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# The contemporary China resources boom\*

Ross Garnaut<sup>†</sup>

Commodity prices are formed by the interaction of global economic growth and costs of expanding supply of commodities. They tend to be high for long periods when global average growth rates are high, and low for long periods when growth rates are low, and to fluctuate around these averages as short term demand departs from expectations. The growth of advanced developing countries is especially influential in determining global demand for resources. Exceptional growth and resource intensity of China have been the main determinants of high energy and metals prices since about 2003. Short term cyclical factors have pushed energy and metal prices higher still, because markets did not anticipate the strength of Chinese demand and supply takes time to catch up. The high resource intensity of Chinese growth has been the result of high investment rates and rapid increases in urban population and the export share of production. Strong growth is likely to continue although at slowly receding rates, but growth will become less resource intensive, leading to moderation of global commodity prices. Strong growth in China and the world are at risk if effective policies are not adopted to break the nexus between economic growth and pressure on the environment.

**Key words:** Chinese economy, commodity prices, resource economics.

Australia is currently experiencing a resources boom of historical dimensions. Its immediate cause is sustained rapid resource-intensive growth in China. Australia's terms of trade have reached heights unknown on a sustained basis in the historical record. Australian exports are now (although in the 21st century decreasingly) more diversified away from commodities than they were through most of its history, so relative prices of commodities had to move higher than in earlier times to take overall terms of trade above peak levels in the late nineteenth and most of the 20th century.

After several years in which investment in expanding supply capacity lagged behind the lift in prices, the rates of growth of investment in the resources sector have been rising strongly since about 2005. Since the Global Financial Crisis of 2008, resources have been overwhelmingly the main contributor to exceptional growth in Australian business investment in general. Minerals

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and energy production and investment together are now larger relative to other sectors in the Australian economy than at any time since Federation.

The rising and eventually exceptionally high terms of trade kept Australian incomes and public revenue growth well above the rate of expansion of production for several years from 2003 to 2008. Commodity prices receded temporarily with the Global Financial Crisis. Since then, the growth of public revenues has been moderated by the effects of the exceptionally large capital expenditure in resources on deductions against income and resource rent taxes.

The rising terms of trade from 2003 allowed Australia to avoid what would have been a painful and probably recessionary end to a virulent early 21st century housing and consumption boom. The high rates of business investment in the resources sector have been a major factor in the strong economic growth performance of Australia relative to other developed countries in the aftermath of the Global Financial Crisis.

The resources boom has shifted the centre of gravity of national economic growth decisively to western and northern regions. This has challenged long-standing assumptions of Federal fiscal relations, which had been calibrated to redistribute public revenues from Victoria and New South Wales to the smaller states and the two territories.

The resources boom is global and not only national and so is changing fundamentally the environment for Australian international relations. Amongst our immediate neighbours, in Papua New Guinea, the China boom has provided the foundations from which the public finances have been rebuilt, economic stability restored and strong economic growth established after a decade of stagnation. Growth has been assisted in several Southeast Asian economies – although for a while less powerfully than might have been expected in Indonesia, as it grappled with the implications of the political decentralisation that accompanied the transition to democratic government at the beginning of the new century. Economic growth has been enhanced in Brazil, Chile and other resource-rich economies in Latin America (although not Mexico), which emerged from periods of difficulty in the 1990s into better economic times. Chinese investment and demand is incubating new projects and industries through many countries in Central Asia, the Middle East, Latin America and Africa. In Africa, a buoyant resources sector has been one element of a marked lift in economic growth trajectories in the early 21st century in all countries that are not experiencing high levels of political disorder. The boost from the new international resources environment has supported Russian economic performance and self-confidence, with implications running through domestic and international political arrangements. It has expanded the economic power of oil exporting countries in the Middle East.

For all of these reasons of national economic change and international relations, it is of great importance to Australian national policy to understand the origins and dynamics of the resources boom, its future dimensions, and its likely longevity and stability.

This paper focuses on the central cause of these changes rather than the wide-ranging implications. It begins with analysis of the economics of price determination in the resources sector. It examines the recent increases in prices for energy and metals and their origins in exceptional growth in Chinese demand. It shows that without China's contribution, there may have been no growth in demand for many mineral resource products in the second half of the first decade of the 21st century. The paper examines the sources of especially strong growth of Chinese demand for resources. It discusses the prospects for continued growth and structural change in China, and how this will interact with wider developments in global supply and demand for resources to determine the longevity of the current Australian and global resources boom. In assessing possible future developments, the paper illustrates some possibilities from the experience of rapid economic growth in other Northeast Asian countries at earlier times, while noting differences between economies. It also analyses the implications for resources demand and prices of prospective structural change as China moves through the 'turning point' in economic development in which labour becomes relatively scarce and expensive (Lewis 1954; Ranis and Fei 1961, 1963; Minami 1973).

### **1. The economics of resource price determination**

The natural resources that are used in the production of the energy and metals that are essential to economic development are not scarce in any absolute sense. All of the industrial metals are abundant in nature, to an extent that is unlikely to be challenged by human demands. And while the growth of demand will test the limits of some particular sources of energy – notably petroleum occurring naturally in liquid form – the total potential supply of natural energy sources that are available for human use exceeds any conceivable requirements.

All of the important economic questions about natural resource 'limits to growth' are about the costs of converting naturally occurring metallic minerals and the various sources of energy into forms that are suitable for supporting economic development and the costs of transporting them to the places of human demand, or else relate to the external environmental costs of resource use.

The environmental costs are especially high for fossil fuels, because of the potential for greenhouse gas emissions to destabilise the climatic conditions in which human civilisation has developed. The environmental limits to the rational use of fossil fuels will be reached long before the absolute or even economic availability of the natural resources comes into question. Indeed, growth outcomes for China near those that this paper judges to be most likely, accompanied by reasonable rates of growth in other large developing economies in which it has accelerated over the past decade, in the absence of effective international policy response, would put the continued growth of humanity's material standards of living at risk from climate change. If this

reality leads to effective constraints on expansion in the use of fossil fuels, the demands on other energy sources will increase. Supply of energy from some combination of other sources could be expanded beyond practical limit at some cost. This was the subject of extensive analysis in the Garnaut Climate Change Review (Garnaut 2008, 2011a. See also Cline 1992; IPCC 2007a,b,c; Nordhaus 2007, 2008; Stern 2007).

The economically valuable minerals that are available abundantly in nature are found at varying concentrations and in different chemical associations with other elements that affect the cost of extraction, concentration and purification. They are available in nature at varying depths below the earth's surface and separated by varying distances and natural barriers from the locations in which they are in demand for economic activity (see Garnaut and Clunies Ross 1983, Chapter 2 for discussion of the economics of resources price determination).

The costs of supplying minerals to the places where there is demand for them have several elements. One is the cost of discovery and definition of the ore bodies that have the high concentrations of the economically valuable element, and other characteristics, that make them economically suitable for use. A second is the capital cost of building the mine and the processing facilities to convert the natural mineral into an economically valuable form. The third is the recurrent cost of producing and processing the mineral from an established mine. The fourth is the cost of transporting the product of mining to the place where it is to be used.

