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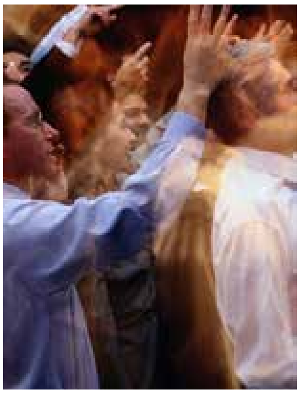


September 2013

Resource Revolution: Tracking global commodity markets

Trends survey 2013

The McKinsey Global Institute

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Resource Revolution: Tracking global commodity markets

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Preface

This is the first edition of the McKinsey Resource Revolution trends survey. This, together with a new interactive web tool (www.mckinsey.com/insights/mgi/research/natural_resources), will track movements in commodity prices, including those of energy, metals, and agriculture, along with the drivers of these movements. The McKinsey Global Institute (MGI), McKinsey & Company's business and economics research arm, and the McKinsey Sustainability & Resource Productivity Practice decided to develop this survey in response to concerns raised by many McKinsey clients about the lack of a holistic view of movements in resource markets that takes into account the increasing linkages between many of them, and a robust assessment of the drivers underpinning movements in commodity prices.

The survey draws on the knowledge of McKinsey experts in the Firm's Basic Materials Institute, the Oil and Gas Practice, the Agriculture Practice, and Energy Insights. The survey is not intended to be a price-forecasting exercise, but rather a comprehensive examination of how resource markets are evolving. This edition of the resource trends survey tracks prices through the first quarter of 2013, the latest quarterly data available. In this first edition, we also present a broader overview of historical price trends and our assessment of the major drivers of future price trends. Subsequent surveys will provide a more concise, focused analysis of the most recent price trends. We welcome feedback on this survey.

This work was led by Richard Dobbs, a McKinsey and MGI director; Jeremy Oppenheim and Scott Nyquist, McKinsey directors and co-leaders of the McKinsey Sustainability & Resource Productivity Practice; Sigurd Mareels, a McKinsey director and leader of the McKinsey Basic Materials Institute; and Sunil Sanghvi, a McKinsey director and leader of McKinsey's Global Agriculture Service Line. Fraser Thompson, an MGI senior fellow, headed the project team, which included Krzysztof Kwiatkowski.

We are grateful for the advice and input of many McKinsey colleagues, including Tim Beacom, Michael Birshan, Marcel Brinkman, Elizabeth Bury, Mark Dominik, Tim Fitzgibbon, Stewart Goodman, Sara Hastings-Simon, Berend Heringa, Laurent Kinet, Ajay Lala, Michael Phillips, Stefan Rehbach, Occo Roelofsen, Jaap Strengers, Roberto Uchoa de Paula, and Yulia Woodruff. Many experts in academia, government, and industry have offered invaluable guidance, suggestions, and advice. Our particular thanks to Richard Cooper, Maurits C. Boas Professor of International Economics at Harvard University.

The team benefited from the contributions of Janet Bush and Lisa Renaud, MGI senior editors; MGI's Rebeca Robboy and Gabriela Ramirez for their help on external relations; Julie Philpot, MGI's editorial production manager; and Marisa Carder, visual graphics specialist.

This survey contributes to MGI's mission to help global leaders understand the forces transforming the global economy, identify strategic locations, and prepare for the next wave of growth. As with all MGI research, we would like to emphasize that this work is independent and has not been commissioned or sponsored in any way by any business, government, or other institution.

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Executive summary

Trends in resource prices have changed abruptly and decisively since the turn of the century. During the 20th century, resource prices (in real terms) fell by a little over a half percent a year on average. But since 2000, average resource prices have more than doubled. Over the past 13 years, the average annual volatility of resource prices has been almost three times what it was in the 1990s.[1] This new era of high, rising, and volatile resource prices has been characterized by many observers as a resource price "super-cycle." Since 2011, commodity prices have eased back a little from their peaks, prompting some to question whether the super-cycle has finally come to an end. But the fact is that, despite recent declines, on average commodity prices are still almost at their levels in 2008 when the global financial crisis began. Talk about the death of the super-cycle appears premature.

