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Asia's Imprint on Global Commodity Markets

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ABSTRACT

Dynamic growth patterns of developing Asia will continue to make strong impressions in world commodity markets. Driven by rapid income growth and economic development, developing Asia has surfaced as a major demand force behind the price dynamics of primary commodities. The region's economic growth and development has been tightly associated with rapid industrialization, urbanization, and massive infrastructure investments, all of which are highly resource-intensive. These trends are set to intensify as Asia's mammoth economies emerge. Real incomes in the People's Republic of China are now reaching a level at which demand for energy and resource-intensive consumer durable goods usually takes off. India may not be too far behind in its catch-up process. The paper provides an overview of Asian influence in world commodity markets and examines its changing patterns. It also attempts to quantify the impact of the rapidly growing Asian economy on long-term resource utilization, using a General Equilibrium Model for Asian Trade (GEMAT) to project regional growth scenarios for 2005–2015. The model captures long-run equilibrium tendencies in product and factor markets for natural resources. The estimated results point to fundamental changes in market dynamics for a broad range of primary commodities.

I. INTRODUCTION

Since the beginning of 2002, primary commodity prices have surged. The overall index of primary commodity prices has more than doubled, driven by strong energy and metal prices. Energy prices rose by about 32% on average each year during 2002–2005 on significant increases in oil and natural gas prices. Prices of nonenergy commodities also rose by 11% annually in the same period as base metal prices accelerated. Although metal prices have eased from this year's May peak, the broad picture remains intact. Soaring prices can be traced to robust global demand and restraints on supply stemming largely from chronic underinvestment in earlier years, particularly in energy and metal sectors.

Increasingly, global commodity price dynamics have been influenced by the role of developing Asia as a consumer rather than producer of primary commodities. For example, the commodity price upswing of the 1990s and the fall in commodity prices in the late 1990s correlates with a period of fast growth in Asia, subsequently punctured by Asia's financial crisis. Again, more recently, the resumption of fast growth in developing Asia has helped drive global commodity prices up.

Allied to rapid growth are profound structural changes that are feeding Asia's craving for commodities. Industrialization, urbanization, and massive infrastructure investment have all increased the energy- and resource-intensiveness of output. The impact of an emerging middle class and rising affluence on consumer preferences is also to exert leverage on demand for food commodities. These trends are set to intensify as Asia's mammoth economies emerge. Real incomes in the People's Republic of China (PRC) are now reaching a level at which demand for energy- and resource-intensive consumer durable goods, such as automobiles, usually takes off. India, while lagging behind, may soon begin to catch up (Asian Development Bank 2006). Asia's rapid transformation will do more than drive price. It is also likely to spur competition in trade and investment, which will reshape commodity market dynamics and change global commodity prices in a more fundamentally different way.

Changing dynamics of primary commodity prices have important implications for both developing Asia and the world. This paper assesses the impacts of emerging Asian economies on global commodity markets in the process of their rapid growth and development and examines challenges arising from these trends. The following section reviews commodity price dynamics in terms of both long-term trends and recent developments. After a brief summary of overall commodity market dynamics from a long-term perspective, the factors that are responsible for the recent boom in commodity prices are examined in different sectors. The subsequent section will take a closer look at Asian influence behind the commodity price movements. Evidence presented here supports the view that developing Asia is playing an increasingly important role as a consumer in pushing up the prices of primary commodities. Historical patterns also suggest that such evolving consumption patterns may continue to shape the future of world commodity trade. In the next section, a model-based analysis helps quantify the impact of developing Asia on global commodity demand and prices. The results provide the outlook for global commodity prices into 2015 based on the assumption that there are little changes in developing Asia's economic and policy environments over the next decade. Simulations based on different sets of economic and policy assumptions for developing Asia suggest an important role for policy in influencing outcomes.

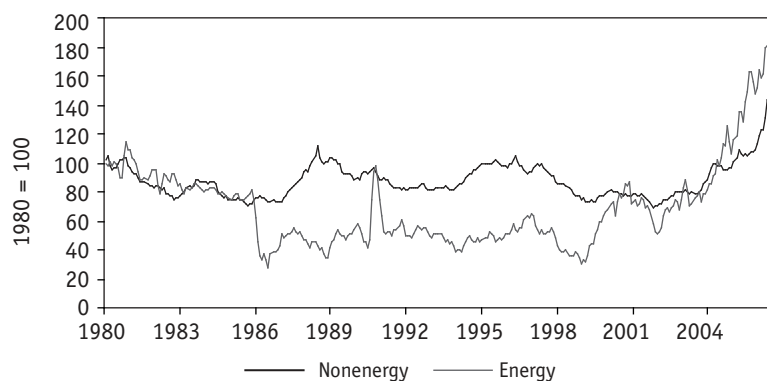
The paper concludes by discussing policy issues arising from the longer-term prospects of commodity prices. Challenges arise from developing Asia's thirst for a broad range of commodities and how policies should address meeting the growing commodity needs effectively without precipitating resource depletion and environmental degradation. These issues are tightly linked to other major challenges that developing Asia faces regarding efficient resource management, environment protection, and poverty reduction, hence cutting across a broad array of development policies.

II. COMMODITY PRICES: LONG-TERM TRENDS AND RECENT DEVELOPMENTS

A. Long-run Trends

Figure 1 shows the path of the price indexes of both energy and nonenergy commodities since 1980 (=100) (Box 1). Both plots show a sharp escalation in global commodity prices since 2002. The recent surge in primary commodity prices has been driven by strong global recovery since 2002, combined with sustained high growth in developing Asia. However, a number of factors behind the recent strength of commodity prices may reflect long-term structural changes, which may have enduring impact on market fundamentals.

FIGURE 1
COMMODITY PRICE INDEXES



Source: *Primary Commodity Prices Database*, downloaded 9 October 2006 (International Monetary Fund 2006b).

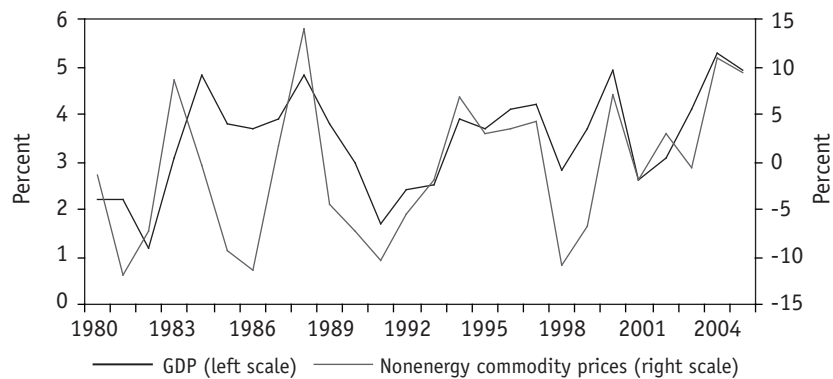
Box 1 PRIMARY COMMODITIES

Primary commodities are defined as raw materials and industrial inputs that are close to the initial production stage. The price indexes of primary commodities employed throughout this paper are the International Monetary Fund (IMF) commodity price indexes.

The IMF overall commodity price index covers a total of 41 commodities. The overall price index is divided into energy (47.8%) and nonenergy (52.2%) subindexes. The components of the nonenergy subindex are food and beverages (food [21.7%] and beverages [3.1%]) and industrial inputs (agricultural raw materials [11.3%] and metals [16.1%]). The energy subindex is comprised of prices of crude oil (39.9%), natural gas (4.5%), and coal (3.4%). The weights used for the IMF commodity price indexes are 1995–1997 average world export earnings. Data for its nonenergy subindex starts in January 1980. Since its energy subindex begins only in January 1992, crude oil price is used as a substitute for the energy price subindex from 1980 to 1991.

Historically, fluctuations in commodity prices have been highly associated with the global business cycle (Figure 2). As the global economy enters into an expansionary phase, inventories fall and a further increase in demand pushes commodity prices sharply higher. However, as commodity prices become elevated—partly responsible for heightened inflationary pressures during the economic boom, thus inviting contractionary policies and also slowing economic activity—additional production comes on stream and helps balance supply and demand. Once the business cycle begins to ebb, demand for primary commodities declines and prices begin to reverse. Cyclical adjustments could be steep if high prices in the expansion phase lead to a glut in inventory and supply.

FIGURE 2
GROWTH IN REAL GDP AND NONENERGY COMMODITY PRICES



Sources: *Primary Commodity Prices Database* (International Monetary Fund 2006b); *World Economic Outlook Online Database*, downloaded 16 October 2006 (International Monetary Fund 2006c); *Commodity Price Indexes* (World Bank Development Prospects Group 2006).

Given the generally high volatility of commodity prices, it is useful to put the recent evolution in a longer-term perspective. Despite recent increases in commodity prices, real prices of nonenergy commodities are deemed to be relatively low by historical standards after a long-run decline (Box 2). Cashin and McDermott (2002) find that real commodity prices have declined by about 1.3% per year over the past 140 years. Technological innovations that have opened up new sources of supply and increased total factor productivity; the development of synthetic substitutes; reduced transportation costs; trade liberalization, economic reforms and changes in market structure; and financial innovation have all contributed to a long-term trend of decline in commodity prices.

In sum, commodity prices are influenced by both cyclical and structural forces. The recent surge in commodity prices has been tightly linked to the strong global recovery that began in 2002 and hence bears some of the traits of earlier episodes of commodity price inflation during an economic upswing. While there is much familiarity about the current pattern of upswing in commodity prices, the past is not always a perfect guide for the future. There are two new elements behind the recent upward movements as to suggest some ongoing structural changes in underlying market fundamentals have longer-term consequences. First, the pull of developing Asia, and particularly the PRC, on global commodity markets has a profound impact on world commodity market dynamics. To the extent that growth in developing Asia is driven by opportunities for economic “catch up” rather than the international business cycle, with the weight of developing Asia rising in the global economy, there may now be greater persistence in the factors driving demand for primary commodities. Second, there is now much greater dissonance about the energy supply outlook than

ever before. The influence of geopolitical factors is certainly clouding the prospect of stable supply in the short run, which could possibly drag on in the long run too. While these factors seem to most directly affect crude oil markets, the generally high energy intensity of other commodity production may signal a more broad-based boom in commodity prices. Apart from these two major elements, structural factors are often sector-specific. The following sections review the recent developments in various commodity markets and prices.

Box 2
LONG-RUN COMMODITY PRICE DYNAMICS

Prebisch (1950) and Singer (1950) claim that the prices of primary commodities should decrease over time relative to those of manufactured goods, due to (a) the lower income elasticity of demand for commodities and (b) productivity and wage differences between industrialized countries that produce manufactures and developing countries that relatively lean toward commodity production. The Prebisch-Singer (P-S) hypothesis, which was named after Prebisch and Singer for their seminal work, has been one of the most intensely tested hypotheses in the economic literature.

Empirical evidence on the P-S hypothesis has been largely mixed depending on the model specification that identifies the sources of the downward trend. A school of studies that suggests there has been a declining tendency in primary commodity prices relative to manufacturing prices, thus in support of the P-S hypothesis, include Grilli and Yang (1988) and Ardeni and Wright (1992). Spraos (1980) reports a declining trend of 7.3% per year between 1900 and 1938, but no statistically significant trend is detected when the data series is extended to 1970. Cashin and McDermott (2002) confirm a trend decline in the series by 1.3% per year, but claim that high variability of commodity prices renders a small long-term decline nearly meaningless. In contrast, Cuddington and Urzúa (1989), Powell (1991), Bleaney and Greenaway (1993), and Cuddington et al. (2002) find structural breaks in the series, but no deterministic trend.

Another salient feature in the commodity price movements is the large variability and generally high persistency in their cycles. Cashin et al. (1999), in examining the cyclical behavior of commodity prices, find that a price slump tends to last longer and that the magnitude of the slump is often greater than that of the price boom. But they argue that the duration of the shocks cannot be determined by the time already spent either in the slump or boom. Deaton and Laroque (1992) also identify an asymmetry that commodity prices spend long periods in doldrums with occasional extreme spikes. Shocks to real commodity prices are also found to be quite persistent, lasting for several years or longer in each cycle. Cashin et al. (2000) also confirm that shocks to commodity prices are typically long-lasting.

The validity of the P-S hypothesis or the existence of a deterministic trend in real commodity prices remains in question with many time-series properties of commodity prices left unanswered. However, empirical findings point to highly responsive commodity prices to shocks over the short to medium term. Over the long term, more persistent changes in the underlying supply and demand conditions seem to dictate commodity price movements.

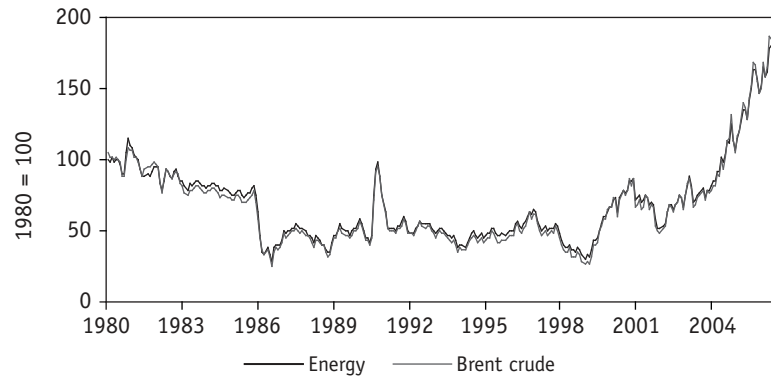
B. Recent Developments

1. Energy Commodities

Figure 3 shows the trajectory of the price index of the energy basket along with the benchmark Brent crude price from 1980 until September 2006. Since 2002, prices have more than tripled. Among all the commodity classes, recent price inflation has been most pronounced for energy. Since energy is also an intermediate input into the production of many other primary commodities, movements

in the price of energy reverberate through other markets. Crude oil prices, which are primarily responsible for energy price movements, have risen steadily higher, leading to an impressive run-up well into the first half of 2006.