In the early stages of modern economic activity, mines were mainly located close to the main centres of industrial production – first of all in the North Atlantic. In these early stages, mining was confined to ore bodies with high concentrations of the economically valuable mineral, close to the surface of the earth, in chemical forms from which they could be extracted at low cost with technology that was available in the early industrial world. The expansion of global industrial activity led to the extension of the locations of mining beyond the main industrial centres, to the mining of minerals with lower concentrations of metals and to technological innovation that increased the range of chemical compounds that had economic value as a source of metals or energy.

There are high capital costs in exploration and mine development. The supply price of investment is higher in some locations than in others. Today, the supply price of investment is typically much higher in developing countries with poor legal and political institutions and in which international investors have less confidence in the stability of property rights, contracts, the fiscal regime and the political order more generally.

It is typically much cheaper to expand the production of valuable minerals from an established mine than to create new capacity to mine a similar ore body. It is obviously much cheaper to supply minerals from an ore body close to an established centre of industrial activity and joined to it by an established transport infrastructure. Transport economics plays a much larger role in the

supply of commodities with low value relative to volume or weight (iron ore, bauxite), than to commodities with high value to weight (gold).

These characteristics of the economics of the global minerals industries might be expected to lead to steadily increasing mineral prices with the expansion of global demand. Depletion of the best-located and highest quality ore bodies would require the mining of higher-cost and more distant mines, located in countries where the supply price of investment is higher. The more global economic activity expanded, the faster the rate of increase in global mineral prices. Within this framework, more rapid modern economic growth in major countries – Japan in the third quarter of the 20th century and China in the late twentieth and more influentially the early 21st centuries – would lead to acceleration in the rate of increase in global commodity prices.

The natural tendency for resources prices to rise over time is reinforced by another characteristic of the natural resource industries: known resources are depleted over time, and economically optimal rates of depletion would cause the value of resources in the ground to rise over time at the interest rate (Hotelling 1931; Garnaut and Clunies Ross 1983).

The tendency for global resources prices to rise with the expansion of the global economy and over time was obscured through much of the 20th century by a tendency for technological and institutional change affecting the cost of supplying mineral commodities to proceed more rapidly than productivity-raising change in the total economy. Political change has expanded the number of countries from which minerals can be drawn into world markets and lowered the supply price of investment to many countries. The decentralisation of global economic activity away from the North Atlantic, especially to East Asia, has reduced the remoteness of many ore bodies, notably in Asia and the Pacific, including Australia. Innovations in transport technology have reduced the costs of supplying minerals from remote locations. Developments in technology have reduced the costs of discovering new ore bodies and facilitated the identification of potential mines that are so deep or otherwise obscured to humans that their presence had hitherto gone undetected. New processing techniques have allowed the extraction of minerals from chemical compounds that once had no economic value. New construction technology has reduced the capital cost of establishing new mines. And innovations in mining methods and equipment have reduced the recurrent costs of mining.

The history of technological innovation in economic development tells us that necessity is the mother of invention, so looming scarcity and rising prices of minerals could be expected to support high rates of innovation (Griliches 1984). But the links between rising resources prices, the profitability of investment in commercialisation of new technologies and the rate of technological improvement provide no reason why technological change should have proceeded so much more rapidly in mining than in other industries that the price of minerals relative to other goods and services would actually have fallen over much of the 20th century. And yet the real price of many minerals and



energy products did fall for considerable periods – a fact that, pending explanation, we should put down to specific and not general causes. There are no economic reasons to expect falling real prices of commodities to be a permanent feature of global economic development. The 20th century tendency for commodity prices to fall with global economic expansion and over time appears to have been reversed in the early 21st century.

Minerals and energy prices over long periods have been characterised by wide cyclical fluctuations. This derives from the long lead times in the generation of production from investment in exploration and mine development and from uncertainty about future demand at times when exploration and mine development decisions are taken. Once the investment has been committed, the owner of a mine has an economic interest in continuing production from it so long as the price of the product covers recurrent costs, even if it makes little contribution to recoupment of the cost of capital expenditure on exploration and mine development. Production levels are, therefore, maintained even if demand growth is unexpectedly low – as a result of recession or political dislocation, or a change in growth trajectory, in major economies. This can keep prices at levels well below the total cost of production for long periods, while global demand catches up with earlier expectations and investment in new capacity is discouraged. On the other hand, if major economies grow at an unexpectedly rapid rate, prices can remain well above the total cost of production for the long period that is required to find and to develop a sufficient number of sufficiently large new mines.

So, we can characterise the behaviour of resources prices over time in the following manner. There is a tendency for mineral prices to rise over time and with global economic growth, as a result of requirements to bring lower quality and more poorly located ore bodies into production, and to reflect the cost of tying up capital in an undeveloped mineral resource. This tendency is stronger the more rapid is global expansion of economic activity. It is offset to some extent by institutional and technological innovation, which proceeds more rapidly at some times than others. One might expect more rapid institutional and technological improvement in mining than other industries simply because, in its absence, the real prices of mineral products would be rising, thus increasing the incentive to innovate. But there is no reason why the technological improvement should proceed so much more rapidly in mining than in other industries that real prices of mineral products actually fall. Indeed, notwithstanding 20th century experience, one should be surprised to find that the prices of resources-intensive products have fallen in real terms over long periods of economic growth.

Around these determinants of long-term tendencies in real prices of mineral products, there are wide and sometimes long-lasting cycles in prices, resulting from market participants' failure to anticipate correctly the growth in global demand.

The effects of growth and fluctuations in demand interact with supply conditions to determine global prices. Some resources are characterised by greater

natural abundance than others. The naturally abundant are likely to see expansion of supply occurring relatively quickly, so that prices do not go up so far nor stay up so long in response to unexpectedly strong growth in demand.

Here, the outstanding contrast has been between many minerals and energy commodities, which require large and protracted investments, and agricultural commodities, where supply can usually be expanded with much shorter lead times.

Petroleum (and its close substitutes) stood out in the 1950s and 1960s for the ease and low cost at which supply could be expanded on the back of immense reserves in the Middle East. Petroleum stands out again in recent times, but for the limited availability of natural deposits that can be brought into production at costs comparable to historical prices.

Supply capacity for some resource-based products can be expanded more easily and quickly and at lower cost than for others. Prices will not go up so far nor stay high for so long when the investment required to increase the supply of a resource product yields early returns.

There is an important feedback from price to demand for commodities. The strength of the feedback depends on opportunities for substitution in use. The many natural sources of energy and the many metallic minerals are substitutes in demand for each other and for non-mineral products. Substitution in use introduces powerful corrective forces if the real price of one product rises or falls a great deal.

The easy supply response to increased demand for petroleum in the 1950s and 1960s allowed growth in demand to continue strongly. When supply conditions tightened in the 1970s, and prices rose and remained high, demand growth decelerated sharply in response. The higher petroleum prices at this time spurred high levels of investment in thermal coal capacity for international trade for the first time. Since that time, the prices of petroleum and thermal coal have been closely linked.