Some of the key findings of our analysis are:

- Despite intense current focus on shale gas and its impact on reducing natural gas prices in the United States, most, if not all, resource prices remain high by historical standards—even at a time when the world economy has not fully emerged from its post-recession period of slow growth.

- The volatility of resource prices has also been considerably higher since the turn of the century. While short-term volatility is influenced by many factors, such as droughts, floods, labor strikes, and restrictions on exports, there also appears to be increasing evidence of a more structural supply issue that is driving longer-term volatility. Supply appears to be progressively less able to adjust rapidly to changes in demand because new reserves are more challenging and expensive to access. For example, offshore oil requires more sophisticated production techniques. Available arable land is not connected to markets through infrastructure. Mineral resources increasingly need to be developed in regions that have high political risks. Such factors not only increase the risk of disruptions to supply but also make supply even more inelastic. As supply becomes increasingly unresponsive to demand, even small changes in that demand can result in significant changes in prices. Investors may be deterred by the volatility in resource prices and become less inclined to invest in new supply or resource productivity initiatives.

- The prices of different resources have been increasingly closely correlated over the past three decades.[2] While rapid growth in demand for resources from China has been an important driver of these increased links, two additional factors are also important. First, resources represent a substantial

1 Volatility is measured by the standard deviation from the mean commodity price.

2 Correlation is measured using Pearson's correlation coefficient. It is calculated by dividing the covariance of the two variables by the product of their standard deviations. The Pearson correlation is +1 in the case of a perfect positive correlation and –1 in the case of a perfect negative correlation. If the variables are independent, Pearson's correlation coefficient is 0.

proportion of the input costs of other resources. For instance, rising energy costs in fertilizers drive higher production costs in agriculture. Second, technology advances are enabling more substitution between resources in final demand—for instance, biofuels link agriculture and energy markets. As a result, shocks in one part of the resource system today can spread rapidly to other parts of the system.

- With the notable exception of shale gas, long-term supply-side costs continue to increase. While the world does not face any near-term absolute shortages of natural resources, increases in the marginal costs of supply appear to be pervasive and put a floor under the prices of many commodities. At the same time, there is no shortage of resource technology, and higher resource prices are likely to be a catalyst for faster innovation. Technology could transform access to both resources and its productivity. For example, 3D and 4D seismic technology could significantly improve energy exploration, while organic chemistry and genetic engineering could foster the next green revolution. In the years ahead, resource markets will be shaped by the race between emerging-market demand and the resulting need to increase supply from places where geology is more challenging, and the twin forces of supply-side innovation and resource productivity.

- The historical and future drivers in energy, metals, and agriculture (food and raw materials) vary:

  — **Energy.** Prior to the 1970s, real energy prices (including those of coal, gas, and oil) were largely flat as supply and demand increased in line with each other. During this period, there were discoveries of new, low-cost sources of supply, energy producers had weak pricing power, and there were improvements in the efficiency of conversion of energy sources in their raw state to their usable form. This flat trend was interrupted by major supply shocks in the 1970s when real oil prices increased sevenfold in response to the Yom Kippur War and the subsequent oil embargo by the Organization of Arab Petroleum Exporting Countries (OAPEC). But after the 1970s, energy prices entered into a long downward trend due to a combination of substitution away from oil in electricity generation in Organisation for Economic Co-operation and Development (OECD) countries, the discovery of low-cost deposits, a weakening in the bargaining power of producers, a decline in demand after the break-up of the Soviet Union, and subsidies. However, since 2000, energy prices (in nominal terms) have increased by 260 percent, due primarily to the rising cost of supply and the rapid expansion in demand in non-OECD countries.[3] In the future, strong demand from emerging markets, more challenging sources of supply, technological improvements, and the incorporation of environmental costs will all shape the evolution of prices.

3 The role of gas in the energy index is important to note. Gas represents just over 12 percent of the energy index. There has also been significant regional divergence in global gas prices, as we describe later in this survey.