FIGURE 3
ENERGY AND BRENT CRUDE PRICE INDEXES



Source: *Primary Commodity Prices Database*, downloaded 9 October 2006
(International Monetary Fund 2006b).

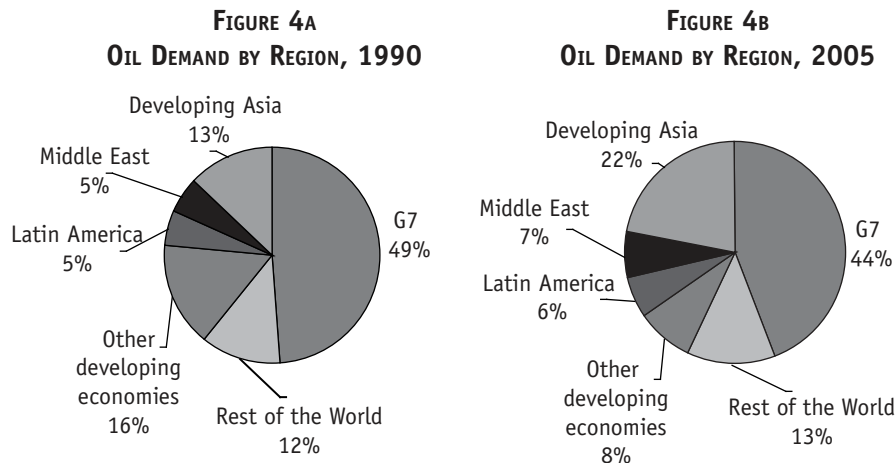
Oil prices are driven mainly by supply and demand factors like most other commodities. Crude oil, a still dominant resource for generating energy, has been particularly vulnerable to supply disruptions, as its production is much more concentrated geographically than other natural resources. The impact of geopolitical risks on global oil prices has been phenomenal as seen in the drastic rises in oil prices during the first and second oil shocks. Excluding the events of supply disruptions, however, the crude oil price cycle, which may extend over several years each time, has largely responded to changes in world demand.

The world demand for oil is dominated by industrialized countries, led by the Group of Seven (G7) accounting for roughly half of the total demand over the last two decades. However, oil demand growth has been much faster in the developing world, apart from the former Soviet Union (FSU), which experienced an economic collapse in much of the 1990s. Oil demand in total developing economies, including developing Asia, Latin America, and Middle East (in descending order according to share of total demand), grew by 36.2%, or 78.8% excluding FSU, compared to 12.5% growth in the G7 over the 1990–2005 period. Developing Asia alone accounted for nearly 60% of world oil demand growth during the same period. Figure 4 illustrates the rising importance of Asian economies in oil price developments since 1990.

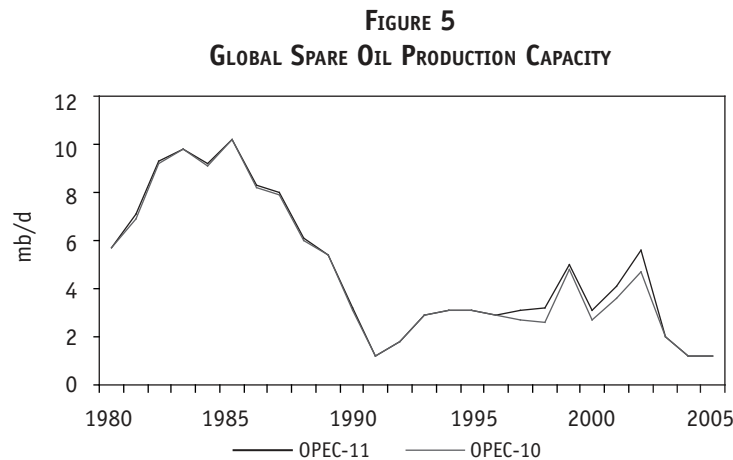
On the other hand, a rather long period of relatively low prices through the late 1980s to the 1990s resulted in underinvestment in general on the supply side, creating significant bottlenecks along the line of the supply chain, as global oil demand accelerated. Despite marginally improving supply/demand conditions in the upstream oil market, generally low levels of spare capacity (Figure 5) as well as binding constraints in the upstream production and downstream infrastructure continue to put upward pressures on global oil prices.

There are signs that indicate significant uncertainties surrounding supply/demand conditions for some time ahead. The oil futures market continues to be volatile, reflecting the heightened sense

of supply risks. The movement of futures prices has closely mirrored the fluctuation of spot prices, which tend to respond more strongly to “news” (Figure 6). A rise in futures contract prices in all time horizons suggests a market assessment of an unlikely meaningful improvement in oil supply and demand balance in the near term (Figure 7). Moreover, oil futures prices are again in “contango” (distant futures prices exceed spot prices), encouraging a continuing buildup in inventories, which itself is usually a tell-tale sign of jittery market sentiment (Box 3). Indeed, average commercial stock holdings in the Organisation for Economic Co-operation and Development (OECD) countries have steadily increased since 2004, despite rising prices.

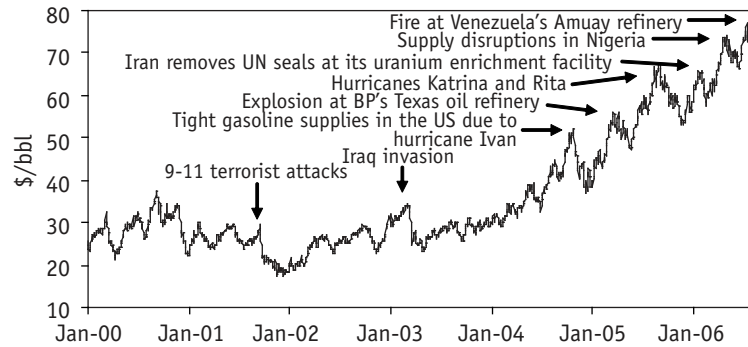


Source: *Statistical Review of World Energy 2006*, downloaded 30 June 2006 (BP 2006).



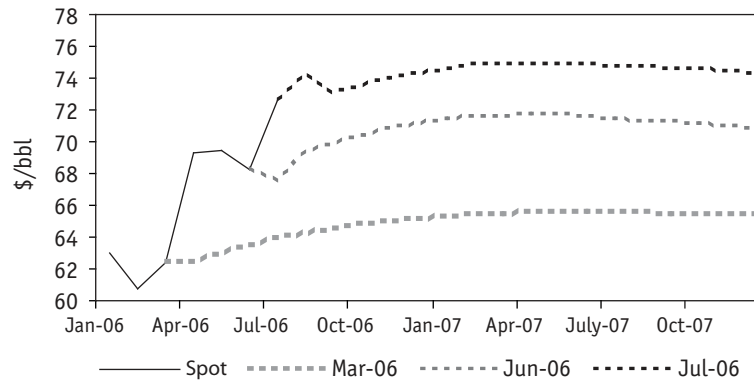
Source: *World Economic Outlook Online Database*, Table 1.21 downloaded 23 June 2006 (International Monetary Fund 2006c).

FIGURE 6
CHRONOLOGY OF BRENT CRUDE OIL PRICE SPIKES



Source: Datastream, downloaded 24 August 2006.

FIGURE 7
BRENT SPOT AND FORWARD PRICES



Source: Datastream, downloaded 8 August 2006.

BOX 3
OIL PRICES, REFINERIES, AND FUTURES

Crude oil quality is important for refinery margins as it determines the level of processing and reprocessing required to obtain the optimal output portfolio. Depending on its density and sulfur content, crude oil is classified into "light" or "heavy", "sweet" or "sour." As lighter and sweeter crude is relatively easy to refine and produces greater yields of high-quality products (also required by tightened environmental regulations), world demand is increasingly driven by this crude grade. But recent additions to production capacity have been rather concentrated in heavy and sour crude grades that require more complex refining facilities. Given the relative ease of supply in heavy and sour crude as well as greater profitability of downstream processing, additional refinery capacity has leaned toward more complex and upgrading facilities since the 1980s.

As one of the world's biggest oil consumers, the United States (US) accommodates the world's largest refining facilities. It accounts for about a quarter of world crude distillation capacity, with the Gulf Coast area hosting nearly half of the country's capacity. Downstream processing capacity is even more concentrated in the US, especially in the Gulf Coast area. Therefore, when Hurricane Katrina hit the region, it caused extensive damage to upgrading capacity, and the prices of some refined products, particularly gasoline, shot up. Higher gasoline prices increased the difference between the prices of refined products and the prices of crude oil—called "crack spread." This stimulated refineries with less sophisticated processing capacity to come on stream. However, these simpler refineries have relatively lower product yields (i.e., higher crude input demand), thus pushing crude oil demand and prices higher. In addition, many of them cannot even take heavy crude. As they sought light crude to maximize their yields, the prices of light crude surged even further.

The rise in the crack spread also affected the futures markets. Refineries profit from wide crack spreads, but if the gasoline price falls at the time of sale or crude prices suddenly rise, the refineries will lose substantially. Thus, refineries have an incentive to hedge against price risks, by taking a short position in gasoline futures (a legal obligation to sell gasoline at an agreed future time at an agreed price) and a long position in crude (a legal obligation to buy crude oil at an agreed future time at an agreed price). In last year's period of uncertainty, refineries started to buy crude futures, bidding futures prices up, and to sell gasoline futures. But given the shortage in upgrading capacity, gasoline prices were unlikely to fall significantly, thus the narrowing crack spreads came mostly from rising crude prices.

The futures market situation in turn reinforced spot market conditions. Given tight refinery conditions and unlikely improvement for the next couple of years, futures prices surged. Normally, as longer-dated futures prices rise much higher than spot prices or near-month futures ("contango"), refiners have an incentive to hold larger inventories. This is an unusual situation: generally, oil futures prices are in "backwardation" (i.e., spot prices are higher than futures prices), reflecting the "convenience yield", i.e., what refiners will pay to hold stocks for ensuring smooth day-to-day operations (bearing in mind that crude can be stored most efficiently and at lowest cost with producers, not the refiners). This convenience yield is greatly discounted for distant futures, say 12 months ahead. However, when distant futures prices are significantly higher than spot prices, thus creating a sufficiently wide "contango", refiners are willing to hold the actual oil and to pay for the cost of carry. This leads to an increase in spot prices and, at the same time, a buildup in inventories.

Overall, strong market fundamentals, i.e., robust demand and tight supply, have been the main reason for currently high oil prices. Nevertheless, underlying market structures appear to play an important role by reinforcing the crude oil/refinery products price dynamics through the futures markets.

2. Nonenergy Commodities

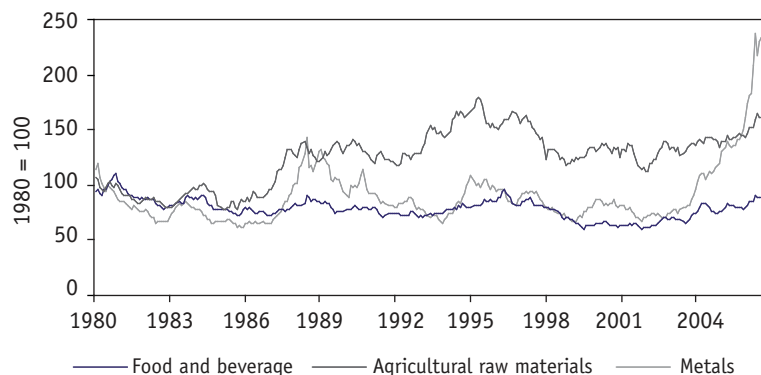
Nonenergy commodities have seen the price rally that began in 2002 and stretched into May 2006, largely on strong base metal prices (Figure 8). Despite some similarities in price movements across groups, individual commodities are frequently subject to idiosyncratic influences, both short-term and structural (the supply of agricultural commodities, for example, is influenced by weather). One common factor is the influence of energy prices as many nonenergy commodities are energy-intensive in their production (Box 4).

3. Base Metals

Prices of base metals have made handsome gains since 2002 on the back of strong demand, low inventories, and high oil prices (Figure 9). Driven by strong demand for industrial production in developing Asia, including the PRC—the PRC is currently the world’s biggest importer of iron and steel, and second-biggest importer of metal ores and nonferrous metals—the prices of aluminum, copper, iron ore, lead, nickel, zinc, and other widely used metals have surged in recent years. On average, base metal prices have grown at an annual rate of 24.9% from 2002 to 2005. Copper, iron ore, lead, nickel, and zinc (in descending order) have been the strongest movers. These metals are generally used in steel production (a rapidly growing industry in the PRC and India), stainless steel, electrical wire, cable, and building infrastructure. Copper prices more than tripled in the period, whereas the prices of iron ore, lead, nickel, and zinc more than doubled.

The steady and steep increase in metal prices over the past several years accelerated even further in early 2006, largely on the ground of metals’ attractiveness to investors in search of higher yields and driven by the prospect of capital gains. Investing in various commodities as a part of hedging against financial risks or portfolio investment has a long history. The past few years, however, have witnessed a flurry of hedge funds and institutional investors into commodity futures markets in a hunt for better yields given the historically low interest rate environment (Box 5). This asset demand became more pronounced in early 2006, as the dollar precipitated the fall amid heightened global financial market and interest rate uncertainties. Changes in market expectations for global liquidity conditions in mid-May brought about a large sell-off across a broad range of financial markets, including commodity markets. This underscores the underlying asset demand in the latest rally in commodity prices.

FIGURE 8
NONENERGY COMMODITY PRICE INDEXES



Source: *Primary Commodity Prices Database*, downloaded 9 October 2006 (International Monetary Fund 2006b).

