-3}$***	0.220 (2.37)
Δ ***$OECD\_IP_t$***	4.307 (4.80)
Adj-R^2	0.319
ADF t-stat: (p-value)**	-3.940 (0.044)
Jarque-Bera	1.835

* T-statistics are given in parenthesis, unless otherwise stated.
** MacKinnon (1996) critical values used.

Estimation of the dynamic ECM equation was performed using OLS. Variables found to significantly influence the short-run dynamics of metals price movements were growth in OECD industrial production as well as the first and third lag of first-differenced metals prices. Since the change in OECD industrial production is included

[22] Tests were conducted beginning with the longest sample 1975Q3-2006Q4, with observations removed from the endpoint recursively until cointegration was found.
[23] Ericsson and MacKinnon (2002) criticial values used for the t-statistic of the adjustment parameter.

contemporaneously, we also estimated the equation using GMM to account for possible endogeneity.[24] The GMM parameter estimates did not differ significantly, suggesting that endogeneity is not an issue. Ljung-Box Q-statistics on the residuals also do not detect any serial correlation up to 8 lags out, and Jarque-Bera statistic suggests they are normal with zero mean.

Interestingly, the long-run relationship found between metals prices and OECD industrial activity appears to break down once the sample is extended beyond 1997Q3. When the same long-run equation is estimated over the full sample 1975Q3-2006Q4, the ADF test statistic of -1.766 fails to find evidence of cointegration over this period. Figure 6 compares the estimated long-run equilibrium from the cointegrated system in M1 against actual metals prices, while Figure 7 plots the gap between metals prices and this equilibrium. Upon examination of the gap, it appears that the failure to find cointegration between the two variables beyond 1997Q3 stems from the fact that metals prices remained persistently below equilibrium levels suggested by OECD industrial production for several years after this point. Similar to our findings for oil prices, this may have been caused by the Asian currency crisis, which significantly reduced world demand for commodities around that time. Since 2003, however, metals prices have surged well above equilibrium levels defined by OECD activity.

Fig. 6. Real Metals Prices vs. Equilibrium

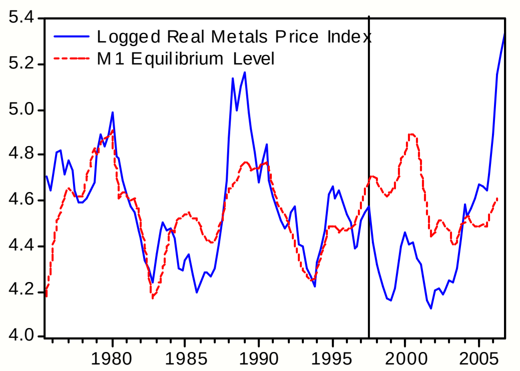
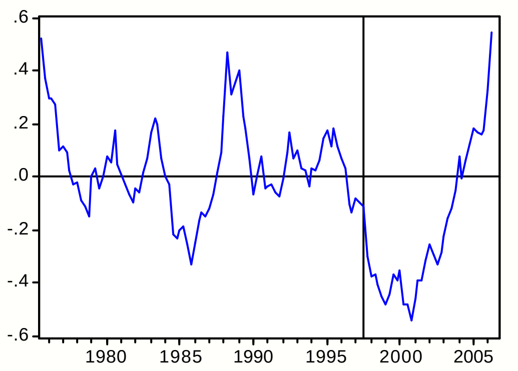


Fig. 7. Equilibrium Gap (M1)



The results suggest that since the end of 1997, metals prices have been driven primarily by factors other than industrial activity in the developed world. Determining whether this factor is emerging Asia poses a challenge, however, given the relatively recent period since the region's role would have likely become significant. This makes finding any long-term relationship between metals prices and emerging Asia particularly difficult within the "cointegration" framework. In order to assess whether the collapse of the long-run relationship between real metals prices and OECD industrial production is related to a greater influence from emerging Asia, we thus conduct a series of experiments. This exercise consists of testing whether including various emerging Asia variables into the long-run equation (6.2) over the extended sample can explain the discrepancy between metals prices and their equilibrium since the end of 1997. To

[24] Four lags of each regressor were used as instruments for the estimation, with robust standard errors of the estimated parameters calculated using Newey-West correction with 8 lags.

capture the possible significance of these variables since 1997, we also experiment with interacting them with dummy variables which assume a value of zero up to 1997Q4, and a value of one afterwards.