- **Metals.** Real metals prices overall fell by 0.2 percent (increased by 2.2 percent in nominal terms) a year during the 20th century. However, there was some variation among different mineral resources. Steel prices were flat, but real aluminum prices declined by 1.6 percent (increased by 0.8 percent in nominal terms) a year. The main drivers of price trends over the last century included technology improvements, the discovery of new, low-cost deposits, and shifts in demand. However, since 2000, metals prices (in nominal terms) have increased by 176 percent on average (8 percent annually). Gold has increased the most of the major metals, driven predominantly by investors' perceptions that it represented a safe asset class during the volatility of the financial crisis, rising production costs, and limited new discoveries of high-grade deposits. Copper and steel prices (in nominal terms) have increased by 344 percent and 167 percent, respectively, since the turn of the century, even taking into account recent price falls. Many observers of these price increases have pointed to demand from emerging markets such as China as the main driver. However, McKinsey's Basic Materials Institute finds that, while demand from such emerging markets has played an important role, the changing cost of supply, driven by a combination of geological issues and input cost inflation (particularly energy), has also been an important factor behind rising prices—but one that has received less attention to date. In the future, a similar set of factors as in the case of energy—namely demand from China, more challenging access to supply, logistical and skills challenges, and the incorporation of environmental costs—will all shape metals prices.

- **Agriculture.** Food prices (in real terms) fell by an average of 0.7 percent (increased by 1.7 percent in nominal terms) a year during the 20th century despite a significant increase in food demand. This was because of rapid increases in yield per hectare due to the greater use of fertilizers and capital equipment, and the diffusion of improved farming technologies and practices. However, since 2000, food prices (in nominal terms) have risen by almost 120 percent (6.1 percent annually) due to a declining pace of yield increases, rising demand for feed and fuel, supply-side shocks (due to droughts, floods, and variable temperatures), declines in global buffer stocks, and policy responses (e.g., governments in major agricultural regions banning exports). Non-food agricultural commodity nominal prices—including timber, cotton, and tobacco—have risen by between 30 and 70 percent since 2000. Rubber prices have increased by more than 350 percent because supply has been constrained at a time when demand from emerging economies for vehicle tires has been surging. In the future, agricultural markets will be shaped by demand from large emerging countries such as China, climate and ecosystem risks, urban expansion into arable land, biofuels demand, and the potential for further productivity improvements.

1. The changing resource landscape

During most of the 20th century, progressively cheaper resources underpinned global economic growth. Although demand for resources such as energy, metals, food, and water grew during this period, this was offset by expanded supply and increases in the productivity with which supply was used. During the 20th century as a whole, the global prices of key resources, as measured by the McKinsey Global Institute's Commodity Index that includes energy, metals, and food, fell by almost half in real terms.[4]

However, since 2000, the resource landscape has been transformed. On average, resource prices have more than doubled (Exhibit 1).[5] Underpinning these changes in prices has been rapid demand from emerging markets such as China and India and a generally more challenging supply landscape. Incomes, particularly in Asia, are rising on a scale and at a pace that are unprecedented. For example, China's average incomes are growing ten times as fast as the United Kingdom's economy did during the Industrial Revolution and with 100 times as many people. This rapid economic growth has led to large demand for the mineral resources needed to build the infrastructure required to support expanding urban populations; energy to meet demand from industry and households; and non-food agricultural raw materials to satisfy increasing nutritional requirements. At the same time, with the exception of unconventional oil and gas, the supply of resources has proved to be more challenging due to a combination of geological issues and rising input costs.

The volatility of energy, metals, food, and other non-food agricultural raw materials also has increased. Since the turn of the century, the average annual volatility of resource prices has been almost three times what it was in the 1990s.[6] While volatility has recently eased somewhat from its high in 2008 when the global financial crisis erupted, it remains significantly higher than it was during the past century. While short-term volatility has been influenced by many factors, including droughts, floods, labor strikes, and restrictions on exports, there also appears to be increasing evidence of a more structural supply issue driving

4 *Resource Revolution: Meeting the world's energy, materials, food, and water needs*, McKinsey Global Institute and the McKinsey Sustainability & Resource Productivity Practice, November 2011. Some of the numbers in this analysis may differ from that report due to the use of quarterly data and slightly different data sources.

5 The MGI Commodity Price Index is made up of 43 key commodities broken into four commodity sub-groups: energy, metals, food, and non-food agricultural raw materials (see Appendix 1 for further details).