Box 4
ENERGY AND THE COST STRUCTURE OF PRIMARY COMMODITY PRODUCTION

Higher energy prices generally translate into higher commodity prices. Typically, the production of basic commodities and semifinished manufactures (e.g., fertilizers) is highly energy-intensive compared with that of manufactures. For example, most base metals including aluminum and steel are known for their energy-intensive production processes such as metallurgy and smelting. Paper and pulp, cement, and fertilizer industries tend to rank high in their use of energy. Highly energy-intensive production of fertilizers in turn affects the prices of agricultural food commodities in general. There are also indirect effects of high oil prices on demand and prices of nonenergy commodities. For instance, some agricultural commodities are used to produce energy substitutes, such as sugar and soybeans for the production of ethanol and other biofuels. Demand for crude rubber rises as energy prices increase given the relatively high energy intensity of synthetic rubber production.

A more formal way of investigating the relationship between energy and nonenergy commodity prices is to test Granger causality. The Granger causality test is simply to see if lagged values of one variable (X) have any statistically significant information on future values of the other variable (Y) given the lagged values of Y. If it does, X is said to "Granger-cause" Y. The box table provides test results for Granger-causality between energy and nonenergy commodity prices. In this case, Granger causality is tested for both directions between energy and nonenergy commodity prices using monthly data with different lags up to 12 months from January 1980 until September 2006. Test results suggest that changes in energy prices "Granger cause" changes in nonenergy commodity prices but not the other way around. The results are statistically significant and indicate marginal significance of energy prices in the equation for nonenergy commodity prices, and only in that direction.

NUMBER OF LAGS (MONTHS)	NULL HYPOTHESIS	
	NONENERGY PRICES DO NOT GRANGER-CAUSE ENERGY PRICES	ENERGY PRICES DO NOT GRANGER-CAUSE NONENERGY PRICES
1	1.58057	3.76222*
2	0.50940	1.49629
3	1.11809	4.18756*
4	1.45697	3.28997*
5	1.08427	4.37094*
6	1.15413	3.64133*
7	1.20773	3.03238*
8	1.04487	2.67009*
9	1.08210	2.70782*
10	0.96809	2.38883*
11	0.75858	2.45541*
12	0.73875	2.02904*

* Indicates significance of F-statistics at the 5% level and rejection of the null.

Note: The results report F-statistics, which form the basis for which the null hypothesis is accepted or rejected. In terms of the actual numbers reported, a higher number represents greater statistical significance, thus leading to rejection of the null. For example, in column 2 with one month lag, the test statistic (F-stat) is 1.58, which is statistically insignificant, thus leading to nonrejection of the null that nonenergy commodity prices do not Granger-cause energy prices. On the other hand, in column 3 with one month lag, the test statistic is 3.76, which is statistically significant, thus implying rejection of the null that energy prices do not Granger-cause nonenergy commodity prices.

Source: Staff calculations.

FIGURE 9A
ALUMINUM PRICE INDEXES

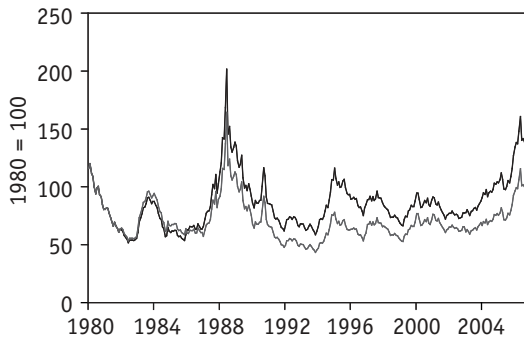


FIGURE 9B
COPPER PRICE INDEXES

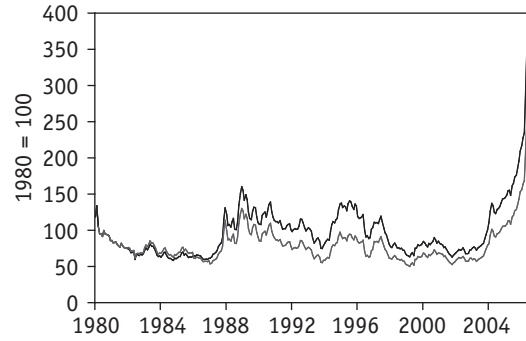


FIGURE 9C
IRON ORE PRICE INDEXES

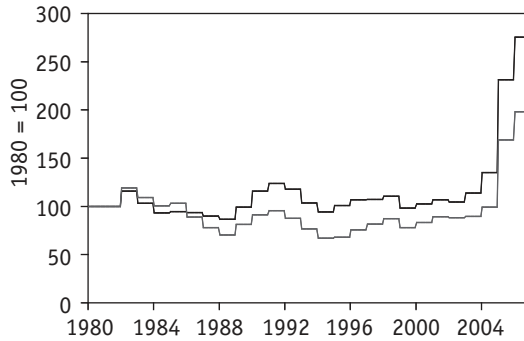


FIGURE 9D
LEAD PRICE INDEXES

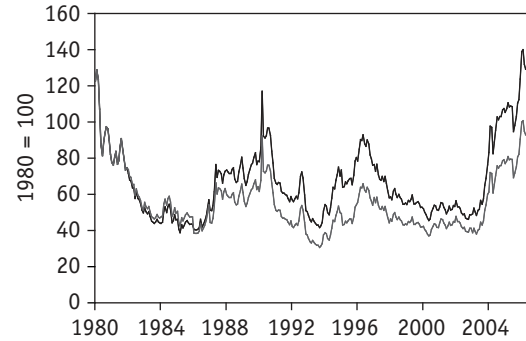


FIGURE 9E
NICKEL PRICE INDEXES

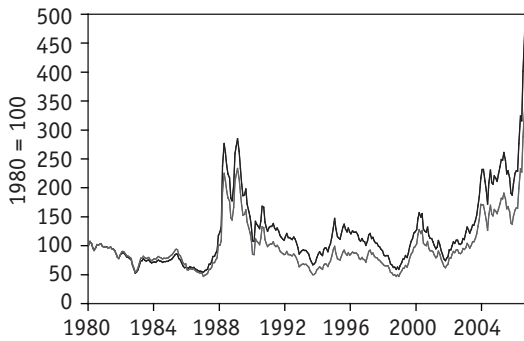
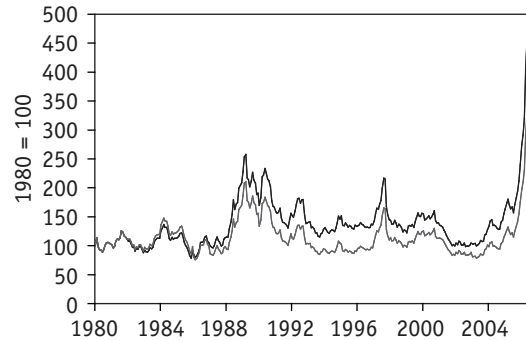


FIGURE 9F
ZINC PRICE INDEXES



— Nominal — Real

Sources: *Primary Commodity Prices Database*, downloaded 9 October 2006 (International Monetary Fund 2006b); *Commodity Price Indexes* (World Bank Development Prospects Group 2006).

Box 5
SPECULATION AND COMMODITY PRICES

The role of speculation in commodity price volatility is a highly contentious topic. There are two major players in the commodity futures markets: hedgers and speculators. Hedgers participate in futures trading for insurance purposes against price movements. They are often commercial traders who are actually involved in the economic activity related to the underlying commodity, and thus have intrinsic interest in protecting themselves against adverse price movements. Unlike hedgers with commercial interests who want to hedge against price movements, speculators seek trading profits coming from price changes between the selling and buying points in the futures market. That is, speculators assume price risks in the hope that prices will move in their favor. By taking the price risks that hedgers want to transfer, speculators act as a counter party to the futures contract, so that hedgers may shed unwanted risks.

Speculators' participation in the futures markets contributes to market liquidity and diversity. The market liquidity literature explains that a large pool of speculators with diverse expectations and risk profiles help markets to function more efficiently by allowing the hedgers with specific needs to unload the risks at lower costs. At the same time, however, an increase in trading volume due to their activities may lead to higher price volatility in the short term. The futures market is a place where a seller meets a buyer through clearing prices. Like any other market, the futures market is subject to asymmetric information between the seller and buyer. In order to find out the true value of the financial product involved, traders rely on trading volume and prices to deduce the right information. This is called a price-discovery process. An arrival of new information triggers the process of price discovery, leading to an increase in trading volume and price volatility. As traders filter out relevant information from noise through vigorous trading activities, higher trading volume is generally accompanied by strong price reactions. Empirical studies also find a positive relation between trading volume and price volatility (see Karpoff 1987 for a survey). While an exogenous information shock along with an increase in futures trading could heighten the level and volatility of spot prices in the short run, the participation of a diverse group of investors in futures trading may improve the overall information content in trading behavior and prices. Earlier literature suggests that better information content in increased futures trading helps stabilize spot prices by facilitating the price-discovery process (see Anderson 1991 for a survey). Moreover, increased speculative activities in the futures markets provide easier hedging and inventory-adjustment opportunities to help reduce financial risks. Empirical evidence on the stabilizing effect of futures trading and speculation on spot price movements, however, remains largely mixed. Cox (1976) and Danthine (1978) found that an introduction of futures trading helps stabilize spot prices thanks to improved information. However, Kawai (1983) and Newbery (1987) provided evidence that speculation could be destabilizing for storable commodities.

The impact of speculation in futures markets on the level and volatility of spot prices is still under debate. However, a diverse group of speculators enhance liquidity and broaden the scope of trading in the commodity futures markets. Such benefits of market liquidity appear to be unambiguous over the long run (see BIS 1999 for a survey). Increased market liquidity lowers trading costs and facilitates the price-discovery process. Along this line, establishment of liquid futures markets with active participation of speculators would be a welcome progress, as more effective price discovery together with hedging opportunities through the futures markets would help reduce fundamental price volatility in the long run. In the meantime, however, increasing trade flows with heterogeneous beliefs accompanied by broader participation of financial investors could continue to trigger sudden spikes in response to news in short-term price movements.

Nevertheless, the fate of different metal prices was critically influenced by market fundamentals. Given firm demand driven by higher global growth and rapid industrialization in developing Asia, overall tight market conditions appeared to provide support for metal prices. For example, during the May sell-off, the price of nickel held its ground, given low inventory levels. Likewise, copper

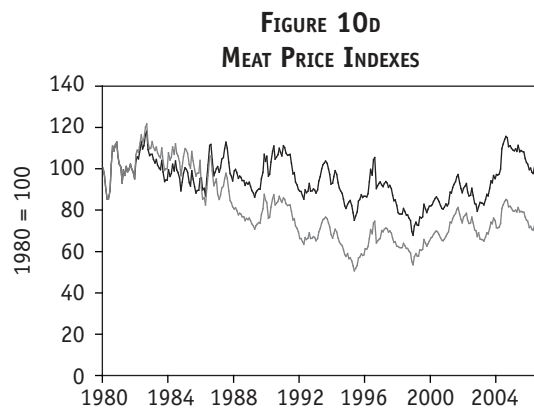
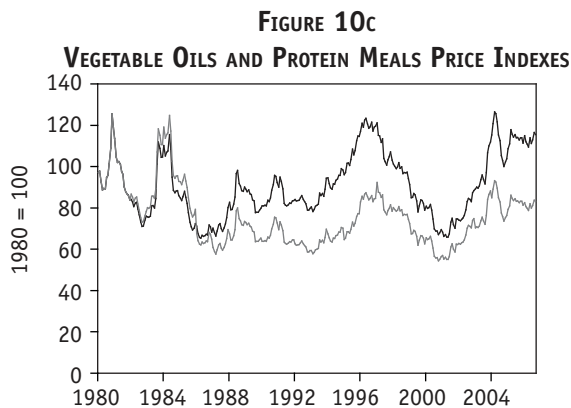
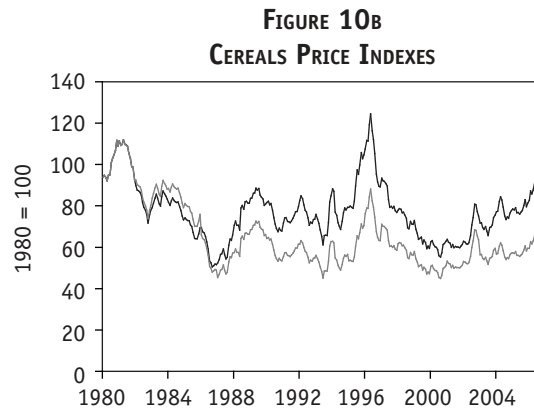
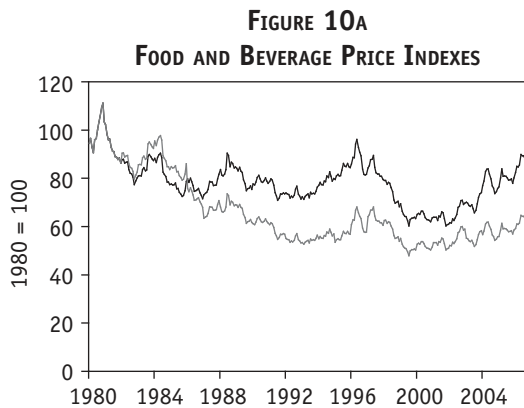
and zinc rebounded fairly quickly, on the back of tight supply conditions. More generally, base metal production has been constrained by tightened global mining and smelting capacity.¹ Supply disruptions and labor disputes, sometimes related to political instability in the producer countries, are also helping keep a tight supply/demand balance in recent years.

4. Food and Other Agricultural Commodities

Prices of food and beverages have been on a long-term downward trend owing to increased agricultural productivity and technological advances (Figure 10). Real prices of food and beverage declined rather sharply during the 1980s and continued to be depressed until 2001. Food prices started to rise partly in response to adverse weather conditions in 2002–2003. After reaching a cyclical peak in early 2004, agricultural food prices generally stabilized during late 2004 and 2005. The recent performance of steady food prices reflects restored demand/supply balance based on both firm demand and improved supply management over the past couple of decades. For some food commodities such as rice, soybeans, meat, fruits, and vegetables, Asian demand particularly from the PRC has been strong, largely reflecting rapidly changing dietary patterns along with rising income levels. A surge in soybean prices bears witness to growing consumption by the PRC of feedstock for live animals, as well as of vegetable oil. In the past few years, high crude oil prices have also lifted demand for soybeans and sugar to produce ethanol, as a partial substitute for transportation fuels.