In general, the emerging Asia variables that generated the best results are the industrial production index *ASIA_IPDT* (with the deterministic trend removed)[25], and the metals intensity index (*INTENS*). Figure 8 compares the disequilibrium gap from equation M1 with that created when the emerging Asia industrial production variable is included in the long-run equation, but interacted with a dummy variable so it is only active over the 1997Q4-2006Q2 (*Dum1*) interval. This specification is labelled M2. The full sample now becomes 1982Q1-2006Q2, based on the data available for emerging Asia. It can be seen that incorporating this variable considerably reduces the negative disequilibrium gap created by the original equation over the 1997 to 2003 interval. This could signify that weakness in emerging Asia was a factor pulling metals prices below equilibrium levels suggested by OECD industrial activity over this period.

Figure 9 also illustrates that while industrial activity in emerging Asia may have contributed to the metals price weakness relative to equilibrium in the period after 1997, it does not explain well the relative strength observed in metals prices since the end of 2003. As discussed in Section 5.1, this could be because rising metals intensities in Asian manufacturing sectors are not well captured by this emerging Asia industrial production index. As a result, we further add the metals intensity index in the equation. Since metals intensity data was only available from 1995 onwards, the index was interacted with a dummy variable in the model. We find good results are achieved when *ASIA_IPDT* is included over the full 1982Q1-2006Q2 sample, with the metals intensity index included from 1997Q4-2006Q2 – this specification is labeled M3. We also experiment with a specification in which the metals intensity index is only included from 2002Q1-2006Q2, labeled M4. Figures 11 and 13 compare the disequilibrium gaps from these respective scenarios with that from equation M1. We can see that accounting for rising metals intensities in emerging Asia appears to explain the surge in metals prices quite well up to the end of 2005, especially in the case of M4. Where these specifications fall short, however, is over the last two quarters of the sample, 2006Q1-2006Q2. This may be explained by what appears to be a decline in emerging Asia's metals intensity over this period (see Fig. 5). While the reason for this decline is not clear, it is possible that the intensity data for 2006 is less reliable, given that metals consumption data tends to undergo frequent revisions. It is also possible that increased speculative investment activity has been a larger influence on metals price behaviour in 2006.

Despite that the need for dummy variables makes it no longer possible to consider these equations within a cointegration framework, it is interesting to compare the fit of these alternative specifications with the original M1 specification. This time, GMM estimation of the dynamic ECM produced significantly different coefficients on the $\Delta OECD\_IP_t$ variable than the OLS estimates, suggesting there may be issues with endogeneity. The GMM estimation results are thus reported in Table 3, along with the

[25] The emerging Asia industrial production index was de-trended by subtracting the fitted value from a regression of the variable on a constant and time trend.