6 Volatility in this survey is measured by the standard deviation from the mean commodity price. Academics have used alternative measures that try to understand changes in volatility relative to long-run structural cycles in resource prices (e.g., correcting for the general upward trend in resource prices since the turn of the century). After "detrending" commodity price series, there remains academic evidence that volatility of resource prices has increased. See, for example, Rabah Arezki, Daniel Lederman, and Hongyan Zhao, *The relative volatility of commodity prices: A reappraisal*, World Bank policy research working paper number 5903, December 2011; and Rabah Arezki, Kaddour Hadri, Prakash Loungani, and Yao Rao, *Testing the Prebisch-Singer Hypothesis since 1650: Evidence from panel techniques that allow for multiple breaks*, International Monetary Fund (IMF) working paper number 13/180, August 2013.

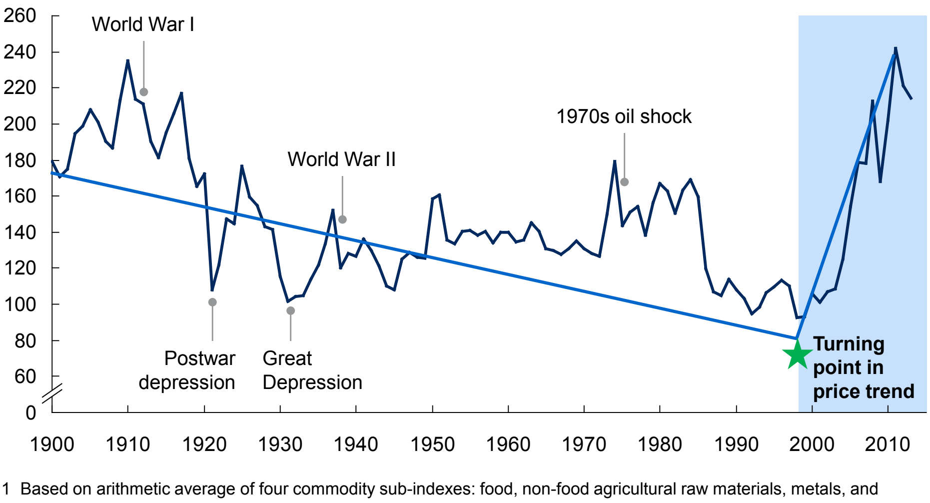
longer-term volatility. Demand for many resources today has already moved to the limits of short-run supply curves where supply is increasingly inelastic—in other words, a point at which it is more difficult for supply to react quickly to meet rising demand. This means that even small shifts in demand can drive greater volatility. We believe that this trend will persist because long-run marginal costs are also increasing for many resources. This is due to the fact that the depletion of supply is accelerating and, with the notable exception of natural gas and renewable energy, new sources of supply are often in more difficult, less productive locations. For example, feasible oil projects are mostly smaller than they were in the past, and more expensive. The average real cost per oil well has doubled over the past decade. New mining discoveries have been broadly flat despite a quadrupling in spending on exploration, and nearly half of new copper projects are located in regions with high political risk. As urbanization proceeds on an unprecedented scale, new and expanding cities could displace up to 30 million hectares of the highest quality agricultural land—roughly 2 percent of land currently under cultivation—by 2030. Over 80 percent of available arable land is subject to high political risk and/or infrastructure challenges. This volatility can also have important implications for the market response to high prices. Investors may be deterred by the volatility in resource prices and become less inclined to invest in new supply or resource productivity initiatives.

Exhibit 1

Resource prices have increased significantly since the turn of the century

McKinsey Commodity Price Index[1]

Real price index: 100 = years 1999–2001[2]



1 Based on arithmetic average of four commodity sub-indexes: food, non-food agricultural raw materials, metals, and energy.