## **2. The resource prices and global growth in historical perspective**

The expansion of the modern global economy has been marked by short-term fluctuations in activity, which is the major cause of large cyclical variations in commodity prices. It has also been subject to periodic changes in pace, faster for an extended period and then slower. The extended periods of faster growth have caused commodity prices to be relatively high over considerable stretches of time as large-scale investments have been made to increase supply capacity. The periods of slower growth have seen tendencies to excess supply of commodities, as demand could be met from established capacity, and production has been maintained in these facilities even if prices have provided what would have been seen in advance as an inadequate return for investment in exploration or new mine development.

Looking back to the beginning of the 20th century, we can discern three extended periods of stronger growth (we are now in the third) and two of



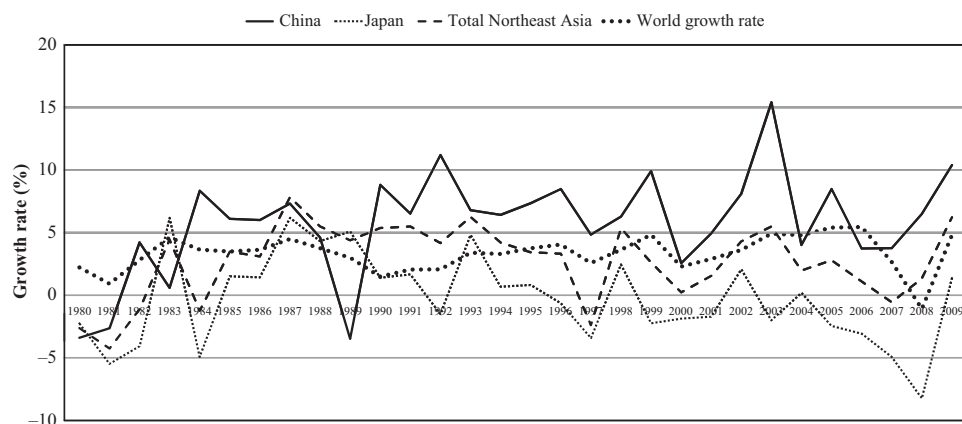
weaker growth. The first stronger period, up to the First World War, was characterised by especially strong expansion in the United States and Germany, as they moved towards the frontier of global industrial productivity established by the United Kingdom. This was followed by a long period of tepid growth, which saw uneven recovery from war in Europe, and then the Great Depression. A long period of strong global economic expansion after the Second World War encompassed European and Japanese reconstruction and then the rapid movement of Japan to the world's productivity frontiers. This was the 'Golden Age' of the 1960s and 1970s, which ended in inflationary boom and bust, with the inflexion point marked by the large oil price increases of 1973.

The last quarter of the 20th century saw slower growth, although a foundation was laid for the acceleration of global development in the early 21st century. The foundation for stronger growth was laid when modern economic growth at sustained high rates was established for the first time in the populous countries of Asia – China from the late 1970s, Indonesia from the mid-1980s and India from the early 1990s. When it came, the stronger growth of the new century was centred in the large developing countries but extended well beyond them.

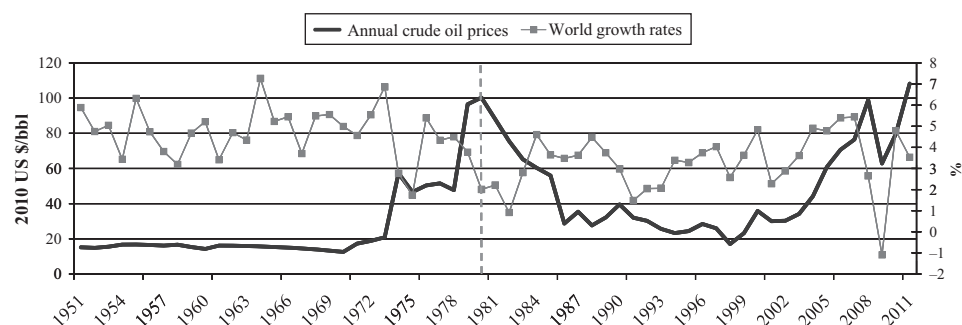
I have called the period of strong sustained growth that commenced in the early 21st century the 'Platinum Age', as it provided rapid increases in living standards to more low-income people than ever before in the history of humanity (Garnaut with Llewellyn-Smith 2009, Chapter 1). Because Platinum Age growth is concentrated in the developing countries, it is more resource intensive than it would have been if it had been spread more evenly through the global economy. Since the Global Financial Crisis, economic expansion in the old developed countries of Europe, the United States and Japan has moved onto a decisively lower trajectory (Garnaut with Llewellyn-Smith 2009, Chapter 11), but developing economy strength has continued to underpin reasonably strong expansion of global output and demand for energy and metal commodities.

Figure 1 presents data on global and Northeast Asian demand for petroleum over the past three decades. It shows that global demand growth is highly sensitive to price. The Golden Age, ending in 1973, was characterised by rapid growth in global energy demand, commonly around 8 per cent per annum, and well in excess of world economic growth. Growth in Japanese energy demand itself commonly contributed about one quarter of growth in global demand. This happened to be a period of stable oil prices in real terms (Figure 2), which ended with the 'oil shock' of 1973. Over the two decades to 1973, global supply was able to keep pace with rapid increases in demand as new discoveries were made in the Middle East and as major United States and British oil companies turned themselves into effective multinational corporations.

The much higher energy prices from 1973 to 1986 (gradually extending from oil to energy in all its forms) greatly reduced growth in consumption.



**Figure 1** Growth rates of demand for petroleum: Northeast Asia and the world (1980–2010). Source: Calculated using consumption data from US Department of Energy, World Growth Rate data from IMF World Economic Outlook September 2011.



**Figure 2** Annual crude oil prices (real). Source: Crude oil prices from IMF International Financial Statistics; Growth rates from Maddison, A. *The World Economy* OECD 2001 (1950–1980) and IMF World Economic September 2011 Outlook 2011 (1980–2010).

World energy use fell from 1979 to 1983 – at first as the United States and some other major economies went into recession, but still as global economic activity recovered. Northeast Asian now moved more or less in line with global demand – after the deceleration of Japanese growth, and at a time of deliberate and effective phasing out of energy-intensive industries and processes in Japan, and before Korea and China were large enough to make a mark on the global economy. From 1987, rapid expansion in the Korean and Chinese economies began to contribute a large proportion of the growth in global demand for energy, but at a time when demand growth in the rest of the world was weak.

China only became large enough for strong growth in its demand to be associated with tightness in global commodity markets in the early 21st century. After recovery from the ‘tech wreck’ recession over the millennium, strong growth in consumption re-emerged in the rest of the world – encour-

aged by historically low prices in the immediate aftermath of the East Asian financial crisis.

The large developing countries, above all China, contributed most of the considerable expansion that continued after the developed world moved onto a lower growth trajectory with the Great Crash. Between 2005 and 2010, China alone was responsible for most of the growth in consumption of most energy and metal commodities – more than the whole for some (see Figures 6 and 7).