Fig. 8

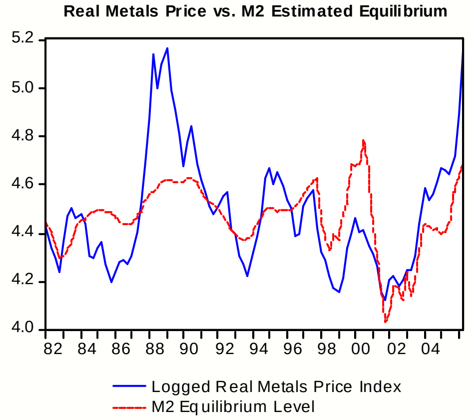


Fig. 9

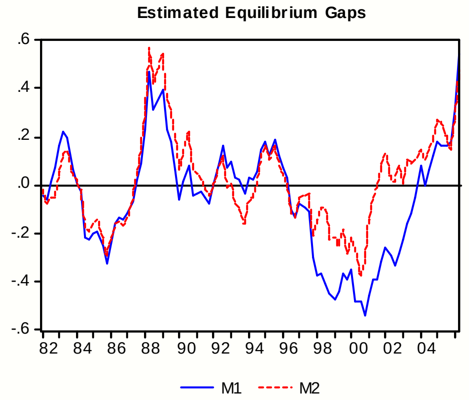


Fig. 10

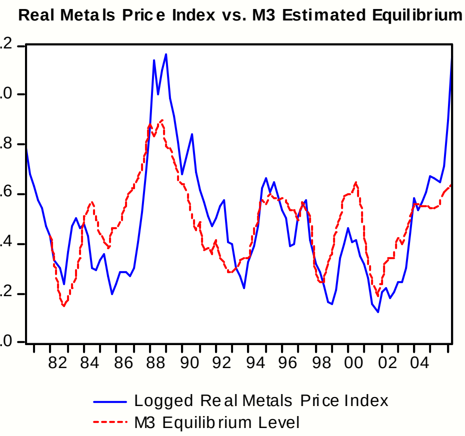


Fig. 11

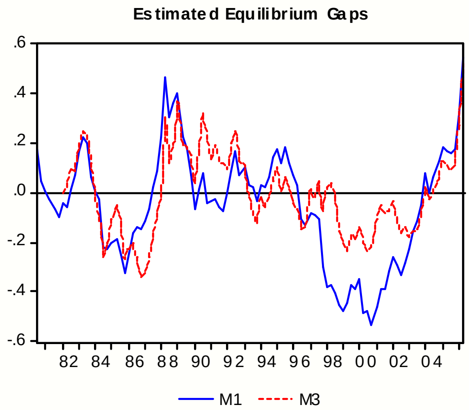


Fig. 12

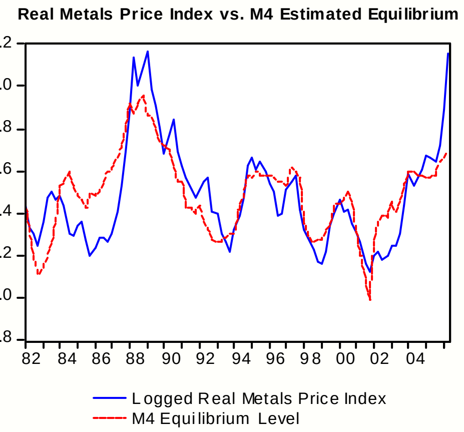


Fig. 13

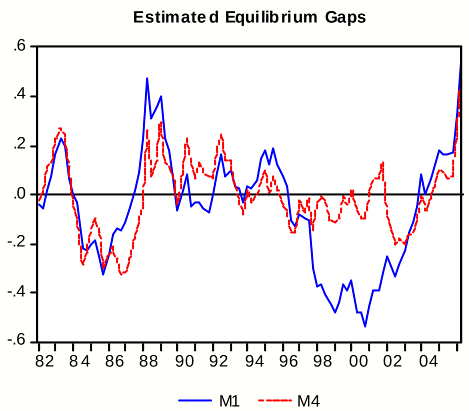


Table 3. Real Metals Prices: Estimated ECM with Emerging Asia (1982Q1-2006Q2)

Variable	M1e	M2	M3	M4
Long-Run Parameters				
C	-8.265 (-2.02)	-8.26 (-2.29)	-2.904 (-0.82)	-9.388 (-2.81)
Trend	-0.018 (-3.17)	-0.016 (-3.12)	-0.16 (-3.26)	-0.024 (-4.976)
$OECD\_IP_{t-1}$	2.997 (3.11)	2.975 (3.51)	1.818 (2.19)	3.341 (4.24)
$ASIA\_IPDT_{t-1}$			4.960 (6.20)	4.547 (7.72)
$Dum1 * ASIA\_IPDT_{t-1}$		10.359 (4.45)		
$Dum1 * INTENS_{t-1}$			1.369 (4.40)	
$Dum2 * INTENS_{t-1}$				1.359 (6.79)
Equilibrium Adjustment Parameter	-0.036 (-1.70)	-0.045 (-2.30)	-0.099 (-3.64)	-0.087 (-2.66)
Dynamic Parameters				
C	-0.034 (-3.49)	-0.035 (-3.75)	-0.036 (-4.07)	-0.036 (-3.63)
$\Delta RMTLS_{t-1}$	0.161 (2.79)	0.169 (2.89)	0.156 (2.52)	0.152 (2.40)
$\Delta OECD\_IP_t$	4.926 (4.08)	4.804 (4.15)	4.567 (4.51)	4.659 (4.28)
$\Delta USREER_t$	-1.267 (-3.19)	-1.238 (-2.89)	-1.04 (-2.89)	-1.119 (-2.88)
$\Delta ASIA\_SHR_{t-1}$	6.553 (3.70)	6.689 (4.02)	6.579 (3.96)	6.434 (3.84)
Adj-R^2	0.311	0.311	0.337	0.324
Jarque-Bera	0.079	0.096	0.107	0.008

results from the original specification re-estimated over the sample 1982Q1-2006Q2 (M1e) and modified to include the change in U.S. exchange rate and change in emerging Asia's trade share (Δ *ASIA_SHR)* in the short-run dynamics. As expected, the long-run coefficient on OECD industrial production is smaller in all cases over the longer sample relative to the sample ending in 1997Q3. Meanwhile, the short-run dynamic coefficient on this variable remains roughly unchanged from the M1 equation in all scenarios. The U.S. exchange rate and emerging Asia trade share are now also found to be statistically significant in explaining the short term dynamics of metals price movements.

With respect to the long-run impact of emerging Asia variables, interpreting the parameter estimates in Table 3 remains difficult, given the relatively short sample over which these variables are found to be significant. This is especially the case for the metals intensity variable, which is only significant from 1997Q4 onwards. Nonetheless, the results suggest that industrial activity in emerging Asia has played a considerably larger role in driving metals prices since 1997. This is supported by the observation that the t-statistics on the adjustment parameters are larger when emerging Asia variables are incorporated into the defined "equilibrium", relative to when it is defined only by OECD activity.