2 Data for 2013 are calculated based on average of the first three months of 2013.

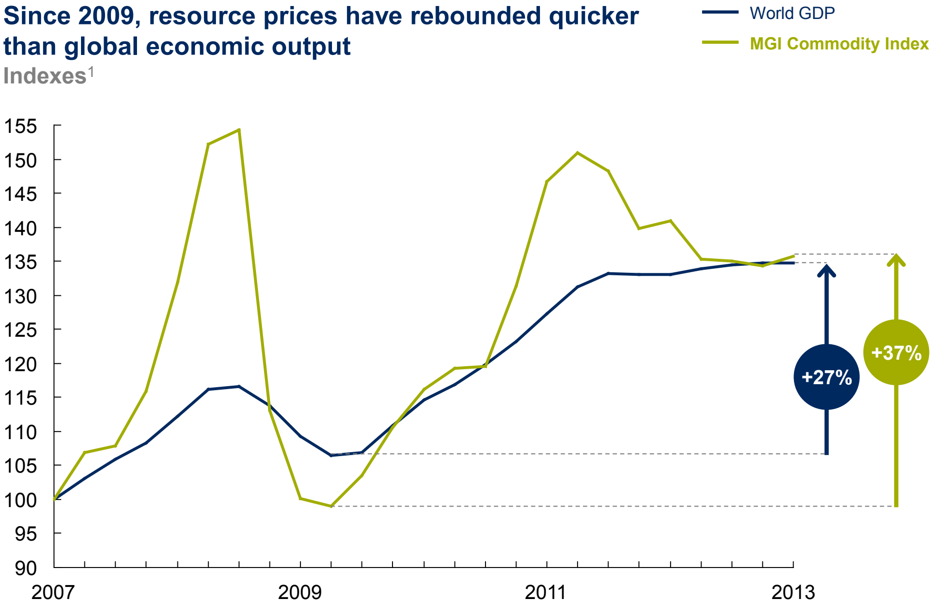
SOURCE: Grilli and Yang; Pfaffenzeller; World Bank; International Monetary Fund; Organisation for Economic Co-operation and Development statistics; Food and Agriculture Organization of the United Nations; UN Comtrade; McKinsey Global Institute analysis

Because commodity prices have fallen slightly since 2011, many observers have questioned whether the so-called super-cycle of high resource prices has come to an end.[7] But it is noteworthy that, even taking into account their recent modest decline, commodity prices on average remain roughly at their levels in 2008 when the global financial crisis began. They have risen more sharply than global economic output since 2009 (Exhibit 2).

Exhibit 2

Since 2009, resource prices have rebounded quicker than global economic output

Indexes[1]



1 Nominal data indexed to 1Q2007.

SOURCE: Oxford Economics; World Bank; International Monetary Fund; Organisation for Economic Co-operation and Development; Food and Agriculture Organization of the United Nations; UN Comtrade; McKinsey Global Institute analysis

Another major change in the resource landscape has been an increasingly close correlation between resource prices over the past 30 years (Exhibit 3). The rapid growth in resource demand (primarily from China) is one cause of the increased price linkages we observe.[8] However, two additional factors are driving new links between resources:

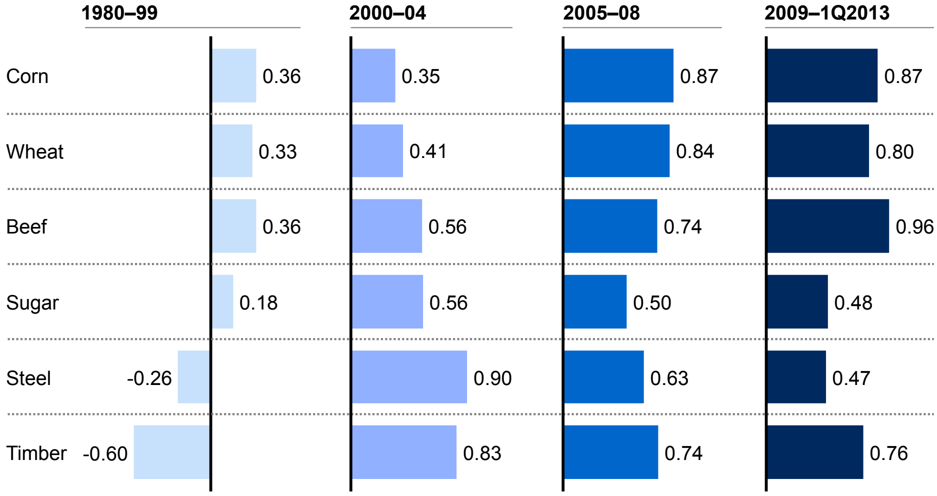
7 See, for example, Javier Blas, "Supercycle runs out of steam—for now," *Financial Times*, July 17, 2012.