After a sharp decline that coincided with Asia's financial crisis, agricultural raw materials prices are on a gradual recovery (Figure 11). In fact, the economic performance of the PRC since the early 1990s has exerted a growing influence on movements of cotton, rubber, and timber prices. As the production of textile and clothing in the PRC rose rapidly in the 1990s, domestic demand for cotton increased, pushing global prices higher. The PRC also emerged as the world's major consumer of forest products since the 1980s, on the back of strong construction activities. In the 1990s, the PRC's demand for timber was lifted again by the takeoff in the wood products industry for furniture and interior decoration. Buoyant construction activities and a pickup in the domestic furniture industry in the PRC continue to be a major driver behind strong growth in global timber prices since the Asian crisis. Similarly, surging automobile production in the PRC has lifted rubber prices strongly (due to demand for tires). The PRC's tire production has increased at about 20% per annum since the early 1990s according to a report by the International Rubber Study Group (2004), which has pushed the PRC as the world's largest consumer of natural rubber since 2001. Recently, high oil prices have provided additional upward momentum to rubber prices as synthetic rubber has become more expensive.

¹ Various industry reports claim that a rather long period of relatively low prices and capacity overhang through the 1990s led the mining industry to reduce excess capacity through mergers and restructuring (see Kitco Base Metals 2006 for example). Investment in exploration and development of new mines has been also limited. Even when metal demand started to rise after the Asian crisis, several major producers continued to reduce their inventory overhang rather than add new production capacity, a process that is now becoming more drawn-out as regulations on environmental concerns tighten.



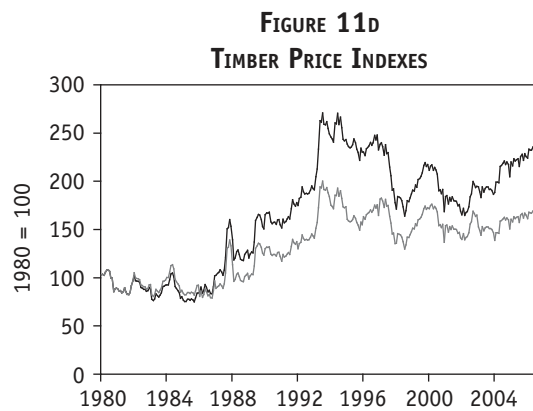
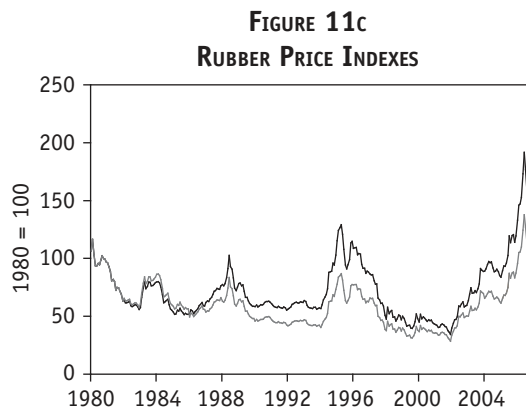
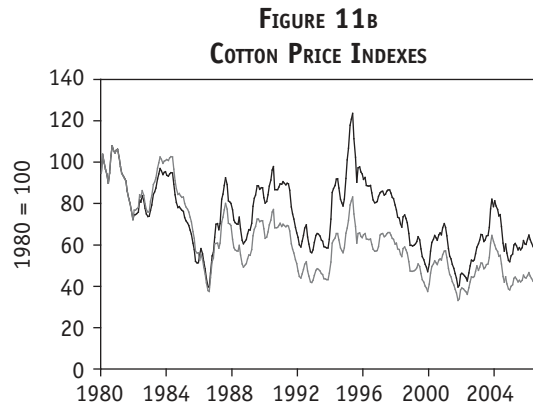
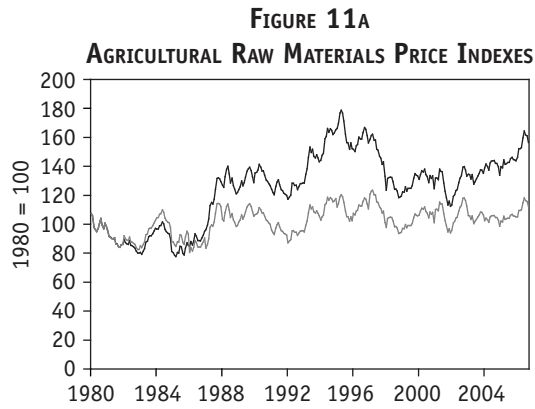
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Sources: *Primary Commodity Prices Database*, downloaded 9 October 2006 (International Monetary Fund 2006b); *Commodity Price Indexes* (World Bank Development Prospects Group 2006).

III. DEVELOPING ASIA'S IMPRINT ON GLOBAL COMMODITY MARKETS

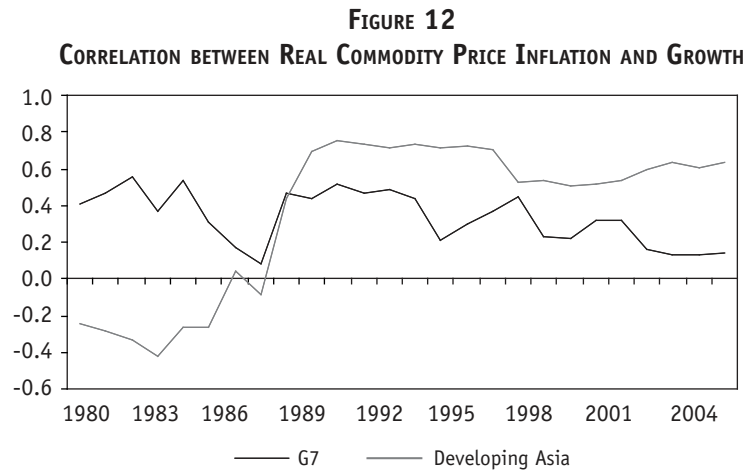
A. Growth, Structural Change, and Commodity Demand

In the past, global business cycles were dominated by the growth performance of industrialized countries, thus commodity price fluctuations were dictated primarily by the business cycles in these countries. But with developing Asia's growing presence in the global economy, the region exerts increasing—and now considerable—influence on international commodity markets and prices. Figure 12 illustrates evolving correlations between gross domestic product (GDP) growth rates of both G7 and developing Asian economies and commodity price fluctuations. While the linkage between G7 growth and the global commodity price cycle gradually weakened, that between developing Asia's growth and the global commodity price fluctuations jumped since around the early 1990s. It can be readily inferred that strong growth in developing Asia's demand was a major driver behind an upswing in commodity markets through the mid-1990s prior to the Asian financial crisis—while the crisis itself led to a slump in commodity markets during 1998–1999.



— Nominal — Real

Sources: *Primary Commodity Prices Database*, downloaded 9 October 2006 (International Monetary Fund 2006b); *Commodity Price Indexes* (World Bank Development Prospects Group 2006).



Sources: *World Development Indicators Online Database*, downloaded 24 August 2006 (World Bank 2006); *Commodity Price Indexes* (World Bank Development Prospects Group 2006).

Although developing Asia as a whole exhibited remarkable dynamism in economic growth and development, the progress of economic achievement has not been uniform across the region. At the subregional level, East Asia including the PRC grew most rapidly, followed by South Asia including India. East Asia and South Asia grew at an annual average rate of 9.1% and 5.7% per year, respectively, in the period 1991–2004. As of end-2004, East Asia and South Asia account for 17.7% and 7.2% respectively of total world GDP measured in terms of purchasing power parity (PPP), followed by Southeast Asia for 4.5% and Central Asia for 0.4% (Table 1). The relative weight of these subregions in the world economy is in turn reflected in their respective shares of world commodity consumption. For instance, the East Asian countries' demand for crude oil rose by an average of 6.2% annually in the same period, nearly four times as fast as total world consumption, contributing 36.0% to total world consumption growth. Steel use in the East Asian countries also became intense, with consumption increasing by an estimated rate of 13.9% on average per year between 1999 and 2004, about twice as fast as total world consumption.

TABLE 1
CONTRIBUTION TO WORLD GDP AND COMMODITY DEMAND

	SHARE OF WORLD ACTIVITY, 2004			CONTRIBUTION TO GROWTH, 1991–2004		
	GDP ¹	PETROLEUM DEMAND	STEEL DEMAND	GDP ^{1,2}	PETROLEUM DEMAND ²	STEEL DEMAND ³
World	100.0	100.0	100.0	100.0	100.0	100.0
Developing Asia	29.9	21.6	43.1	41.2	63.0	75.3
East Asia	17.7	12.1	34.9	26.3	36.0	65.3
South Asia	7.2	3.6	3.4	8.9	9.8	3.7
Southeast Asia	4.5	5.0	4.8	5.1	12.8	6.3
Central Asia	0.4	0.8	n.a.	0.3	-2.3	n.a.

¹ In purchasing power parity terms.

² 1992–2004 for Central Asia.

³ 1999–2005.

Sources: *World Economic Outlook September 2006*, downloaded 16 October 2006 (International Monetary Fund 2006e); *International Energy Annual 2004* (Energy Information Administration 2004); *World Steel in Figures 2006*, downloaded 1 August 2006 (International Iron and Steel Institute 2006); JP Morgan (2006).

Rapid population and income growth in East Asian economies have also been key drivers behind the rising demand for world food commodities. Along with increasing food demand, changing dietary patterns play an important role. While the consumption of traditional coarse grains typically decreases with income growth, demand for meat, fruits and vegetables, and vegetable oil increases. Table 2 illustrates considerable changes in the dietary composition in the economies of developing Asia in the last decade. Reflecting its economic prowess, East Asia again leads the changes among the subregions. In terms of total calorie intake, there has been a noticeable drop in the share of cereals, while the other food products have gained considerable shares along with growing food diversity toward more protein and fat consumption.

Overall, per capita income is an important variable for commodity demand. However, changes in technology and consumer preferences along with the long-term development path are often

TABLE 2
DIETARY COMPOSITION (% OF TOTAL ENERGY CONSUMPTION)

1994	CEREALS	VEGETABLE OILS	SUGAR AND SWEETENERS	MEAT AND OFFALS	ROOTS AND TUBERS	MILK, EGGS, AND FISH	FRUITS AND VEGETABLES	ANIMAL FATS	PULSES	OTHERS
Developing Asia	63.32	9.11	5.74	6.34	3.75	4.58	3.88	0.68	2.09	0.52
East Asia	62.99	8.78	2.41	10.98	5.14	3.22	4.50	1.14	0.54	0.29
South Asia	63.62	8.55	9.76	1.15	1.73	6.55	3.12	0.14	4.53	0.86
Southeast Asia	63.99	11.50	6.43	4.36	4.33	3.19	3.86	0.56	1.34	0.43
Central Asia	61.17	7.84	5.03	7.78	3.08	10.69	3.46	0.55	0.07	0.33
2004	CEREALS	VEGETABLE OILS	SUGAR AND SWEETENERS	MEAT AND OFFALS	ROOTS AND TUBERS	MILK, EGGS, AND FISH	FRUITS AND VEGETABLES	ANIMAL FATS	PULSES	OTHERS
Developing Asia	54.35	12.20	6.46	7.89	4.29	5.61	5.53	0.89	2.00	0.78
East Asia	47.01	12.33	3.68	14.68	6.10	4.97	8.70	1.59	0.45	0.50
South Asia	59.96	12.27	9.17	1.27	2.12	7.02	2.71	0.15	4.23	1.09
Southeast Asia	60.87	12.16	7.93	4.97	4.34	3.24	3.72	0.76	1.19	0.84
Central Asia	57.06	8.25	4.32	7.66	5.07	12.07	4.19	0.53	0.12	0.73

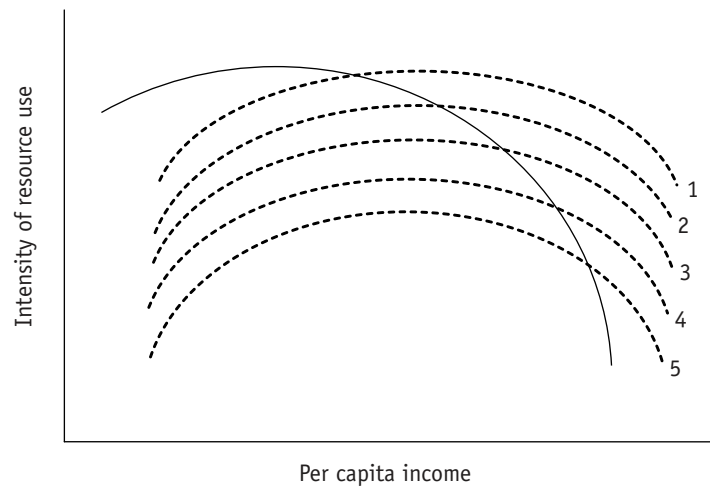
Source: Food and Agriculture Organization (2005), downloaded 31 July 2006.

as important for the consumption patterns. In general, economic development accompanies significant changes in industrial structures as well as rising income levels, which in turn affect commodity consumption. Earlier studies² argue that resource use increases in the initial stage of development but then tends to taper off after income reaches a certain level. This creates an inverted U-curve for the intensity of resource use. For example, in the early stage of development, resource requirements particularly for metals are low as the economy often relies on unmechanized subsistence agriculture. Industrialization pushes resource demand to build urban, industrial, and transportation infrastructure. As the economy matures and the industrial structure shifts toward services, resource demand for infrastructure building and industrial inputs would then decline. In light of resource-saving technological developments over time, Bernardini and Galli (1993) also claim that intensity of use curves tend to shift downward over the long term.