As discussed in section 6.1, the coefficient on the emerging Asia industrial production variable is likely capturing some metals demand that has simply shifted from the developed world, as multinational firms have outsourced manufacturing activity to emerging Asia. The parameter estimate on this variable may therefore over-estimate the impact from emerging Asia as far as incremental demand coming from the region. The upward bias may be further magnified by any effects coming from recent supply shortfalls, which are not incorporated in the model based on a failure to find significance in our supply indicator variable over the entire sample.

Upon examination of Figure 8, it appears that the M2 specification (with *ASIA_IPDT* included from 1998Q1-2006Q2) produces an equilibrium that overshoots actual metals prices over the upward cycle in 1999-2000 as well as the downward cycle in 2001. This suggests that the long-run coefficient of 10.359 on *ASIA_IPDT* in M2 likely overstates the true impact from this emerging Asia variable. While Figures 10 and 12 show that the M3 specification better matches actual metals prices over this period, and M4 even better, both scenarios remain slightly more volatile. This signifies that the long-run coefficient of 4.547 on *ASIA_IPDT* from the M4 version mat still contain some upward bias.

Similar to oil, the results suggest that metals price fluctuations have become increasingly aligned with the emerging Asia business cycle since 1997. Unlike the case for oil, including the emerging Asia industrial production is not sufficient to explain the surge in metals prices since 2002. In the case of metals, it appears that rising intensities in the region have provided the additional boost to metals prices over recent years. Because these influences began so recently, it remains too soon to obtain precise estimates of their long-run impact. While the observed increases in metals intensities in the past 5 years have likely originated from both domestic demand and export channels, deciphering between which influence is larger also remains difficult.

7.0 Concluding remarks

The purpose of this paper was to investigate the impact of emerging Asia on the real prices of oil and base metals in the Bank of Canada Commodity Price Index (BCPI). While we find strong evidence that oil and metals prices have historically moved with the business cycle in developed economies, this relationship has broken down since mid-1997. Thereafter, results suggest that metals price fluctuations have become increasingly aligned with emerging Asia industrial activity, and rising metals intensities of production may have been a more important factor behind the acceleration in prices since 2002. For oil, the emerging Asia business cycle appears to have become a more dominant driver of price movements since mid-1997. This may be related to the increased outsourcing of production to Asia from the developed economies, which would generate higher levels of energy demand as relatively energy-inefficient Asian firms take on greater shares of world manufacturing activity. Rising intensities *within* emerging Asia may also play a larger role going forward, as expanding urban infrastructure and shifts in Chinese manufacturing from labour-intensive goods towards capital-intensive goods are expected to push metals and energy intensities higher for many years to come. Resource-intensive consumption may also become more important in the future, as rising incomes generate greater motor vehicle ownership and consumption of household durables.

The fact that an increasing share of world manufacturing activity has relocated to emerging Asia in recent years suggests that the impact captured in the estimated parameter on emerging Asia industrial production may reflect not only the incremental commodities demand from the region, but also the demand that has simply relocated from the industrialized world. Since a substantive portion of manufactured goods are then re-exported out of the region, the source of this demand is arguably more linked to the developed world than to emerging Asia itself. The parameter estimate therefore likely overstates the true impact from emerging Asia as far as incremental demand coming from the region. The upward bias may be further amplified by other excluded factors that may have been at play, such as supply shortfalls, speculative investment demand, increasing U.S. productivity, globalization, or geopolitical unrest (in the case of oil).

Our analysis suggest that emerging Asia, and particularly China, can be expected to continue to be an important factor underlying prices movements of oil and base metals. This impact is likely to persist for several years to come as metals and energy intensities continue to rise alongside urbanization rates.

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Appendix

Table A1. Component Weights in Bank of Canada Commodity Price Index

Weights	Canadian Production shares (1988-99)
ENERGY:	33.9%
Oil	21.4%
Natural Gas	10.7
Coal	1.8%
NON-ENERGY:	66.1%
Metals	14.3%
Base Metals:	11.7%
Aluminium	5.0%
Copper	2.0%
Nickel	2.4%
Zinc	2.2%
Precious Metals:	2.6%
Gold	2.3%
Silver	0.3%
Minerals	2.3%
Potash	1.7%
Forestry	33.4%
Lumber	13.6%
Pulp	12.1%
Newsprint	7.7%
Food	16.8%
Grains & Oilseeds:	5.9%
Wheat	3.4%
Canola	1.2%
Barley	0.7%
Corn	0.5%
Livestock:	9.7%
Cattle	7.9%
Hogs	1.8%
Fish	1.2%

Data Sources and Definitions

Commodity prices: Real oil price used is the West Texas Intermediate crude oil price deflated by the U.S. GDP deflator. Real metals price used is the base metals price index from the Bank of Canada Commodity Price Index (BCPI), deflated by the U.S. producer price index for finished goods. The BCPI has a base of 1982-90 =100 and is expressed in U.S. dollars.