8 Others have suggested that the growing role of financial markets in commodity trading (e.g., commodity index funds) has been the reason that financial indexes and resource prices have tended to move together—and be more volatile. However, while there has, on average, been a tighter correlation between these indexes and resource prices over the past 20 years, some question whether the reason for this has been that the economic cycle has pushed both in the same direction, rather than the growing role of financial markets in commodities trading. For further discussion, see Diego Valiante, *Commodities price formation: Financialisation and beyond*, CEPS-ECMI Task Force report, Centre for European Policy Studies, June 2013.

Exhibit 3

Commodities have begun to show significant correlation with oil prices

Correlation with oil prices[1]



1 Pearson's correlation coefficient, calculated by dividing the covariance of the two variables by the product of their standard deviations. The Pearson correlation is +1 in the case of a perfect positive correlation and −1 in the case of a perfect negative correlation. If the variables are independent, Pearson's correlation coefficient is 0.

SOURCE: World Bank; International Monetary Fund Organisation for Economic Co-operation and Development; Food and Agriculture Organization of the United Nations; UN Comtrade; McKinsey Global Institute analysis

- **Resources represent a substantial proportion of input costs to other resources.** There are strong cost-based linkages between different resources. For example, while agriculture may account for only around 2 percent of global energy demand, energy can be an important driver of the cost of agricultural production. This reflects the cost of fuel used for machinery and transportation in the sector as well as the significant energy-cost component of key agricultural inputs such as nitrogen-based fertilizers that are made from natural gas. Overall, energy accounts for 15 to 30 percent of the cost of crop production.[9] Energy also accounts for about 25 to 40 percent of the cost of steel. In some cases, technological improvements have reduced the volume intensity of resource linkages. In the United States, for instance, the energy intensity of steel has declined by 66 percent since 1950 as production has become more efficient. However, with the exception of lower natural-gas prices that have helped reduce the price of fertilizer in some regions, recent price increases have more than offset such improvements in intensity and resulted in stronger linkages between any one commodity price and the cost of producing other resources. Future changes in prices and production processes could continue to compound these linkages. For example, if carbon had a price of $30 per tonne, linkages would be tighter because products produced or transported with carbon-intensive energy would have a higher share of energy in total costs. Unconventional energy sources are expected to require more inputs such as steel. Steel accounts for around 30 percent of the capital cost of any new oil project, and steel costs are likely to increase as the oil and gas industries move increasingly into more challenging forms of exploration such as ultra-deep-water wells. J. P. Morgan notes that the global count of shallow wells dropped by 25 percent between 2005 and 2009,

9 Randy Schnepf, *Energy use in agriculture: Background and issues*, Congressional Research Service, 2004.

while ultra-deep-water wells increased by 30 percent.[10] In addition, more complicated drilling methods, such as horizontal drilling, can require four times the amount of steel as traditional vertical drilling. Mineral resources such as rare-earth metals are also critical inputs for renewable energy technologies such as solar photovoltaics.

- **Technological advances and the growing scarcity of resources increasingly result in substitution between resources.** Substitution results in closer links between the prices of resources. The most prevalent example of this is biofuels. Higher energy prices can encourage the use of land for energy production. In the past, the prices of corn (maize) and oil have been largely uncorrelated. However, since autumn 2007, there has been a very strong positive correlation between the two. A driver of this significant change is likely to be the fact that the ethanol industry has become the marginal user of corn.[11] This has created a link between the break-even prices of ethanol and realized corn prices.[12] There are other instances. Higher oil prices have driven up the prices of synthetic products such as rubber and nylon fibers. These products have, in turn, put upward pressure on the prices of their natural counterparts in rubber and cotton.[13]

There is growing academic evidence supporting these linkage effects on commodity price correlations. Arshad and Hameed (2009) find evidence of a price relationship between oil, corn, wheat, and rice, with causality flowing from oil to the crops.[14] They relate this effect primarily to cost factors such as the growing reliance of agriculture on energy-intensive fertilizers, transport costs, and fuel used in planting, cultivation, and harvesting. Baffes (2010) has shown that every 10 percent increase in energy prices is associated with an increase of 5 to 6 percent for fertilizers, 4 to 5 percent for precious metals, 2 to 3 percent for food and base metals, and around 1 percent for raw materials.[15] While not the focus of this survey, there are also strong linkages between these resources and water. For example, agriculture accounts for close to 70 percent of the global use of water. Energy accounts for about 8 percent of global water withdrawal. The International Energy Agency (IEA) predicts that the amount of water needed for energy production could grow at twice the rate of energy demand because of a move toward more water-intensive power generation and the expanding

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10 Colin P. Fenton and Jonah Waxman, "Fundamentals or fads? Pipes, not punting, explain commodity prices and volatility," J. P. Morgan Global Commodities Research, *Commodity markets outlook and strategy*, August 2011.