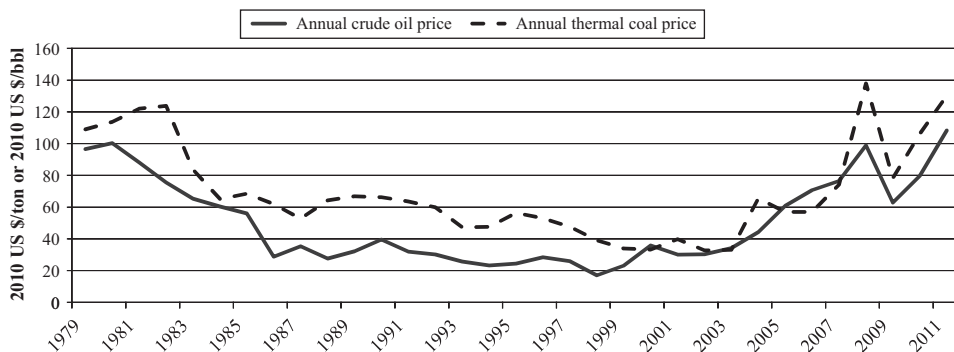
The low value to weight of thermal coal meant that there was little international trade in this commodity before the big lift in oil prices in the 1970s. It then became significant in international trade. Since then, substitution has caused prices of oil and thermal coal to move reasonably closely together (Figure 3).

Figures 4 and 5 set out the global price experience with a number of energy and metal commodities in recent years, with global output growth in purchasing power terms as a point of reference.

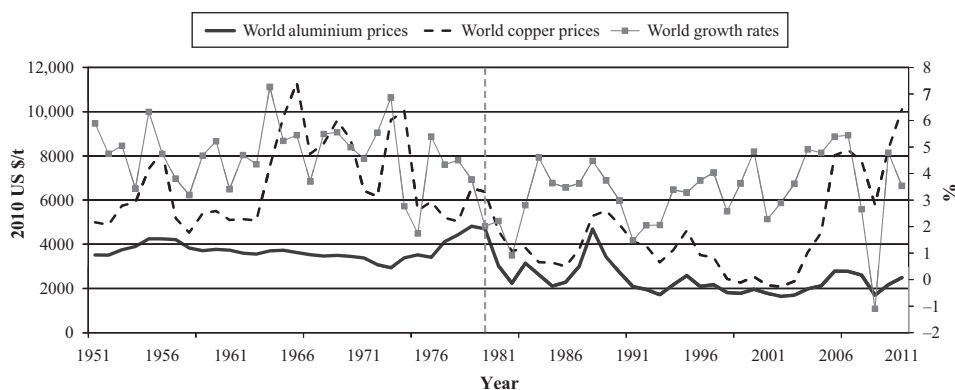
The different experiences with prices of aluminium and copper (Figure 4) illustrate the decisive impact that technological change can have on costs of supply and, therefore, on price over long periods of time. The two metals faced similarly strong demand conditions in the 1950s and 1960s. If there was a difference, it was that technological change affecting demand for the metal was stronger for aluminium. Strong demand growth did not prevent a general slide in the global aluminium price, because cost-reducing technological improvement in aluminium production was more powerful than demand growth in price formation. The cost-reducing effects of technological improvement also outweighed the effects of increased energy costs after 1973, despite energy being overwhelmingly the largest element in productions costs.

Copper prices, on the other hand, were strongly influenced by global aggregate demand throughout the past six decades (Figure 4), as they had been over the preceding six decades.

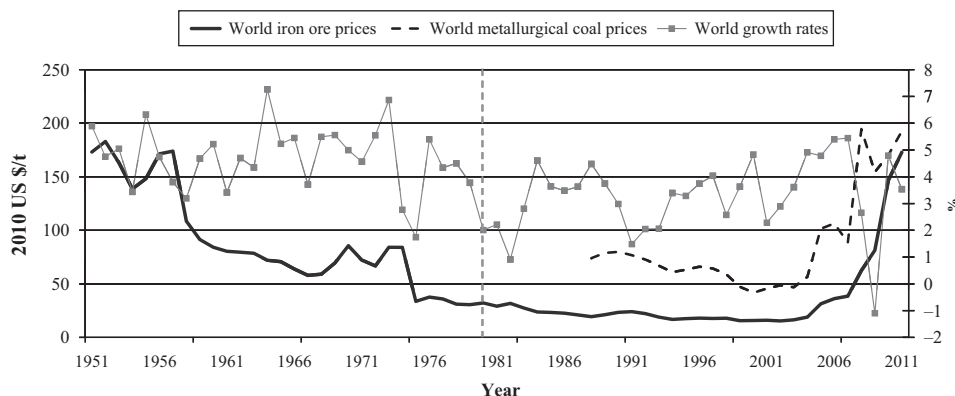
The global price of copper in real terms has fluctuated widely with periodic as well as cyclical variations in consumption growth. There have been four



**Figure 3** Annual crude oil and thermal coal prices (real). Source: IMF International Financial Statistics.



**Figure 4** Aluminium and copper prices (real). Source: Aluminium and Copper prices from IMF International Financial Statistics; Growth rates from Maddison, A. *The World Economy* OECD 2001 (1950–1980) and IMF World Economic Outlook September 2011 (1980–2010).



**Figure 5** Iron ore and metallurgical coal prices (real). Source: Iron ore and metallurgical coal prices from IMF International Financial Statistics; Growth rates from Maddison, A. *The World Economy* OECD 2001 (1950–1980) and IMF World Economic Outlook September 2011 (1980–2010).

distinctive periods for global copper prices since the late 19th century. Prices fluctuated around 180 cents per pound in early 21st century prices in the rapid global economic expansion from the recession of the early 1890s until the First World War. They fluctuated around a much lower level through the relative stagnation of the 1920s and 1930s – with a mean about 100 cents per pound in early 21st century prices. The price trend was steadily upward from the Second World War until the oil crisis of 1973. It reached a historically high average above 200 cents per pound over the last decade of this period, corresponding to the time of sustained rapid Japanese growth after Japan had become large enough to influence global markets. The trend was then steadily down: a bit above a dollar in the 1980s and 1990s, and to Great Depression levels near and below 80 cents in the years straddling the turn of the century.

Since then, we have entered a fifth period, marked by price revival and broken briefly by the slump in demand in the immediate aftermath of the Global Financial Crisis of 2008. The 2011 spot prices have been shockingly high by the standards of the immediately preceding decades, but not unusual for the peaks of earlier periods of sustained global prosperity.

Demand for copper and other metals is linked closely to their intensive use in capital goods, the demand for which is highly sensitive to the business cycle.

Iron ore and metallurgical coal have contributed most to the Australian terms of trade boom that began in 2003 and continues today. Both are inputs into the steel industry, and the demand for both derives from demand for steel. Long distance trade in metallurgical coal was relatively unimportant until the late 1960s and 1970s, when Japanese steel-making began to make use of large-scale supply from Australia.

Global supply from established facilities had little difficulty in meeting nearly all growth in demand until the big lift in Chinese and, therefore, global import demands in the early 21st century. Prices for iron ore eased more or less continuously in real terms – quite rapidly until the late 1980s – broken only by a brief period of febrile global demand in the early 1970s. The price story was similar for metallurgical coal.