Country coverage : Emerging Asia includes the following ten countries: China, India, Hong Kong, Singapore, South Korea, Taiwan, Indonesia, Malaysia, Philippines and Thailand.

Consumption of oil and metals: Consumption data for the metals (zinc, aluminum, nickel and copper) are from the *World Bureau of Metal Statistics* and *UN Commodity Yearbook 2003*. Oil consumption data are from the *BP Statistical Review 2006*. Metals consumption data is only available at an annual frequency starting from 1995. Metals per capita consumption data is constructed from *World Bank Development Indicators* annual population data.

Metal intensity index: The emerging Asia metals intensity index is constructed by first summing the units consumed of a given metal across the 10 countries and dividing by the sum of the region's real GDP to obtain an emerging Asia intensity measure for each metal. Intensity idexes are constructed for each metal with base year 1995. Each of the four intensity indexes are then weighted according to their weight in the BCPI to form the overall metals intensity index. Since all data are annual, a quarterly index is then constructed through interpolation.

Output measures:

- *OECD Industrial Production Index:* Quarterly, from *OECD Main Economic Indicators* database
- *World output gap:* Quarterly production-weighted average of the gaps of U.S., Canada, Mexico, U.K., Europe, and Asia, constructed by the Bank of Canada.
- *OECD output gap*: Quarterly, from the *OECD Economic Outlook* database, in which potential output is estimated from a production function approach.

US effective exchange rate: Foreign exchange value of the U.S. dollar, U.S. Federal Reserve Board of Governors broad index, 1973=100.

Real world interest rate: a trade-weighted average of interest rates of Japan, U.K., the Euro zone, and U.S, deflated by trade-weighted GDP deflator.

Supply side variables:

- *Oil Production Capacity:* constructed by summing data on world oil production with data on world spare production capacity. World oil production data is quarterly from the U.S Department of Energy's *Energy Information Administration*, while spare capacity data is annual from the *IMF World Economic Outlook* (August 2006), with quarterly values interpolated.

- *Real OECD Investment in Metals and Mining industries:* Annual data to 2003 from the *OECD STAN* database, with quarterly values interpolated.

Emerging Asia variables:

- *Emerging Asia Industrial Production Index:* constructed from the 10 individual country indexes of industrial production in the manufacturing sector where available, and total industrial production otherwise. Individual country quarterly indexes are first seasonally adjusted using the X11 method and then aggregated using GDP weights, 1990=100. China's industrial production index is constructed from National Accounts data from the Chinese Statistical Yearbook on real production in the secondary industry. Prior to 1992, this series is only available at an annual frequency, with quarterly values interpolated. Taiwan's industrial production index is constructed from National Accounts data on GDP for the manufacturing sector. For the remaining Asian countries, quarterly industrial production indexes are obtained from the *OECD Main Economic Indicators* database for Indonesia, *IMF International Financial Statistics* (*IFS)* for Malaysia, Philippines, Singapore, Hong Kong, Korea, and India, and the *Bank of International Settlements* for Thailand.
- *China's urbanization rate*: annual from the *World Bank Development Indicators*, with quarterly values interpolated. Defined as the percentage of the population living in cities.
- *China's investment share*: Annual data on nominal investment from the *IMF IFS*, with quarterly values interpolated.
- *Chinese exports of manufactured goods to the U.S.* and *Chinese exports of machinery and equipment to the U.S.:* monthly data from 1997- 2006 from *Datastream*. Prior to 1997, levels are constructed assuming the same growth rate as Chinese total exports of manufactured goods (an annual series from *Datastream*, with quarterly values interpolated).
- *Emerging Asia trade share:* An aggregate of 10 countries' total trade (exports and imports) as a ratio to total world trade. Quarterly nominal export and import data is obtained from the *IMF IFS*, deflated using different price indexes and seasonally adjusted using X11 methodology. For Singapore, Hong Kong and South Korea, the country's export and import price indexes from the *IFS* are used as deflators, and Taiwan trade data is deflated using an average of these countries' deflators. For the remaining emerging Asia countries, exports and imports are deflated using the Asia export and import prices from the *IFS*.