Figure 13 graphically illustrates the intensity of resource use given per capita income. The dotted lines 1–5 represent the intensity of use curves of an individual country going through economic transition in successive periods 1–5 or of a group of countries 1–5 at different stages of economic development (the higher number corresponds to the more advanced stage). Different intensity curves either over time or cross sectionally reflect the tendency of downward shifts in intensity of use curves as technology advances along different stages of economic development. The solid line crossing the different intensity of use curves would indicate an actual intensity of use curve.

² The relationship between the intensity of resource use and income has been established both in theory and empirics. Earlier studies that laid the foundation for the inverted U-shaped intensity of use curves include Malenbaum (1973), Larson et al. (1986), Bernardini and Galli (1993), and Jänicke et al. (1997). See Cleveland and Ruth (1999) for a survey.

FIGURE 13
RELATIONSHIP BETWEEN INTENSITY OF RESOURCE USE AND PER CAPITA INCOME



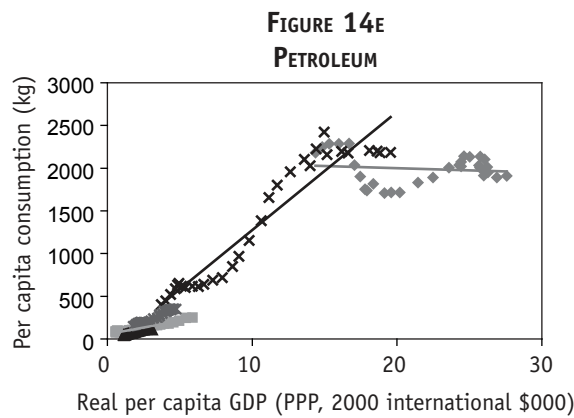
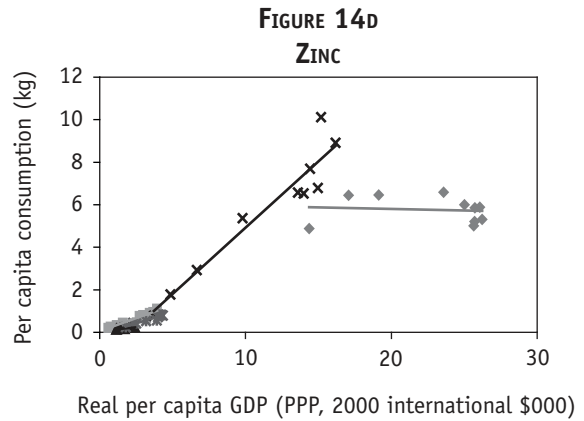
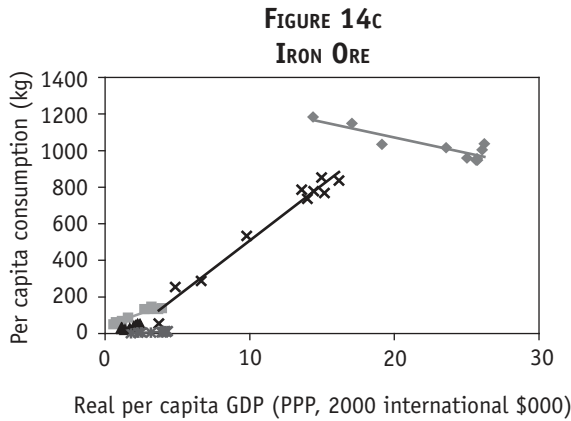
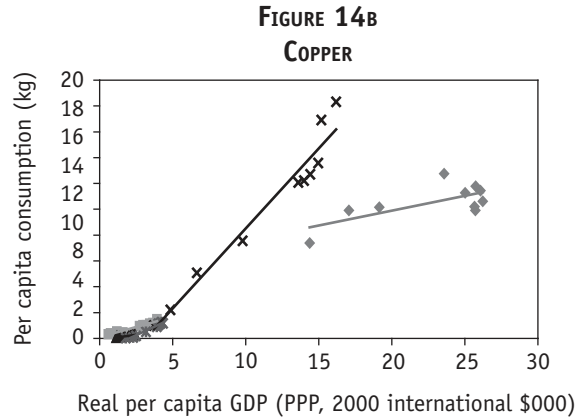
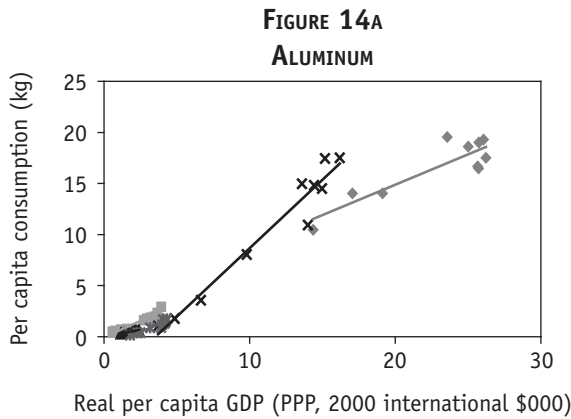
Graphical representation of the intensity of resource use curve as envisioned by Bernardini and Galli (1993). The dotted lines 1-5 represent differences in the intensity of use curve for countries at different stages of development over time. Countries that start the development process later in time enjoy lower intensity of resource use, as they can avail of more efficient technology.

Figure 14 plots per capita consumption of mineral ores and petroleum of different countries over time. Along the development path of selected countries emerges an early phase of the inverted U-shaped or “S-shaped” pattern. The general patterns suggest that resource consumption rises as income grows. When income reaches about \$5,000–10,000 per capita along with industrialization, measured in PPP terms, the consumption of metals and energy seems to grow rapidly. After a rapid expansion period, the intensity of resource use appears to slow at incomes of about \$15,000–20,000 per capita in PPP terms. These patterns typically repeat among countries at different stages of economic development. Moreover, despite the rapid increases in the PRC’s demand for metals and energy, the figure suggests that it may be only the beginning of the PRC’s resource demand.

B. Evolving Patterns of Commodity Demand and Trade

Rapid economic growth and industrialization accompany changes in the level and composition of international trade. Although a country’s domestic resource endowment affects the extent of the country’s reliance on external resources, in general rapid growth and industrialization will face domestic resource constraints. Particularly, rapid economic development in relatively resource-poor countries such as many developing Asian economies would likely signal significant changes in trade composition along with transition from agricultural to manufacturing economies.

Developing Asia’s total trade with the world has increased dramatically over the 40-year period, 1964–2004 (Figure 15). Changing trade patterns attest to the progress of substantive economic transformation of developing Asia from agricultural and largely resource-based economies

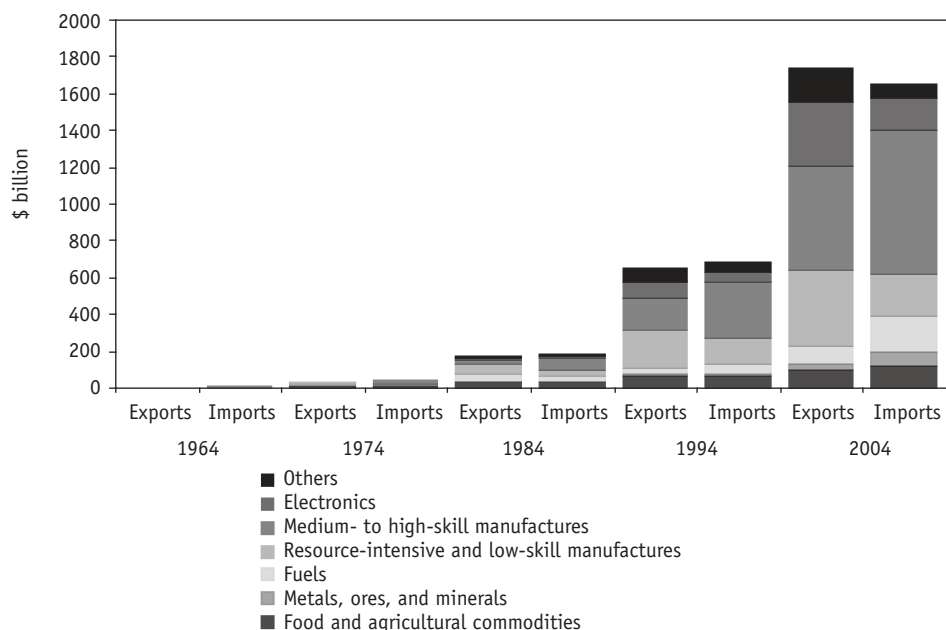


× ASEAN4 ■ PRC ▲ India ◆ Japan × Korea
 — Linear (ASEAN4) — Linear (PRC) — Linear (India) — Linear (Japan) — Linear (Korea)

Sources: *Statistical Review of World Energy 2006*, downloaded 30 June 2006 (BP 2006); *Commodity Yearbook 2003*, downloaded 2 August 2006 (United Nations Conference on Trade and Development 2003); *World Development Indicators Online Database*, downloaded 10 October 2006 (World Bank 2006).

to manufacturing and service-based economies.³ In general, the accumulation of both physical and human capital along with economic development and industrialization accompanies changes in a country's comparative advantage toward capital and skill-intensive products over time. Therefore, it is commonly observed that the share of manufactures in export composition increases in developing countries with rapid industrialization. Faced with increasing domestic resource constraints, imports of primary commodities also rise rapidly, not to mention capital equipment and intermediate inputs especially at the early stage of development.

FIGURE 15
DEVELOPING ASIA'S TRADE



Source: *Commodity Trade Statistics Database*, downloaded 16 October 2006 (United Nations 2006).

While developing Asia's total exports exploded from \$5.3 billion to \$1,654.9 billion between 1964 and 2004, the share of primary commodities in percent of total exports sharply dropped from 74.0% to 13.2% over the same period. In particular, at the beginning of the period, exports from developing Asia were dominated by agricultural and mining products. Propelled by industrialization, however, manufacturing exports gained an increasing weight, initially driven by labor-intensive (and resource) manufactures, such as textile and clothing in the early stage of development, and later by more skill-intensive manufactures, such as machinery, industrial chemicals, and electronics. Along with the manufacturing export drive, Asian demand for primary commodities surged.

A close look at historical commodity import data also reveals developing Asia's burgeoning role as a consumer and importer of industrial raw materials and fuels. Table 3 summarizes the profiles and trends of primary commodity imports in PRC, India, Japan, and Korea, which is designed to provide an example of differences and similarities in their changing import patterns along with industrialization. The table highlights the growing share of total primary commodity imports of fuels and metals during rapid economic growth and industrialization. It is clear from

³ UNCTAD (2005) reports that sustained rapid growth and rising incomes in Asia have been accompanied by a dramatic shift in the pattern of international trade flows.

the table that the weight of primary imports has shifted from agricultural food and raw materials to metals and fuels in Japan, and more so in Korea over time. Fuels especially have continued to explain a significant portion of their commodity needs, accounting for more than a half of total primary commodity imports in recent decades. Not only accounting for a significant share in total commodity imports, imports of fuels and metals also rose sharply in real terms (deflated by the import prices of individual commodities) particularly during the period of rapid economic growth in Japan between 1964 and 1974 and in Korea in the latter decades (Figure 16). Real imports of fuels have more or less stabilized in Japan since 1974, but continued to grow at an accelerated rate in Korea along with its metal imports in the 1980s through the 1990s. On the other hand, real imports of agricultural raw materials have declined in Japan since 1984 and reached a plateau a decade later in Korea. This stands in marked contrast against a sharp pickup in the PRC and India between 1994 and 2004, highlighting a shift in the textile industry from high-labor-cost to low-labor-cost countries. This repeated pattern also underscores a successful shift in the industrial structure from labor-intensive to skill-intensive manufactures in these Asian economies. Moreover, the contemporary surge in the PRC's imports of fuels and metals echoes experience of both Japan and Korea during their early industrialization phase in the 1960s and 1970s. This pattern is most likely associated with the increasing intensity of metal use during the early catch-up phase.

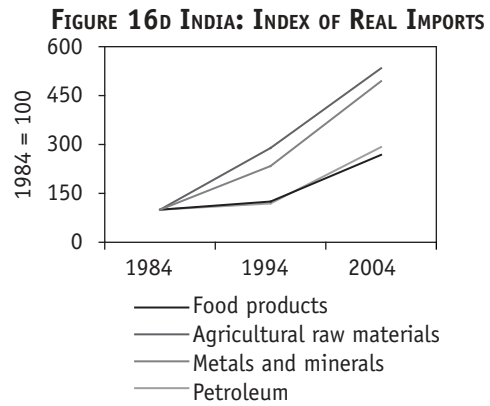
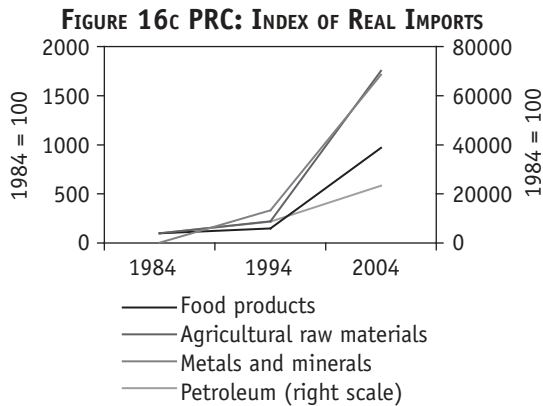
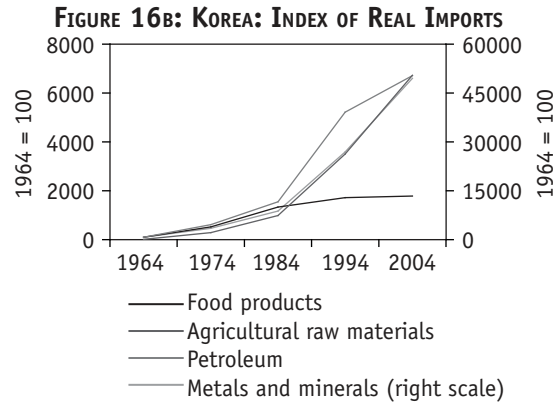
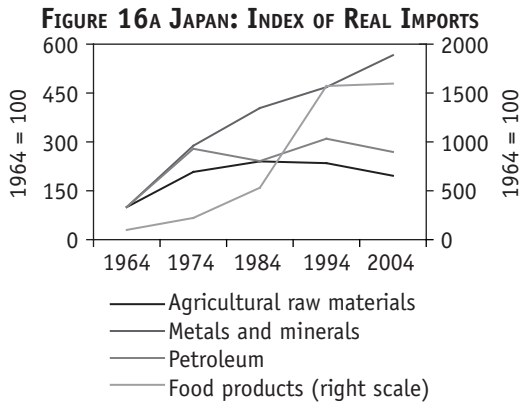
Interestingly, some agricultural food commodities, particularly basic staples, have resisted the general trend of rising import demand in Asia. As a consequence of significant improvements in agricultural productivity with the onset of the "Green Revolution", and the subsequent protection of the agricultural sector, import demand for cereals and cereal preparations actually fell in the PRC and India in the early stage of development (see Boestel et al. 1999). However, changing dietary patterns appear to exert an obvious influence on the level and variety of imports for other food products including meats, vegetables, edible oil, and oil seeds. Rapid urbanization is another contributing factor to the changes in dietary profiles, which often generates additional demand for higher-value processed food and tropical beverages such as coffee. It is clear that this general trend in the dietary pattern would have magnifying impacts on food imports by the PRC and India given their population size. Table 3 also illustrates that imports of meat, fish, edible oil, and oil seeds rose sharply in Japan and Korea over the past four decades, while the share of cereals and cereal preparations steadily declined in total food imports. The PRC imports of meat, fish, vegetable oil, and oil seeds started to take off in the mid-1990s. More recently, imports of vegetable oil and oil seeds in India have also shown fast growth.