Markets were taken by surprise by the sudden increase in Chinese demand from the early years of the 21st century. Prices of iron ore lifted nearly ten-fold and of metallurgical coal about fourfold from the early years of the century to the first half of 2011 (Figure 5).

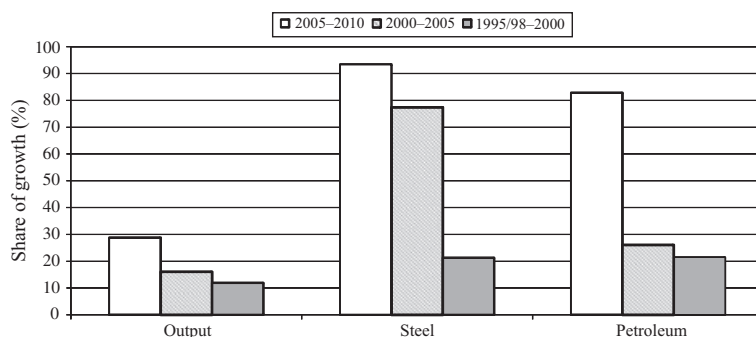
### **3. Why it's a China boom (so far)**

The early 21st century resources boom up to the Global Financial Crisis 2008 was driven mainly by China growing at rates that exceeded market expectations, and with an intensity of use of energy and metals that greatly exceeded expectations, at a time when the Chinese economy had become large enough to be highly influential on a global scale.

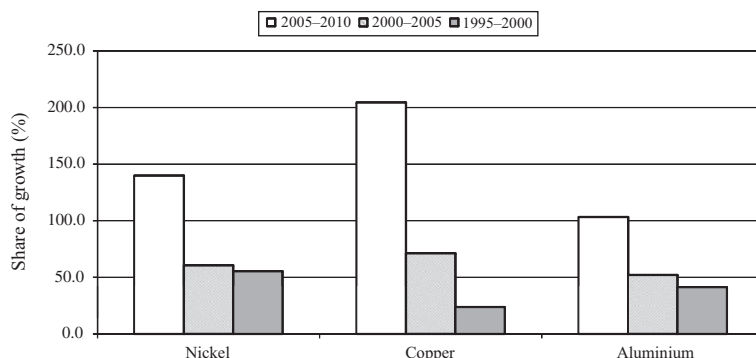
After the financial crisis, high resources prices were driven overwhelmingly by Chinese demand: in the absence of the prodigious growth in Chinese demand for most energy and metallic mineral commodities, reasonable growth in the developing world beyond China would have only cancelled the weakness in growth in the old developed countries. Prices would have languished below trend.

China contributed more than a tenth of the growth in world output in the late 1990s, a higher proportion in the early years of the new century and nearly 30 per cent in the years 2005–10 (Figure 6).

China's contribution to global growth in resources demand was much higher than for expansion of economic activity (Figures 6 and 7). China accounted for over a fifth of the increase in global demand for petroleum, steel and copper and around half for aluminium and nickel in the late years



**Figure 6** China's shares of incremental world demand for petroleum (1995–2010) and crude steel (1998–2010), world output (1995–2010). Source: Calculated using crude steel consumption data from World Bureau of Metal Statistics (via Bloomberg), petroleum consumption data from US Department of Energy and output data from IMF WEO September 2011.



**Figure 7** China's shares of incremental world demand for three metals 1995–2010 (per cent). Source: Calculated using data from World Bureau of Metal Statistics (via Bloomberg).

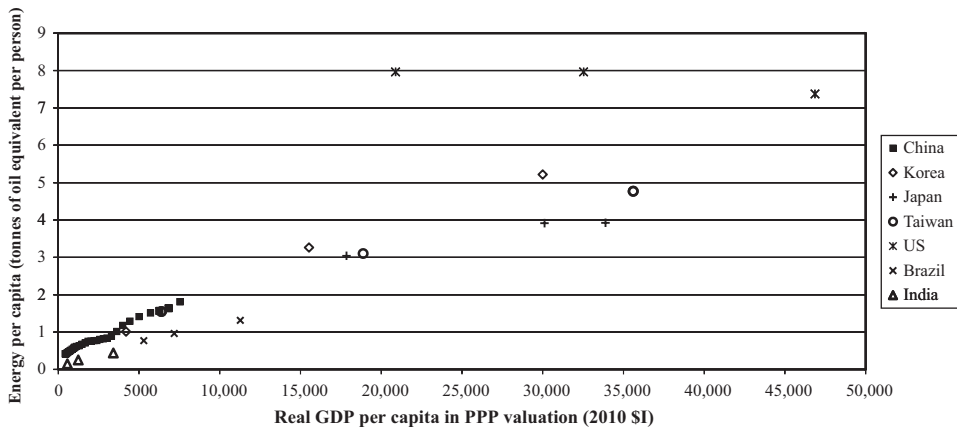
of the 1990s, straddling the Asian Financial Crisis. For the first 5 years of the new century, the Chinese share of consumption growth rose considerably for all energy and metals commodities, to over half for copper, nickel and aluminium. Between 2005 and 2010, China accounted for over four-fifths of the increase in global demand for nearly all energy and metals products. Demand for nickel, copper and aluminium fell outside China, but Chinese growth caused total global demand to be strong enough to take prices close to the highest ever.

What caused the exceptional energy and metal demand growth in China in the early 21st century? Exceptionally strong economic growth is the start of the answer – but Chinese import demand for energy and metals grew much faster than economic output.

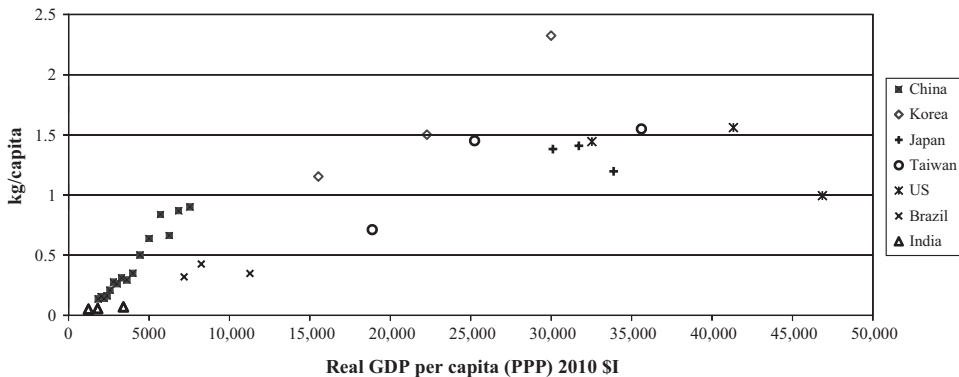
Per capita consumption of fossil fuels and especially metals is exceptionally high for China's income (Figures 8–11).