Fig. A1: OECD Index of Industrial Production (y/y % growth)

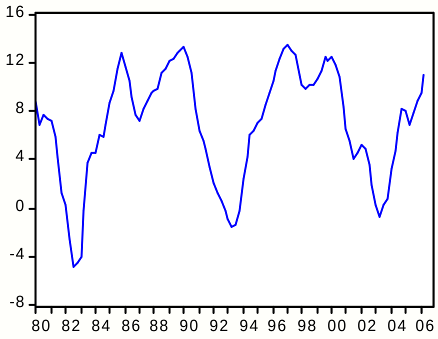


Fig. A2: U.S. Real Effective Exchange Rate

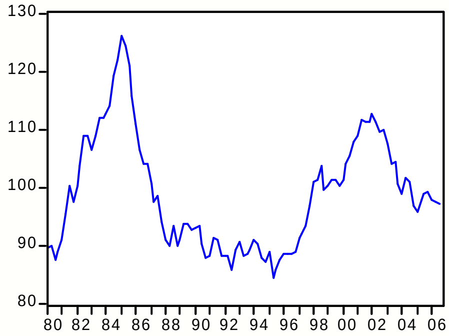
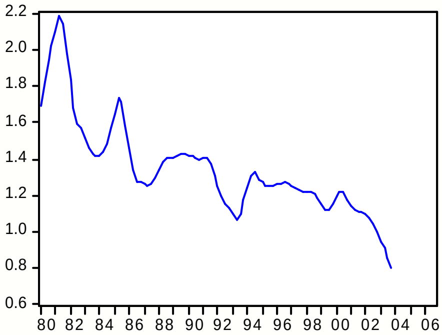
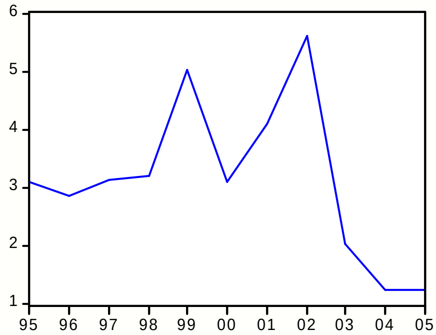


Fig. A3: OECD Real Investment in Metals and Mining Industries (Mlns USD) relative to OECD Industrial Production Index



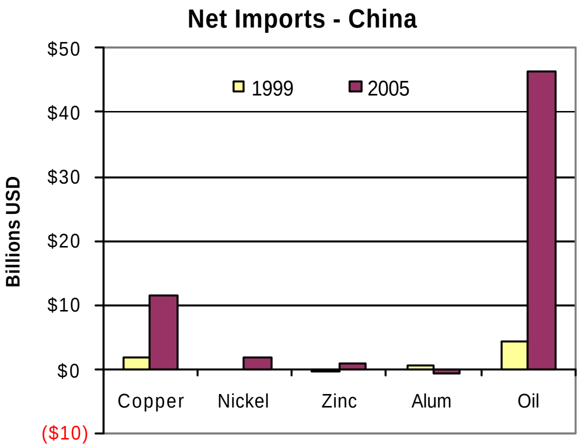
Source: OECD STAN Database

Fig. A4: World Spare Oil Production Capacity (mb/d)



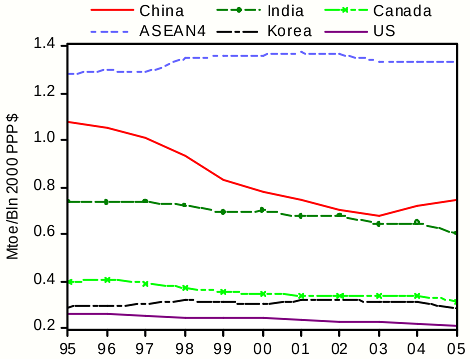
Source: IMF

Figure A5



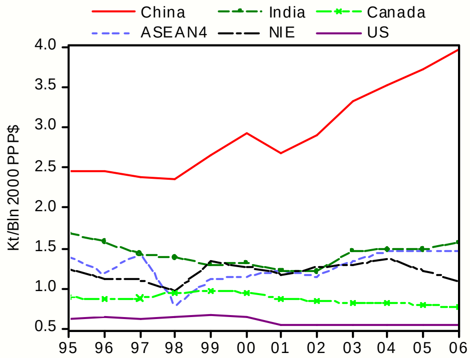
Source: UN COMTRADE

Fig. A6. Primary Energy Consumption per GDP



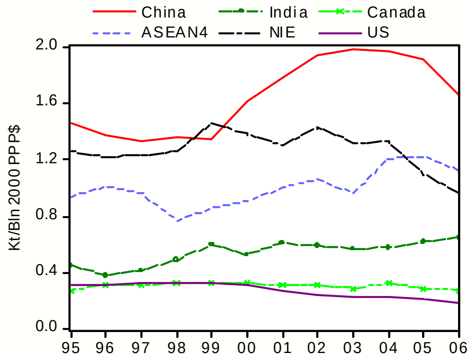
Source: BP Statistical Review 2006, World Bank, IMF