With developing Asia's growing presence in world trade, the region exercises increasing leverage over international commodity markets and prices. In particular, the remarkable economic expansion combined with rapid industrialization in the PRC appears to have considerable repercussions for world commodity demand and prices. Table 4 contrasts the PRC's top 10 primary commodity imports in 1984 and 2004, together with their global shares. In just two decades, food products and inputs for primary and light manufacturing industries have given way to heavier industrial raw materials. It also demonstrates how processes of fast growth and structural change in the PRC have made a large impression on global commodity markets, even at comparatively low income levels. India may be only one or two decades behind in its catch-up process given its recent growth performance and outlook. Given the size of the PRC and India economies—they account for 37.4% of world population and 21.4% of world GDP in PPP terms—world commodity markets are expected to see hefty changes. The relatively low development stages of these countries also suggest that income elasticity of their commodity demand would be higher compared with that of industrialized countries, which would

TABLE 3
SHARE IN PRIMARY COMMODITY IMPORT VALUE

	JAPAN					PRC		
	1964	1974	1984	1994	2004	1984	1994	2004
Primary products	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0
All food products	23.3	16.9	16.3	36.0	26.4	39.6	28.0	10.8
Meat and meat preparations	0.9	1.0	1.9	5.9	4.8	0.1	0.5	0.4
Dairy products and eggs	0.3	0.4	0.3	0.5	0.5	0.4	0.5	0.3
Fish and fish preparations	0.9	2.1	4.1	12.1	7.6	0.5	3.2	1.8
Cereals and cereal preparations	10.3	7.0	4.7	5.0	3.3	28.2	7.4	1.9
Sugar, sugar preparations, and honey	4.5	2.6	0.4	0.5	0.3	4.1	2.5	0.3
Coffee, tea, cocoa, spices, and manufactures	1.1	0.7	1.1	1.3	1.0	0.8	0.3	0.1
Fixed vegetable oils and fats	0.2	0.3	0.3	0.3	0.4	0.9	9.7	3.0
Agricultural raw materials	33.8	17.8	12.5	15.7	8.1	35.3	29.3	23.3
Oil seeds, oil nuts, and oil kernels	4.6	2.6	2.2	1.7	1.5	0.0	0.3	5.6
Crude rubber	2.3	0.5	0.6	0.7	0.7	5.0	3.3	2.3
Wood, lumber, and cork	7.2	7.5	3.9	7.3	2.8	11.7	3.3	3.3
Textile fibers and waste	14.2	3.8	2.5	1.4	0.4	10.9	16.7	5.2
Minerals, ores, and metals	19.9	14.9	11.2	11.7	13.1	22.9	20.0	29.0
Metalliferous ores and metal scrap	15.8	10.8	6.5	5.7	6.6	5.0	10.6	17.9
Nonferrous metals	4.1	4.1	4.7	6.0	6.5	17.9	9.4	11.1
Fuels	22.9	50.4	60.0	36.5	52.5	2.2	22.8	36.9
Petroleum and petroleum products	19.2	42.8	45.2	24.9	35.7	0.8	20.3	34.2
	KOREA					INDIA		
	1964	1974	1984	1994	2004	1984	1994	2004
Primary products	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0
All food products	35.8	26.9	13.4	16.3	12.9	19.9	14.4	9.5
Meat and meat preparations	0.0	0.4	0.5	1.8	1.3	0.0	0.0	0.0
Dairy products and eggs	0.9	0.0	0.1	0.2	0.3	2.1	0.1	0.0
Fish and fish preparations	0.0	0.3	0.5	2.0	2.7	0.0	0.0	0.0
Cereals and cereal preparations	30.1	18.6	7.4	4.7	3.0	2.8	0.2	0.1
Sugar, sugar preparations, and honey	1.9	4.5	1.6	1.4	0.6	1.1	6.2	0.6
Coffee, tea, cocoa, spices, and manufactures	0.1	0.2	0.4	0.8	0.4	0.3	0.1	0.3
Fixed vegetable oils and fats	0.1	0.1	0.5	0.6	0.5	10.9	1.8	5.3
Agricultural raw materials	46.1	30.1	23.0	20.3	7.7	10.8	14.0	6.9
Oil seeds, oil nuts, and oil kernels	0.6	0.6	1.8	1.3	0.8	0.0	0.0	0.0
Crude rubber	2.9	2.3	1.9	1.7	0.9	1.0	1.0	0.9
Wood, lumber, and cork	9.1	10.4	4.6	4.5	1.2	0.1	1.8	1.8
Textile fibers and waste	26.2	9.4	7.0	3.8	1.0	2.7	5.3	1.6
Minerals, ores, and metals	4.0	11.0	10.1	17.1	18.1	6.9	14.6	9.3
Metalliferous ores and metal scrap	1.9	7.8	6.1	7.7	9.0	2.1	6.3	5.2
Nonferrous metals	2.1	3.2	4.0	9.4	9.1	4.8	8.4	4.2
Fuels	14.1	32.0	53.5	46.3	61.3	62.4	57.0	74.3
Petroleum and petroleum products	12.8	30.9	47.2	36.3	45.7	61.7	50.3	65.1

Source: *Commodity Trade Statistics Database*, downloaded 29 September 2006 (United Nations 2006).



Sources: *Commodity Trade Statistics Database*, downloaded 29 September 2006 (United Nations 2006); *International Financial Statistics Online Database*, downloaded 29 September 2006 (International Monetary Fund 2006a).

help sustain the strong demand for an extended period. Extrapolating from the experiences of Japan and Korea with limited commodity endowments suggests that if the PRC and India continue to grow quickly, this will result in enormous increases in their demand for energy, metals, other raw materials, and later food commodities that can only be met through imports.

TABLE 4
TOP 10 PRIMARY COMMODITY IMPORTS OF THE PEOPLE'S REPUBLIC OF CHINA

	1984	
	PERCENT OF PRC IMPORTS	PERCENT OF TOTAL WORLD IMPORTS
Cereals and cereal preparations	7.0	5.4
Nonferrous metals	4.4	2.7
Wood, lumber, and cork	2.9	3.9
Textile fibers, not manufactured, and waste	2.7	3.9
Metalliferous ores and metal scrap	1.2	1.2
Crude rubber including synthetic and reclaimed	1.2	4.1
Pulp and paper	1.1	2.5
Sugar, sugar preparations, and honey	1.0	3.3
Tobacco and tobacco manufactures	0.4	1.5
Feed stuff for animals excluding unmilled cereals	0.4	0.8
	2004	
	PERCENT OF PRC IMPORTS	PERCENT OF TOTAL WORLD IMPORTS
Petroleum and petroleum products	7.9	5.5
Metalliferous ores and metal scrap	4.1	21.9
Nonferrous metals	2.6	8.6
Oil seeds, oil nuts, and oil kernels	1.3	27.9
Textile fibers, not manufactured, and waste	1.2	23.6
Pulp and paper	0.9	19.3
Wood, lumber, and cork	0.8	8.7
Fixed vegetable oils and fats	0.7	13.6
Crude rubber including synthetic and reclaimed	0.5	15.4
Cereals and cereal preparations	0.4	3.4

Source: *Commodity Trade Statistics Database*, downloaded 7 August 2006 (United Nations 2006).

IV. LOOKING AHEAD: PROSPECTS OF GLOBAL COMMODITY MARKETS INTO 2015

Asia's growth prospect in conjunction with rapid industrialization represents fundamental changes in market dynamics for a broad range of primary commodities. Over the past half century, developing Asia has exerted an increasingly strong pull on global commodity markets. Industrialization, urbanization, and rising income levels have fed surging demand for primary commodities including energy, base metals, and soft commodities. In recent decades, the PRC has emerged as the world's leading importer of petroleum, metals, oil seeds, textile fibers, and pulp and paper. The PRC's imports of agricultural products, such as soy and meat products, have now also taken off as dietary patterns change and the scope for agricultural expansion is limited by constraints on land and water supply. Although India still lags behind the PRC in some way, it, too, has embarked on a process of far-reaching economic transformation. If India follows the pattern that has been seen in Japan, Korea, and now the PRC, it will lead a third wave of explosive growth in commodity demands emanating from developing Asia. This section examines the outlook for global commodity markets to 2015 using economic simulations based on a general equilibrium model (see Appendix for detailed information about this General Equilibrium Model for Asian Trade [GEMAT] model).

A. Baseline Scenario

The baseline scenario for global commodity markets and prices assumes that past trends in economic growth and technological developments will continue into the future. In particular, developing Asia is assumed to grow at the rate of the past decade (6.6%), and that the rest of the world moves along a lower trend of growth at 2.8%. It is also assumed that the policy environment remains largely unchanged. The details of the baseline scenario are reported in Table 5. Two alternatives (one in which circumstances conspire to soften commodity prices and another in which prices firm up) will be compared with this "business-as-usual" scenario. These experiments help to define a range within which the actual trajectory of commodity prices may lie. There are many other factors that can potentially influence commodity price trends and many ways in which developing Asia might have an impact on them. Here attention is focused on the impact of GDP growth through four main channels: (i) efficiency of energy and mineral ores use, (ii) reserves of global fossil fuels, (iii) productivity, and (iv) energy taxes and subsidies.

The interplay between demand and supply in global commodity markets is examined using GEMAT. This model captures links among different sectors of the global economy in terms of both quantities and prices, and traces their impacts through to commodity markets and prices. The appendix describes the model's main features. An appealing aspect of the model is that it permits quantitative analysis of the impacts of a variety of different policy and structural factors on commodity prices and trade.

In the baseline scenario, the global economy grows at 3.3% per annum over a 15-year period, which in calendar time starts in GEMAT's base year 2001, ending in 2015. Developing Asia⁴ grows at 6.6% over this interval and accounts for 27.2% of the expansion in global income. This economic growth creates additional demand for commodities, moderated somewhat by improvements in end-use efficiency and income elasticities of demand that are generally less than 1 in value.

⁴ Throughout the modeling analysis in this section, developing Asia includes only East Asia, Southeast Asia, and South Asia. Central Asia and the Pacific are excluded.

TABLE 5
BASELINE SCENARIO ASSUMPTIONS, 2001–2015

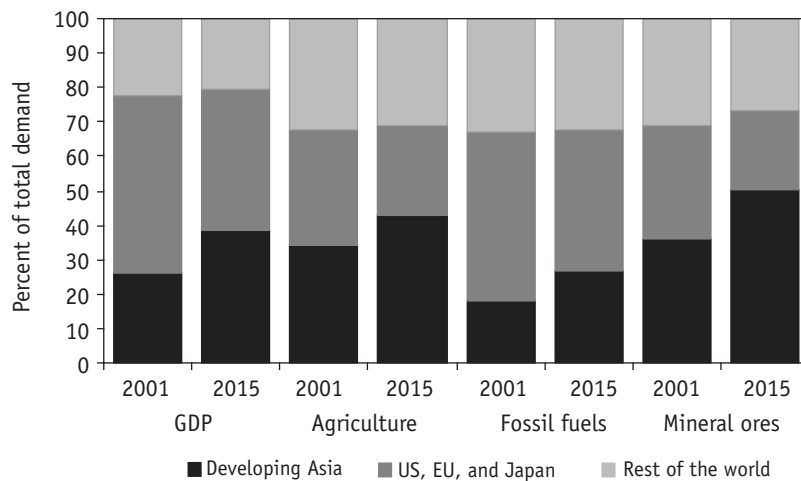
	ASSUMPTION
GDP and total factor productivity (TFP) growth	GDP growth of each region is exogenous, and region-specific nonagricultural TFP growth is endogenous to match the exogenous GDP growth. TFP growth is assumed to be identical across all non-agricultural sectors. Developing Asia is set to grow at 6.6% and the rest of the world at 2.8%.
Efficiency of energy and mineral ores use	Improvement of 1.25% a year, leading to a 19.0% higher energy and mineral ores use efficiency in 2015 relative to 2001.
Reserves of global fossil fuels	Determined by the speed of depletion, the size of unproven reserves, and the conversion rate from unproven to proven reserves. See Table A1 about the assumptions for reserves and conversion rates.
Productivity in agricultural and natural resources sectors	Grows by 1.02% per annum for the world average of crops and 0.72% for livestock, based on the projection by Hertel et al. (2006). There is no TFP growth in forestry, fishing and mining (including fossil fuels and mineral ores) sectors.
Energy taxes and subsidies	No changes.