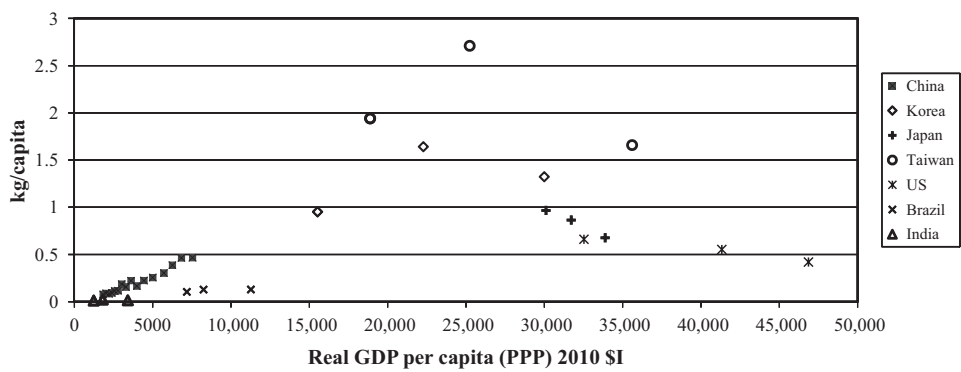
The exceptional resource intensity of Chinese growth had several causes. Two related causes were more important than others: rapid urbanisation, and



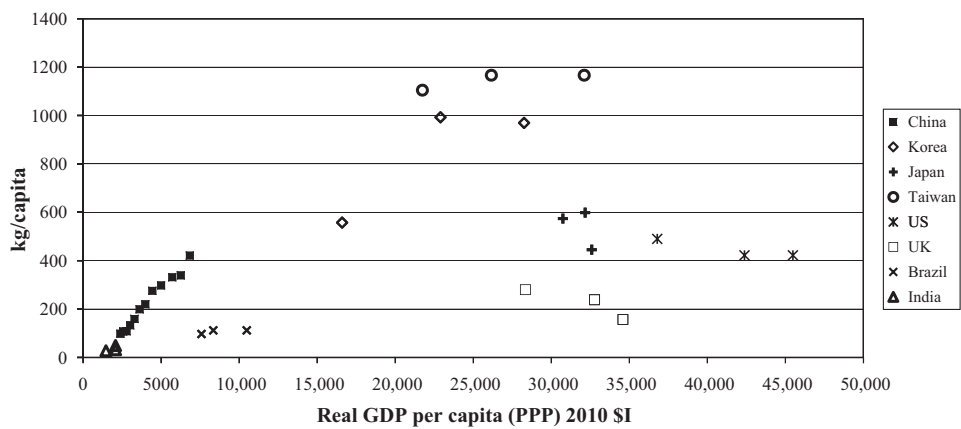


**Figure 8** Total energy consumption intensity (1980–2010). Data points for all countries except China shown for the following years only: 1980, 1995, 2010. Data for China spans 1980–2010. Source: Energy data from British Petroleum Statistical Review June 2011; Real GDP data from IMF World Economic Outlook September 2011.





**Figure 10** Copper use and GDP per capita (1995–2010). Data points for all countries except China shown for the following years only: 1995, 2002, 2010. Data for China spans 1995–2010. Source: Copper consumption data from World Bureau of Metal Statistics (via Bloomberg); Real GDP data from IMF World Economic Outlook September 2011.



**Figure 11** Steel use and GDP per capita (1998–2009). Data points for all countries except China shown for the following years only: 1998, 2003, 2009. Data for China spans 1998–2009. Source: Steel consumption data from World Bureau of Metal Statistics (via Bloomberg); Real GDP data from IMF World Economic Outlook September 2011.

The investment share in GDP has been higher in Northeast Asian economies (and in Singapore) than in any of the other economies that are now developed. It is already higher in China than at any stage of development of any other Northeast Asian economy. Investment continues to grow more rapidly than total output in 2011 (McKay 2011). While China shares many economic characteristics with its Northeast Asian neighbours, its continental size and associated domestic economic diversity suggest that its economic structure is unlikely to remain as strongly skewed towards resource-intensive activities as in its smaller neighbours.

Figure 8 shows that Chinese energy consumption per person has been well above the levels of other low-income economies – see the comparison with Brazil and India in the bottom left hand corner of Figure 8. It has moved to

half that of Japan at a relatively low-income level. Continued growth in energy use at anything like the rate of the 30 years of internationally oriented reform would take per capita energy use above all other economies except the United States (and Australia and Canada, not shown in Figure 8).

Figure 9 shows that the Chinese trajectory for per capita use of aluminium is well above other developing economies. It is already approaching two-thirds of the levels in much richer economies in the old developed world and North-east Asia. If China's per capita aluminium use continued for long at the growth rates of the recent past, it would stand alone with the Republic of Korea.

China's per capita use of copper has grown on an upward trajectory that is similar to aluminium. Again, aluminium use is and has been much higher than in other developing economies at similar levels of income. It is already as high as the United States and nearly as high as Japan. However, other rapidly developing Northeast Asian economies reached peak levels of per capita use of copper that were more than five times (Korea) and three times (Taiwan) the current Chinese levels, at income levels around three times the Chinese levels.

The steel data are especially important for Australia's terms of trade, since Australia's largest exports are now iron ore and metallurgical coal. The trajectory of per capita use is even more striking in international terms for steel than that for other metals. Per capita steel use was once much higher than it is today in the old developed countries. China's per capita consumption is now much higher than the United Kingdom, similar to the United States, and rapidly catching up with Japan. However, as with the other metals China's situation looks less unusual when compared with Taiwan (which has levelled out at about two and a half times the China's current per capita use) and Korea (which has levelled out at about three times).

Note that per capita GDP data in Figures 8–11 are expressed in purchasing power units.

The legacy of central planning and price distortion continues to provide some artificial stimulus to metals and energy consumption. This has been largely unwound over the past two decades of reform, but energy prices remain below international levels despite recent upward adjustments. Low energy prices have provided minor stimulation to the use of metals through the encouragement that they have provided to the consumption of metallic consumer durables, first of all automobiles. The likely unwinding of remaining price distortions in the years ahead will dampen fossil fuel consumption growth, as will the strong focus on reducing the greenhouse gas emissions intensity of economic activity (Garnaut 2011a,b; Wen 2011).

China's relatively low per capita domestic endowment of economically valuable natural resources increases the impact of growth in its demand on global markets. This is notably the case relative to the United States and to most developing countries other than those in Northeast and South Asia. Following the trade policy reforms of the past two decades, a high proportion of incremental Chinese demand for most minerals flows directly into imports.

Coal is an exception, and this has implications for the impact of Chinese industrialisation on the global resources economy.

Of special importance for the growth in import demand has been the unwinding of high protection for domestic production of iron ore. China, like most countries, has large amounts of iron oxide in relatively low concentrations. This was overwhelmingly the main basis of domestic steel production from the early days of modern economic growth until well into the 1990s. Stronger emphasis on economic performance with enterprise, price and trade reform through the 1990s increased the import share of the raw materials used in China. The unwinding of old, autarchic approaches to steel-making continued at a rapid rate through the early 21st century, causing import demand for iron ore to increase much more rapidly than steel production. At the same time, the exceptional rate of growth contributed to a relatively low proportion of incremental supply of steel coming from recycled steel scrap.