Fig. A7. Aluminium Consumption per GDP



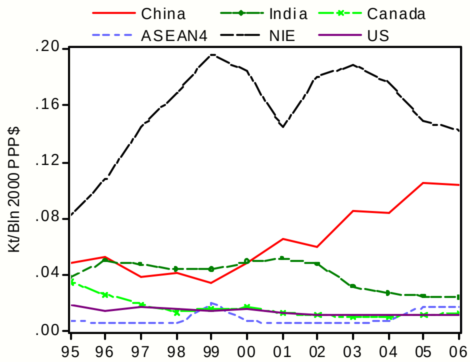
Source: World Bureau of Metals Statistics, UN Commodity Yearbook, World Bank, IMF

Fig. A8. Copper Consumption per GDP



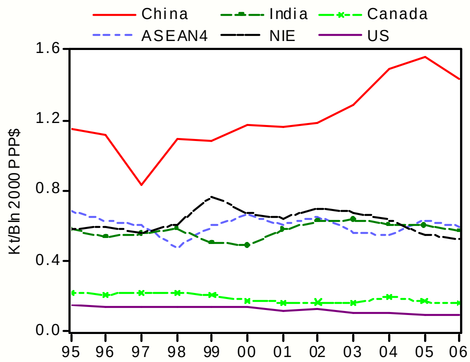
Source: World Bureau of Metals Statistics, UN Commodity Yearbook, World Bank, IMF

Fig. A9. Nickel Consumption per GDP



Source: World Bureau of Metals Statistics, UN Commodity Yearbook, World Bank, IMF

Fig. A10. Zinc Consumption per GDP



Source: World Bureau of Metals Statistics, UN Commodity Yearbook, World Bank, IMF

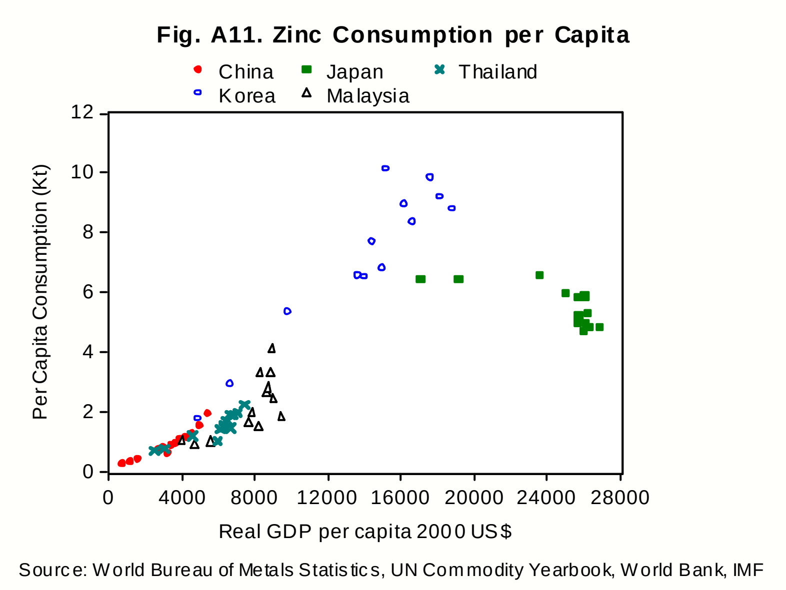


Fig. A11. Zinc Consumption per Capita
China
Japan
Thailand
Korea
Malaysia
Per Capita Consumption (Kt)
Real GDP per capita 2000 US$
Source: World Bureau of Metals Statistics, UN Commodity Yearbook, World Bank, IMF

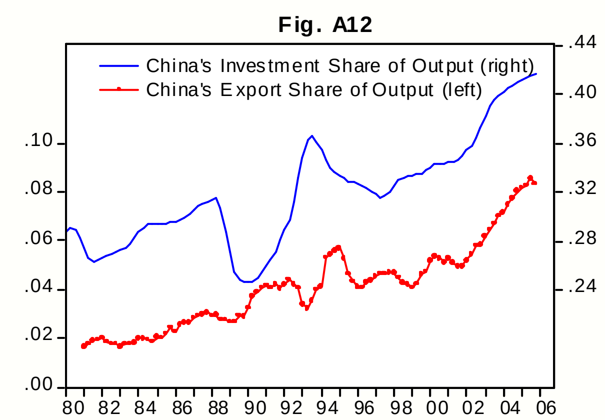


Fig. A12
China's Investment Share of Output (right)
China's Export Share of Output (left)