Note: The assumed 1.25% improvement per year in energy efficiency lies in the high band of the range used in a number of other studies, but is smaller than the estimate for OECD in the period 1970–2000 (see Webster 2005).

Given its faster growth rate, developing Asia's share of global commodity demand rises. Figure 17 shows the increases in its demand shares for agriculture, fossil fuels, and mineral ores compared with those of three major economic regions (European Union [EU], Japan, US) and the rest of the world. Also shown in the figure are developing Asia's weights in the global economy in terms of PPP (which is held constant at the base year 2001 rate for 2015). Between 2001 and 2015, developing Asia's share in global income increases from 26.2% to 38.2%. More striking still is developing Asia's contribution to the expansion of global commodity demand. For agricultural commodities, developing Asia's share in global commodity demand rises from 34.4% to 43.0%; for fossil fuels from 18.1% to 26.9%; and for mineral ores from 36.0% to 50.1%. Over the 15-year period, the model estimates that developing Asia accounts for 61% of the growth in global commodity demand.

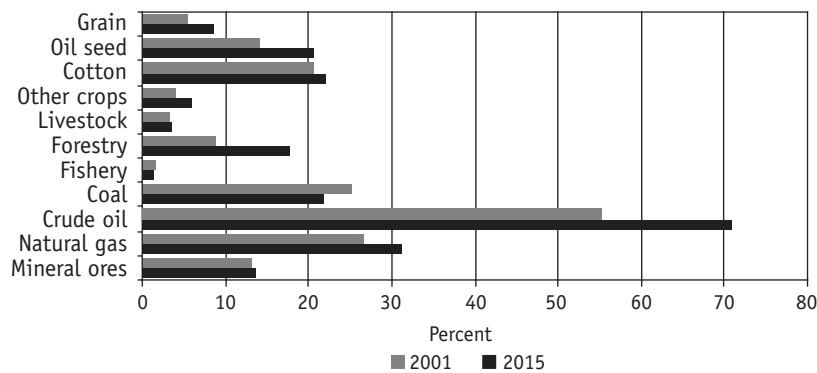
Developing Asia's rapid growth and rising commodity need also leads to its increasing reliance on external resources. Figure 18 illustrates changes in the import share of commodity demands over the 2001–2015 period. By 2015, more than 70% of developing Asia's (excluding the net oil exporters in Central Asia) oil needs will have to be met by imports. Faced with domestic and regional resource constraints, import shares in total demand for most other commodities are indeed projected to rise. The projected increases in the region's import dependence for agricultural and forestry products are associated with increasing losses of arable land and forestry to urban, industrial, and transport infrastructure. These projections highlight the trend of depleting resources and the environmental degradation driven by commodity-intensive economic activities, changing lifestyle with rising income levels in the region's major economies, and continuing high population growth.

FIGURE 17
ASIA'S IMPRINT ON GLOBAL COMMODITY DEMAND



Sources: ADB GEMAT model simulations, staff calculations.

FIGURE 18
DEVELOPING ASIA'S DEPENDENCE ON COMMODITY IMPORTS



Note: Including intraregional exports.

Sources: ADB GEMAT model simulations, staff calculations.

Table 6 (columns 2–3) summarizes model estimates of commodity price indexes in 2015. Table 7 (column 4) shows the implied price levels for energy products (in 2005 prices) according to the model estimates. The commodity price indexes are measured relative to a base of 100 in 2001 (or 2005). All price indexes are deflated by the world consumer price index (CPI), which is held constant throughout the simulation. It is important to understand that Tables 6 and 7 show estimates of equilibrium real commodity prices. These prices are derived to equate supply and demand in commodity markets, given the other prices that clear all the other markets. As such, they do not easily translate to the market prices quoted in commodity exchanges, which are heavily influenced by inventory gluts and shortages. Moreover, market prices are susceptible to macroeconomic fluctuations, weather conditions, political factors that may disrupt supplies, speculation, and price setting behavior by oligopolies (such as the Organization of Petroleum Exporting Countries). Thus, even over a period of several years, market prices may diverge significantly from these theoretical equilibrium levels.

TABLE 6
COMMODITY PRICES PROJECTION IN THE BASELINE SCENARIO

	PROJECTED PRICES IN 2015 (2001 =100)	PROJECTED PRICES IN 2015 (2005 =100)	ACTUAL PRICES IN 2005 (2001=100)
Grain	93.9	88.5	106.1
Oil seed	94.8	77.9	121.7
Cotton	94.4	94.7	99.7
Other crops	102.4	86.4	118.6
Livestock	93.9	88.0	106.7
Forestry	116.7	111.5	104.7
Fishery	127.3	126.4	100.7
Coal	123.2	92.9	132.5
Crude oil	153.3	80.6	190.2
Natural gas	107.1	73.4	145.9
Mineral ores	110.6	67.9	162.8

Note: All prices are real prices deflated by the world CPI.

Sources: ADB GEMAT model simulations; *World Economic Outlook Online Database*, downloaded 26 August 2006 (IMF 2006c); staff calculations.

TABLE 7
REAL ENERGY COMMODITY PRICES IN THE BASELINE SCENARIO (IN 2005 PRICES)

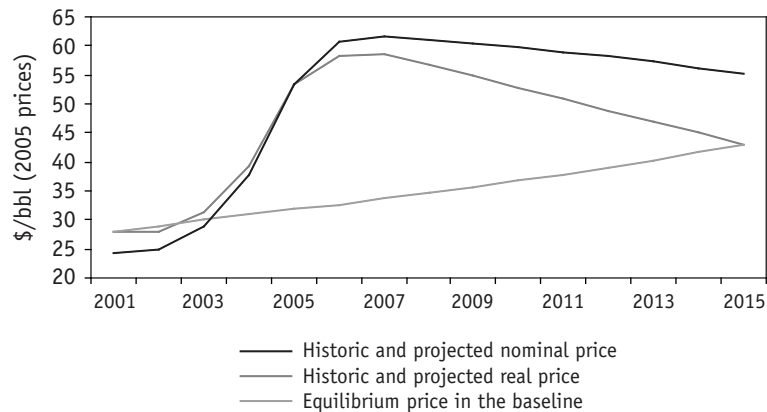
	2001 (ACTUAL)	2005 (ACTUAL)	2015 (PROJECTION)
Coal (\$/mt)	35.9	47.6	44.2
Crude oil (\$/barrel)	28.1	53.4	43.0
Natural gas (\$/mmbtu)	6.1	8.9	6.5

Sources: ADB GEMAT model simulations, *World Economic Outlook Online Database* (IMF 2006c), staff calculations.

A striking feature of the estimates is that they suggest a rising trend for (most) real commodity prices—notwithstanding assumed improvements in productivity and efficiency of resource use (see details in the next section). On average, there is assumed to be about a 19% improvement in energy and mineral ores use efficiency by 2015. Even some agricultural commodity prices, which historically have trended down, edge up. Limited endowments and low productivity growth cause the prices of fisheries and forestry commodities to rise sharply. The prices of “other crops”, including fruits, vegetables, and sugarcane and beet, increase marginally. Of course, not all prices rise. The price of livestock and most crop products trend down; due to fast productivity growth in the case of livestock and a particularly low income elasticity of demand in the case of crops. In mining sectors, global prices increase. Again, this is due to the presence of a tight resource constraint. The model predicts the strongest increase in real prices for crude oil.

Of particular interest are the model estimates for the price trajectory of crude oil. Figure 19 shows the trajectory over 2001–2015. The trend calculated by the model suggests that the real price of oil (measured in 2005 prices) rises by 53% from about \$28 per barrel to \$43 per barrel in 2015. This baseline forecast for the real price of oil in 2015 is in line with those of major energy forecasting agencies, which predict oil prices will settle into a range of \$35–50 per barrel (in 2004 prices) by 2015, barring critical supply disruptions (IEA 2005 and EIA 2006).

FIGURE 19
BASELINE EQUILIBRIUM PRICE TRAJECTORY
AND CONVERGENCE OF MARKET PRICE FOR CRUDE OIL



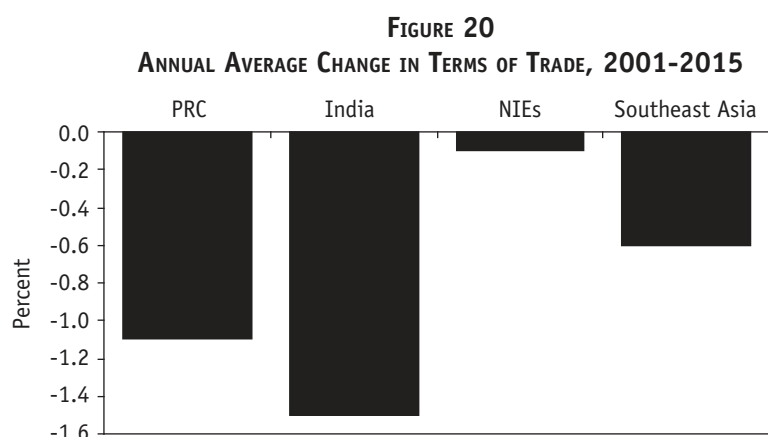
Sources: ADB GEMAT model simulations, staff calculations.

It is clear that the model estimates a gradual decline in the real price of crude oil by 2015 from current highs. The estimated real price of crude oil in 2015 is below the average price for 2005. If for the sake of argument, global CPI inflation is set at 2.5% (rather than 0% as assumed in the model calculations) over the period 2005–2015, this translates to \$55 per barrel by 2015 in current prices, which is still lower compared to the peak reached in 2006. If, in the long-run, oil prices are driven by fundamentals, these estimates suggest that the price of crude oil may be lower in real terms by 2015 than it is today. Nevertheless, crude oil would still be considerably more expensive than it was at the beginning of the millennium, or even a decade ago.

The baseline estimates suggest changes in terms of trade for developing Asia. At an aggregate regional level, developing Asia is a major exporter of agricultural and manufactured goods and a significant importer of energy and mineral commodities. Figure 20 summarizes model estimates of terms-of-trade changes for major countries and subregions of developing Asia. It is notable that the projected terms of trade slide significantly in the PRC and India. Their hunger for commodities and their tendency for manufacturing-industry-focused growth are likely to lower the prices of manufactured and industrial output relative to global commodity prices, particularly of energy and mineral ores.

B. Robustness Check

The baseline scenario makes a number of important assumptions that are subject to significant uncertainty. To gauge how robust the associated price estimates might be, two alternative scenarios are considered. Table 8 describes two alternative sets of assumptions that may be compared with



NIEs means newly industrialized economies, comprising Hong Kong, China; Republic of Korea; Singapore; and Taipei, China.

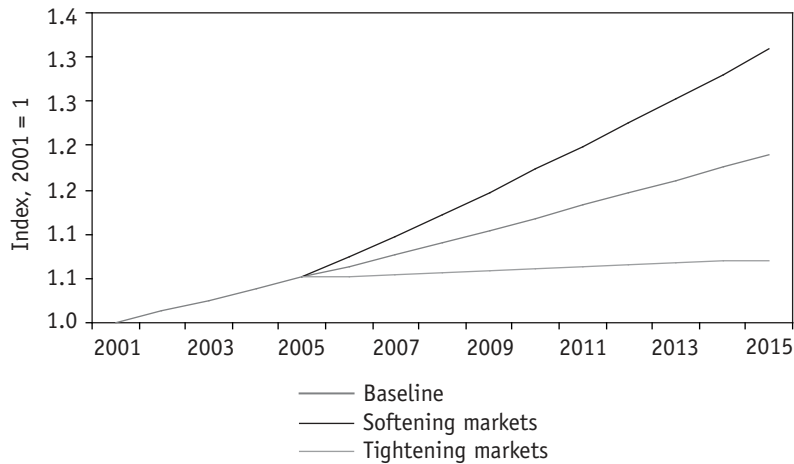
Sources: ADB GEMAT model simulations, staff calculations.

those of the baseline scenario in Table 5. One scenario imagines that factors conspire to strain commodity markets and press further price rises. The other scenario considers developments that would take the weight off of markets and allow commodity prices to soften. Figure 21 illustrates an example of changes in the efficiency of energy and mineral ores use under two alternative scenarios compared to the baseline assumption.

TABLE 8
SCENARIO ASSUMPTIONS

	MARKETS SOFTEN	MARKETS TIGHTEN
GDP and TFP growth	The TFP growth in each region is set at the baseline level and the rate of GDP growth of each region is now endogenous, so that it can adjust to a shock through following channels.	The TFP growth in each region is set at the baseline level and the rate of GDP growth of each region is now endogenous, so that it can adjust to a shock through following channels.
Efficiency of energy and mineral ores use	Faster growth in all regions, leading to a 30.9% improvement by 2015, or 10% higher than the baseline level in 2015.	Slower growth in all regions, leading to a 7.1% improvement by 2015, or 10% lower than the baseline level in 2015.
Reserves of global fossil fuels	10% higher than the baseline level in 2015 due to gradually enlarged unproven reserves.	10% lower than the baseline level in 2015 due to gradually reduced unproven reserves.
Agricultural productivity	Annual growth rate is set at 1 percentage point higher than that in the baseline for all regions, leading to 10% higher TFP in 2015 relative to that in the baseline.	Annual growth rate is set at 1 percentage point lower than that in the baseline for all regions, leading to 10% lower TFP in 2015 relative to that in the baseline.
Energy taxes	Increase the energy tax rates to one third of the EU levels for countries/regions whose energy tax rates are lower than that.	No changes.