China's natural endowment of coal is richer than of iron ore. As a consequence, old, autarchic approaches to use of domestic raw materials were less distorting than for iron ore – and the economic pressures for unwinding them were less powerful. Nevertheless, Chinese imports of substantial quantities of metallurgical coal for the first time in the first decade of the 21st century put upward pressure on world prices.

The big lift in Chinese imports resulting from more open trade policies has just about run its course.

#### 4. How long will it last?

The longevity of Australia's China resources boom depends on the prospects for continued strong economic growth in China, on the resource intensity of that growth and on the extent to which the resource-intensive industries are integrated into international markets. These concluding remarks speculate about each of these factors in turn.

The first and second of the determinants of future import demand for energy and metals – the rate of economic growth and resources intensity – will be affected by scarcity of labour and the associated increases in real wages over the remainder of the 2010s.

China has entered the 'turning point in economic development', or rather, in a large and geographically differentiated economy, the 'turning period'. This is the transition from a labour surplus economy with comparative advantage in labour-intensive products, to an increasingly diverse economy, with diverse comparative advantage centred upon capital-intensive and technologically sophisticated products (Cai 2010; Garnaut 2010 and other contributions to the special issue of the *China Economic Journal*, vol. 3, July 2010, Garnaut 2011c).

The large increases in real wages will reduce the profit share of income, and with it China's prodigious savings rate. It will reduce the profitability of and, therefore, the incentives to invest in the labour-intensive industries that have played a major role in China's growth over the three decades of the reform era.

But these developments will not necessarily reduce the investment rate. That depends on the expected profitability of investment. That, in turn, will be affected by productivity growth in the business sector and the effectiveness of provision of the public goods that become more critical to strong growth as incomes rise: regulatory systems, education, transport and communications amongst other services. If incentives to investment remain strong, the maintenance of a high investment rate can be reconciled with a falling savings rate through reduction in the current account surplus. This reconciliation is evident in the years since the Global Financial Crisis.

The quality of macroeconomic management also affects incentives to invest. The maintenance of macroeconomic stability will be more challenging through the transition out of the labour surplus economy. There is no need for rapidly increasing real wages to be associated with markedly higher inflation: this source of instability can be avoided through the combination of firm monetary policy and nominal appreciation of the currency. But there will be pressures for the authorities to appreciate too little and for inflation to accelerate to an extent that requires retrenchment and an otherwise unnecessary loss of growth potential.

My own assessment is that the investment share of expenditure will remain near the high rates of recent years until the middle of the current decade and then decline moderately.

The relative backwardness of China at the beginnings of internationally oriented reform and rapid growth, together with the magnitude of the obstacles to reform, means that economic growth can proceed at high rates for longer than in its Northeast Asian neighbours before productivity growth is slowed by proximity to the global frontiers. Some increase in total factor productivity growth will be generated by rising wages focussing attention on more economic use of scarce labour.

The third determinant of the rate of growth alongside investment rates and productivity increases is the labour supply. The total number of workers will soon begin to fall, and the fall will accelerate over time. Alongside decline in the total labour supply, there will be rapid increases in the stock of human capital per worker, as large increases in education expenditure are focussed on declining numbers of school children.

These perspectives on growth in the capital stock, productivity and labour supply are embodied in projections within a growth-accounting framework that I undertook for the Garnaut Climate Change Review. The projections took as their starting point Perkins and Rawski 2007. The projections, incorporating my own judgements on investment rates and productivity growth, pointed to average growth of output at a bit below 10 per cent 2009–2015 and then a bit below 7 per cent per annum 2015–2030 (Garnaut 2011d<sup>1</sup>). Something like this remains probable, although necessarily uncertain, and with the

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<sup>1</sup> See Garnaut 2011d for more details. Frank Jotzo of The Australian National University worked with me on the projections in this paper.

cycles associated with a market economy, and the inevitable bumps in the path of rapid, sustained economic growth.

So the prospect is for continued growth a bit below the average of the early 21st century to 2015 and then at about two-thirds of that level on average to 2030. At the end of the period, the Chinese economy would be about four times its current size.

#### **4.1. How resource intensive will this growth be?**

Will Chinese growth turn out to be more like the highly energy- and metals-intensive growth of Korea (especially) and Taiwan, or more like the developed countries that reached high living standards at an earlier time in global economic development? Here, it is salutary to recall that Japan through the 1950s, 1960s and early 1970s followed a distinctively 'Northeast Asian' growth path with unusually high resource intensity, until high energy prices, focus on 'resource security', and policy driven by national economic strategy greatly reduced resource intensity from the late 1970s.

A continued high investment share of expenditure at least to 2015 is positive for high resource intensity of economic activity.

On the other hand, the high rate of urbanisation of the reform period so far will diminish, simply as a matter of arithmetic, now that around half of the Chinese are living in townships and cities. Moreover, and unlike almost any other country, there are some signs that anticipatory investment in transport and other urban infrastructure may reduce future investment demand. Decelerating urban growth and recent high rates of urban investment are negative for high resource intensity in the future.

High energy and metals prices and concerns about resources security have made efficient use of resources a major objective of policy in China – just as they did in Japan from the late 1970s. In China's case, concern about global climate change has made the reduction in the greenhouse emissions intensity of production and consumption a major policy objective since about 2008 (Garnaut 2011a; Wen 2011). The climate change considerations will lead to lower rates of increase in energy use and a reduction in the emissions intensity of energy production. This is likely to be strongly negative for fossil fuel consumption, especially for coal. These influences are negative for metals intensity, more for energy intensity and most for fossil fuel intensity.

The high export orientation of the Korean and Taiwan economies as they matured and developed new comparative advantage in capital-intensive products contributed to high resources intensity. China has entered a period in which the increase in the export share of output is decelerating. This is likely to continue. On this characteristic, China may end up in an intermediate position between Korea and Taiwan on the one hand, and the old, established industrial countries on the other. Export orientation seems likely to be a neutral influence on future resources intensity, rather than positive as in Korea and Taiwan.



There are rather stronger factors pushing China in the direction of the resources intensity of Japan and the old industrial countries, than in the direction of Taiwan and Korea.

What is likely to happen to the import share of Chinese resources demand? The liberalisation of trade contributed a great deal to the increase in resources imports from the beginnings of reform in the late 1970s to late in the first decade of the 21st century. But this was a once-for-all positive influence on global metals and energy prices. Any further positive influence is likely to be balanced by the negative impact on resources demand of raising energy prices to global levels.

As in the 1960s, new institutional arrangements (the Chinese multinational corporation) and new suppliers (Papua New Guinea for nickel and several African and Latin American and Central Asian countries for a wide range of metals) are the focus of large investments. This will be moderately positive for the import share of resources demand, but not for the shares of established suppliers such as Australia.

It is likely that the Chinese economy will continue to grow strongly for the foreseeable future, although at moderately declining rates from about 2015. Resource intensity of production will decline rather more rapidly than seems to be the common expectation and more rapidly still as growth and the investment share of output fall from about 2015.