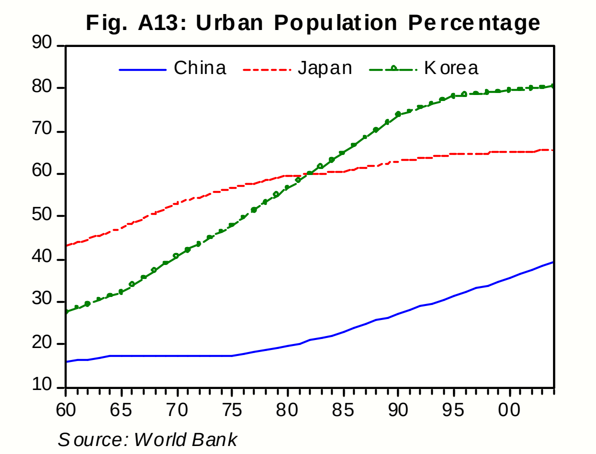


Fig. A13: Urban Population Percentage
China
Japan
Korea
Source: World Bank

Fig. A14

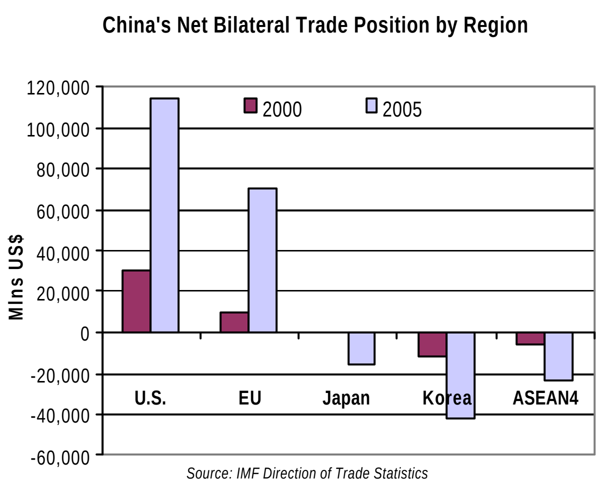

China's Net Bilateral Trade Position by Region
2000
2005
Mlns US$
U.S.
EU
Japan
Korea
ASEAN4
Source: IMF Direction of Trade Statistics

Fig. A15

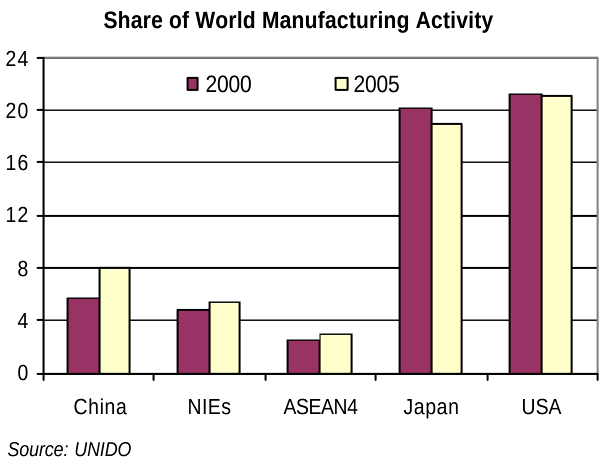


Fig. A16

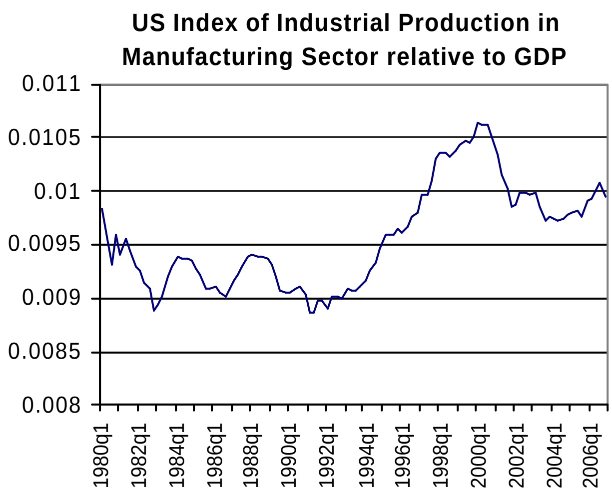


Fig. A17

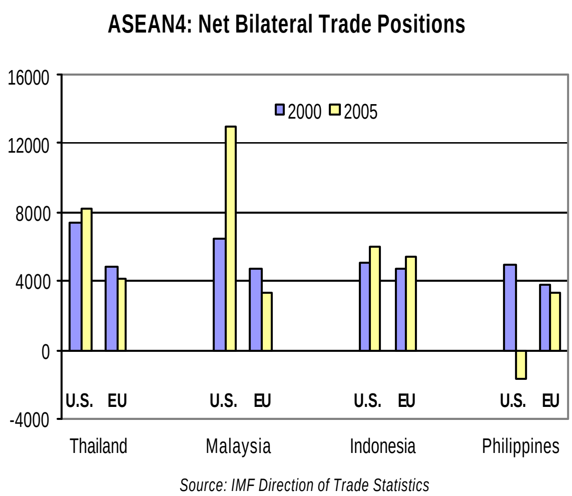


Fig. A18