FIGURE 21
ASSUMED ENERGY AND MINERAL ORES USE EFFICIENCY IN
THE BASELINE AND ALTERNATIVE SCENARIOS



Sources: ADB GEMAT model simulations, staff calculations.

The overall impact of these alternative scenarios on real commodity prices in 2015 is reported in Table 9 (columns 3 for the softening scenario and 8 for the tightening scenario). The other columns show the contribution of each factor in alternative scenarios to the price change, measured in percentage change from baseline differences. Under the scenario where commodity market pressures ease, a reduction in real commodity prices relative to the baseline ranges from 4.7% in mineral ores to 23.6% in crude oil. In general, changes in sector-specific supply conditions result in bigger impacts on prices. A 10% increase in agricultural productivity leads to a roughly equivalent percentage reduction in world prices of agricultural commodities. Improvements in energy reserves also bring about a significant reduction in the prices of energy commodities. It has to be noted, however, that the addition of new reserves in the model simulation is assumed to be of the same quality as old reserves. As the new reserves tend to have higher marginal costs for exploration and production in practice, estimated results may overestimate the price decline.

Table 10 reports energy commodity prices in both softening and tightening scenarios relative to the baseline. For example, the price of oil (in constant 2005 prices) could reach \$46.5 per barrel by 2015 in more stringent market conditions. With an assumed global inflation rate of 2.5% per annum, this implies a market price of \$59.5 per barrel in current (2015) market prices. Given the heightened concerns over future oil supply, it is of particular interest to see how effectively policy and energy efficiency improvements could curb energy demand and prices. To this end, the results show that the removal of energy subsidies and the imposition of energy taxes equivalent to one third of EU rates (EU has very high consumption tax for petroleum products, ranging from around 200% for industrial use to 400% for household consumption) worldwide would bring down the price of oil by as much as 21.4%. Perhaps surprisingly though, the impact of improved energy efficiency on crude oil prices is rather modest. This is because the improved energy efficiency positively affects the overall economic activity and increases oil demand, which partly offsets a reduction coming from energy savings.

TABLE 9
COMMODITY PRICES UNDER THE "SOFTENING" AND "TIGHTENING" SCENARIOS, 2015

	BASELINE	SOFTENING	SOFTENING				TIGHTENING	TIGHTENING		
			HIGHER ENERGY EFFICIENCY	HIGHER ENERGY RESERVES	HIGHER AGRICULTURAL TFP GROWTH	ENERGY TAX		LOWER ENERGY EFFICIENCY	LOWER ENERGY RESERVES	LOWER AGRICULTURAL TFP GROWTH
			(% CHANGE FROM BASELINE)					(2001=100)	(% CHANGE FROM BASELINE)	
Grain	93.9	83.0	-0.2	0.0	-10.8	-0.6	107.2	0.3	-0.1	13.9
Oil seed	94.8	84.8	-0.1	0.0	-10.3	-0.2	107.1	0.3	0.0	13.9
Cotton	94.4	83.7	-0.4	-0.1	-9.8	-1.3	106.5	0.2	0.0	12.9
Other crops	102.4	90.9	0.1	0.0	-10.7	-0.7	116.1	0.5	0.1	12.2
Livestock	93.9	82.7	-0.1	0.0	-11.3	-0.6	107.6	-0.1	-0.1	13.6
Coal	123.2	111.4	-2.7	-2.3	0.8	-3.9	132.7	3.2	5.3	-1.0
Crude oil	153.3	117.1	-1.8	-3.1	0.9	-21.4	165.5	2.0	7.3	-1.2
Natural gas	107.1	97.2	-1.9	-2.2	1.0	-5.1	113.7	2.2	5.3	-1.3
Mineral ores	110.6	105.4	-4.6	0.0	0.7	-0.8	116.4	6.2	0.0	-0.9

Sources: ADB GEMAT model simulations, staff calculations.

TABLE 10
ENERGY COMMODITY PRICES IN THE BASELINE, "SOFTENING", AND "TIGHTENING" SCENARIOS, 2015 (IN 2005 PRICES)

	BASELINE	SOFTENING	TIGHTENING
Coal (\$/mt)	44.2	40.0	47.6
Crude oil (\$/barrel)	43.0	32.9	46.5
Natural gas (\$/mmbtu)	6.5	5.9	6.9

Sources: ADB GEMAT model simulations, staff calculations.

V. CONCLUSIONS

Strong growth in Asian demand has already been a major contributor to growth of world demand for fuels and industrial inputs and signals a long-term structural shift on the demand side for other soft agricultural commodities. The patterns of economic development have been also deeply intertwined with the increasing use of resources, which is driven by commodity-intensive industrialization and urbanization typically in the early stage of development. Per unit output of GDP, the consumption of energy and mineral ores is growing at an alarming pace. For countries in developing Asia that seek supply outside their borders as their commodity needs increasingly

exceed domestic production capacity, changing dynamics in global commodity prices have important implications for their economic management and policies.

The positive development in demand will affect generally all commodity groups going forward. By 2015, developing Asia's commodity demand will reach 43% of world demand for agricultural commodities, 27% of world energy demand, and 50% of world demand for mineral ores. So far, the impact of rapid growth in the PRC and India has been most pronounced in the energy and metals sectors, reflecting the growing intensity of their use in the process of industrialization. Fast demand growth in the past several years has also created strains on current production capacity in the energy and metal sectors. Over the medium term as capacity constraints soften, both energy and metal prices are expected to drift lower from current highs. However, they are unlikely to revert to lower historical averages. Given the long-term nature of necessary investment and infrastructure let alone other noneconomic hurdles, crude oil prices will likely be sustained at much higher levels than the earlier average. Along with higher oil prices to exert upward pressures on production costs, other discernible structural factors, such as changes in market structure, regulatory environment, and financial deepening, will also help support metal prices at higher than historic averages. Agricultural food commodities have entertained comparatively less price booms in the past years. However, rapid income growth is expected to bring about changes in dietary patterns, and when coupled with dense population it will affect the demand for agricultural food commodities drastically in the years ahead.

However, these global trends are certainly not preordained. Prospects for commodity prices may also be influenced by conscious policy choices. In view of these resource-intensive patterns of growth in developing Asia and potential strains on natural resources and the environment, some policy issues warrant serious consideration.

First, it is clear that the provision of adequate energy in a secure and environmentally friendly manner is essential to sustain growth and development in developing Asia. The relatively poor distribution of oil reserves and production capacity among the economies of developing Asia has left the region highly dependent on oil imports and thus exceptionally vulnerable to high global oil prices. However, its energy-intensive development pattern continues to drive energy consumption growth faster than other parts of the world, and to some extent, policy management has neglected the significance of potential problems for the sake of short-term growth prospects. For example, the results presented here show that aligning domestic energy prices to the global level and internalizing its environmental costs through taxes could effectively curb consumption and bring down prices. To cope with the region's energy situation, policy measures will also have to focus on improving energy efficiency and conservation, promoting cleaner and more efficient technology, and diversifying energy sources including renewable energy.

Second, the resource-intensive growth pattern of developing Asia has created severe environmental problems, including land degradation and desertification, deforestation, water shortage, deteriorating water and air quality, and vulnerability to natural disasters. Without appropriate measures to guide the development process, such growth pattern will prove unsustainable over the long term. In terms of establishing an appropriate regulatory and institutional framework in support of sustainable development, there is considerable room for synergy between energy and environment policies. An integrated approach to promoting efficient management of natural resources can be complemented by the adoption of regionwide strategies to ensure the extension of national policies for shared natural resources and to protect the region's biodiversity and ecosystems.

Third, developing Asia's growing demand for agricultural food commodities presents a significant challenge to the achievement of the Millennium Development Goals. Even today, many millions of Asians are malnourished, while pressures on food supply are increasing with a growing population and shrinking arable land resources. With declining agricultural resources and their quality, pollution and climate change also remain a significant threat to future food supply. The outlook for adequate food supply depends critically on continued agricultural productivity growth. The impact of faltering productivity due to depleting resources and deteriorating environment tends to be felt more significantly in the less fortunate economies and the poor that are often bypassed by the growth process. Hence, it is important to continue to support necessary agricultural research and development for future productivity gains. The prospect of dwindling self-sufficiency in food supply also suggests that developing Asia has an interest in pursuing further liberalization in agricultural trade. Availability of food is still less of a problem than accessibility to food, as an open trade system with a broad spectrum of potential suppliers would help reduce the risk of insufficient food availability.

APPENDIX

GEMAT: A GLOBAL GENERAL EQUILIBRIUM MODEL

The General Equilibrium Model for Asian Trade (GEMAT) is an applied general equilibrium model of the global economy, focusing on Asia. It has strong micro foundations and captures detailed interactions among industries, consumers, and governments across the global economy. GEMAT is ideally suited for the analysis of structural changes over periods that are sufficiently long to allow markets to adjust and rigidities to work themselves out.

In GEMAT, producers in each industry are assumed to maximize profits and a representative household in each country or region maximizes their utility. In each (annual) period, relative prices equate demand for and supply of all goods and factors of production—given resource endowments, technology, taste, substitution parameters, and taxes and subsidies. Mobile factors of production are allocated in a way that promotes equalization of factor prices across sectors. Labor is immobile across countries as is capital, once invested. For fixed foreign saving, external balance is assured by adjustment of the real exchange rate. Finally, domestic investment is determined by the availability of domestic and foreign saving. GEMAT models only the “real” economy and does not explain nominal variables such as inflation. The numeraire is the global consumer price index, which is assumed to be constant. Letting it grow simply scales all nominal variables equi-proportionately, and leaves real variables unchanged.

Based on the latest Global Trade Analysis Project (GTAP) database (version 6.2), GEMAT provides a detailed disaggregation of commodities. In the model, the supply of each commodity percolates up from producers’ decisions on profit-maximizing levels of output. Demand is an amalgam of producers’ and consumers’ decisions, at home and abroad, on optimal levels of demand for intermediate, capital, and consumption goods. For those commodities that exploit resources, resource supplies enter the production function as a primary factor. GEMAT features a resources’ depletion module for coal, crude oil, and natural gas to capture the long-term dynamics of energy resource supply, following the GREEN model of the OECD (Lee et al. 1994). The supply of energy resources over time is determined by the initial proven and unproven reserves, conversion rates from unproven to proven reserves, and the production path of the three fuels. The assumption about reserves and conversion rates are presented in Table A1. The production of energy from reserves is price-responsive, as higher prices encourage investment in retrieving higher cost (usually less accessible) sources of supply. In GEMAT, there are differentiated production structures for agriculture, primary energy, oil refining, electricity, and other industry and services sectors. This follows the treatment in the Massachusetts Institute of Technology Emissions Prediction and Policy Analysis (EPPA) model (Paltsev et al. 2005).

TABLE A1
ASSUMPTIONS ON ENERGY RESERVES TO ANNUAL PRODUCTION RATIOS IN 2001

	PROVEN RESERVES			UNPROVEN RESERVES		CONVERSION RATE (%)	
	OIL	GAS	COAL	OIL	GAS	OIL	GAS
PRC	15.4	69.1	66.5	43.4	27.0	2.5	4.5
Japan	9.2	6.7	326.7	15.9	6.7	2.5	3.5
NIEs	6.9	20.0	61.0	26.9	20.0	2.0	2.5
Indonesia	10.4	36.3	37.0	40.4	30.0	2.0	3.0
Malaysia	13.9	41.4	40.0	46.9	33.0	2.0	3.0
Philippines	12.0	30.0	40.0	36.0	24.0	2.0	3.0
Thailand	5.3	16.5	64.0	18.5	13.2	2.0	3.0
Viet Nam	21.8	45.6	30.0	48.8	27.0	2.0	3.0
India	20.1	38.3	259.7	35.1	22.0	3.5	3.0
Rest of Asia	9.2	49.1	79.3	58.3	49.1	2.0	3.0
USA	9.4	10.2	225.4	49.4	24.9	2.2	2.0
Latin America	31.3	45.9	227.2	74.3	43.0	1.3	3.5
Australia and New Zealand	15.8	63.8	207.0	73.2	62.6	2.0	3.0
Europe	6.2	19.1	110.0	30.5	22.3	2.0	1.5
Africa	35.1	100.1	185.3	88.6	63.4	2.0	4.0
Rest of world	70.4	108.4	447.1	102.6	73.8	1.0	2.0
World total	45.0	67.0	180.0	76.6	51.2		

Note: Conversion rate refers to the fraction of unproven reserves (yet-to-find reserves) that can be converted into proven every year. NIEs means newly industrialized economies, comprising Hong Kong, China; Republic of Korea; Singapore; and Taipei, China.

Sources: Proven reserves are estimates based on BP (2006); unproven reserves are estimates based on IEA (2005) and Paltsev et al. (2005).

GEMAT solves recursively from its base year, 2001, to 2015. The model captures long-term equilibrium tendencies in product and factor markets, abstracting from short-term adjustment and fluctuations. The version of GEMAT used in this section aggregates the world economy into 16 regions (including 10 Asian countries/regions), shown in Table A2; 28 economic sectors; and four primary factors (capital, labor, land, and other natural resources).

TABLE A2
REGIONAL DISAGGREGATION IN GEMAT

DEVELOPING ASIA COUNTRIES/REGIONS	NONDEVELOPING ASIA COUNTRIES/REGIONS
China, People's Republic of	US
NIEs	Japan
Indonesia	Australia and New Zealand
Malaysia	Europe
Philippines	Africa
Thailand	Latin America
Viet Nam	Rest of world
India	
Rest of Asia	

Note: NIEs means newly industrialized economies, comprising Hong Kong, China; Republic of Korea; Singapore; and Taipei, China. Rest of Asia comprises Afghanistan; Bangladesh; Bhutan; Brunei Darussalam; Cambodia; Democratic People's Republic of Korea; Lao People's Democratic Republic; Macao, China; Maldives; Mongolia; Myanmar; Nepal; Pakistan; Sri Lanka; and Timor-Leste. Central Asia and the Pacific are not included in the global economy or in developing Asia.

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