Current global resources prices and investment levels seem to embody expectations of continued rapid growth in demand for resources along the lines of the early 21st century so far. This is encouraging huge expansion of supply of many energy and metallic minerals – all those for which there are opportunities in nature for large expansions of production at relatively low cost. The analysis of this paper suggests that these expectations may be disappointed. The next large adjustment forced by Australia's China resources boom is likely to be to markedly lower terms of trade and resources investment.

I have been looking at long-term tendencies. China's rapid growth involves economic, social and political change on a scale that is unprecedented in world history. It is unlikely to proceed over decades without bumps in the road, and an occasional dead end and detour. With China in the 2020s consuming more resource-based products from world markets than the whole of the currently developed world, the rest of the world will feel every bump through energy and metals markets.

Prices and investment in the resources sector are in their nature volatile. As the Australian economy is restructured to expand the role of the resources sector, the inevitable fluctuations in activity in China's market economy will challenge Australia's capacity to maintain economic stability.

This paper has been about the China resources boom, but global development does not end with China. The contemporary China resources boom may lead into a more widely based resources expansion, built on accelerated development in many developing countries. It would have to be truly widely

based to fill the China gap in demand growth: no other large part of the developing world is likely to grow with anything like the resource intensity of China, although some countries, including India, may come to grow as fast. I leave the question of whether acceleration of growth elsewhere can make up for the anticipated deceleration in growth in China's resources demand for others or another time.

Finally, one only has to identify the possibility of China absorbing more resource-based products than the currently developed world to raise some fundamental questions about 'limits to growth'. The experience of development, and not only our theory, inform us that higher prices induce expansion of output and substitution in supply and demand for scarce resources, as well as some modification of the rate and pattern of economic expansion. But while, in the end, supply will equal demand at some higher level of global economic output, the process of adjustment is of great importance and can affect economic activity in the rapidly growing economies and elsewhere.

Another constraint is more fundamental. Economists who draw from the common scientific heritage of humanity are aware that modern economic growth could be prematurely disrupted and in some circumstances truncated by external environmental costs of modern economic growth. The risks to long-term growth can be ameliorated at small short-term economic cost through policy adjustments that internalise the external environmental damage. The limits to growth associated with pressure on natural resources are defined in practice by the capacity of our political systems to apply efficient policies (Stern 2007; Garnaut 2008, 2011a).

## References

- Cai, F. (2010). Demographic transition, demographic divided, and Lewis turning point in China, *China Economic Journal* 3(2), 107–119.
- Cline, W. (1992). *The Economics of Global Warming*. Institute For International Economics, Washington.
- Garnaut, R. (2008). *The Garnaut Climate Change Review: Final Report*. Cambridge University Press, Cambridge, Melbourne.
- Garnaut, R. (2010). Macro-economic implications of the turning point, *China Economic Journal* 3(2), 181–190.
- Garnaut, R. (2011a). *The Garnaut Review 2011: Australia in the Global Response to Climate Change*. Cambridge University Press, Melbourne.
- Garnaut, R. (2011b). Garnaut climate change review update paper 2: progress towards effective global action on climate change. Available from URL: <http://www.garnautreview.org.au/update-2011/update-papers/up2-progress-towards-effective-global-action-climate-change.pdf> [accessed 20 September 2011].
- Garnaut, R. (2011c, forthcoming). Australian opportunities through the Chinese structural transformation, *The Australian Economic Review* 437–45.
- Garnaut, R. (2011d). Garnaut climate change review update paper 3: global emissions trends, paper presented to Australian Agricultural and Resource Economic Society Annual Conference, Melbourne, 11 February. Available from URL: <http://www.garnautreview.org.au/update-2011/update-papers/up3-global-emissions-trends.pdf> [accessed 20 September 2011].

- Garnaut, R. and Clunies Ross, A. (1983). *Taxation of Mineral Rents*. Clarendon Press, Oxford.
- Garnaut, R. with Llewellyn-Smith, D. (2009). *The Great Crash of 2008*. Melbourne University Publishing, Melbourne (also published in Chinese by Social Sciences Academic Press, Chinese Academy of Social Sciences, Beijing, 2010).
- Garnaut, R. and Song, L. (forthcoming). *China's Test of Limits to Growth*. Oxford University Press, Oxford.
- Griliches, Z. (ed.) (1984). *R & D, Patents and Productivity*. University of Chicago Press, Chicago.
- Hotelling, H. (1931). The economics of exhaustible resources, *The Journal of Political Economy* 39(2), 137–175.
- IPCC (2007a). Climate change 2007: the physical science basis, in Solomon, S., Qin, D., Manning, M., Chen, Z., Marquis, M., Averyt, K.B., Tignor, M. and Miller, H.L. (eds), *Contribution of Working Group I to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change*. Cambridge University Press, Cambridge.
- IPCC (2007b). Climate change 2007: impacts, adaptation and vulnerability, in Parry, M.L., Canziani, O.F., Palutikof, J.P., van der Linden, P.J. and Hanson, C.E. (eds), *Contribution of Working Group II to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change*. Cambridge University Press, Cambridge.
- IPCC (2007c). Climate change 2007: mitigation of climate change, in Metz, B., Davidson, O.R., Bosch, P.R., Dave, R. and Meyer, L.A. (eds), *Contribution of Working Group III to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change*. Cambridge University Press, Cambridge.
- Lewis, W.A. (1954). Economic development with unlimited supplies of labour, *The Manchester School of Economic and Social Studies*, XXII (May), 139–191.
- McKay, H. (2011). China's turbulent half-decade, in Golley, J. and Song, L. (eds), *Rising China: Global Challenges and Opportunities*. ANU E Press, Canberra, and Social Sciences Academic Press, Beijing, pp. 9–28.
- Minami, R. (1973). *The Turning Point in Economic Development: Japan's Experience*. Kinokuniya Bookstore Co. Ltd, Tokyo.
- Nordhaus, W. (2007). A review of the stern review and the economics of climate, *Journal of Economics Literature* 45(3), 686–702.
- Nordhaus, W. (2008). *A Question of Balance: Weighing the Options on Global Warming Policy*. Yale University Press, New Haven.
- Perkins, D.H. and Rawski, T.G. (2007). Forecasting China's economic growth to 2025. Available from URL: [http://www.economics.harvard.edu/files/faculty/49\\_Chapter20.pdf](http://www.economics.harvard.edu/files/faculty/49_Chapter20.pdf) [accessed 20 September 2011].
- Ranis, G. and Fei, J.C.H. (1961). A theory of economic development, *The American Economic Review* 51(4), 533–565.
- Ranis, G. and Fei, J.C.H. (1963). The Ranis-Fei model of economic development: reply, *The American Economic Review* 53(3), 452–454.
- Stern, N. (2007). *The Economics of Climate Change: The Stern Review*. Cambridge University Press, Cambridge.
- Wen, J. (2011). Report on the work of the report on the work of the Government, China's 12th five-year plan. Available from URL: <http://online.wsj.com/public/resources/documents/2011NPCWorkReportEng.pdf> [accessed 20 September 2011].