11 Bruce Babcock, "How low will corn prices go?" *Iowa Ag Review*, volume 4, number 4, fall 2008.

12 This does not mean prices in corn would have remained flat in the absence of biofuels. Other market pressures such as weather and increased demand for meat have also put upward pressure on prices. However, when biofuels are the marginal user of corn, increases in ethanol prices can increase the price that this marginal user will pay for corn. For more information, see Bruce Babcock, *The impact of US biofuel policies on agricultural price levels and volatility*, International Center for Trade and Sustainable Development, 2011.

13 Josef Schmidhuber, *Impact of an increased biomass use on agricultural markets, prices and food security: A longer-term perspective*, paper presented at the International Symposium of Notre Europe, Paris, November 2006.

14 Fatimah Mohamed Arshad and Amna Awad Abdel Hameed, "The long run relationship between petroleum and cereals prices," *Global Economy and Finance Journal*, volume 2, number 2, 2009.

15 John Baffes, "More on the energy/non-energy commodity price link," *Applied Economics Letters*, volume 17, number 16, 2010.

output of biofuels.[16] The IEA warns that water shortages could have widespread ramifications for energy production in many regions, including the development of shale gas in China, the production of oil sands in Canada, the generation of power in India, and the maintenance of oil field pressures in Iraq. The mining sector also faces significant water issues. Water shortages have led to shutdowns or lower production in several instances in South Africa, Chile, and elsewhere. Similarly, energy costs drive approximately 50 to 75 percent of the cost of desalination.

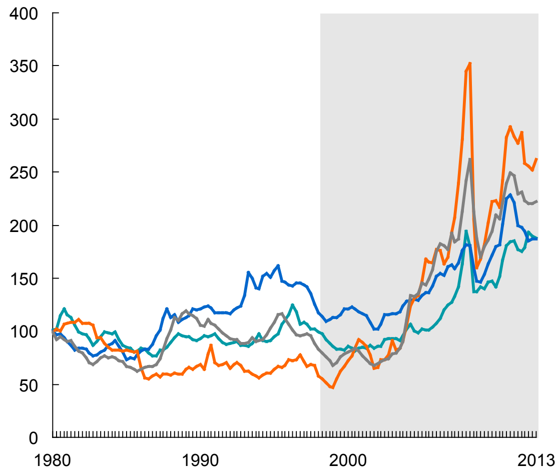
The overall change in resource prices over the past decade masks some interesting variations in the trends of individual resources (Exhibit 4). The nominal price of food commodities has risen the sharpest at 14 percent since 2008 due to a combination of supply-side shocks such as drought and policy responses such as government bans on exports in major agricultural regions. Energy prices have been the most volatile since 2008.

Exhibit 4

Energy prices have been the most volatile of all resource groups over the past decade

Sub-indexes[1]

Nominal price index: 100 = January 1980



	1Q80–4Q99	1Q00–1Q13	1Q08–1Q13	1Q12–1Q13
Nominal price change (%)				
Food	-18	119	14	7
Non-food agriculture	21	54	6	-6
Metals	-21	176	4	-4
Energy	-32	260	-7	-9
Volatility (%)				
Food	10.9	29.7	12.3	3.3
Non-food agriculture	22.1	22.3	12.7	2.1
Metals	17.9	39.5	11.1	0.7
Energy	23.1	46.6	20.7	1.7

1 Each sub-index is weighted by total world export values 2010, with the exception of food, where consumption volumes are used. The specific commodities in each sub-index are listed in Appendix 1.

SOURCE: World Bank; International Monetary Fund; United Nations Conference on Trade and Development; UN Comtrade; McKinsey Global Institute analysis

Some have argued that financial markets are the main reason for higher and more volatile resource prices (see Box 1, "The role of financial markets," for a discussion of the degree to which speculation is leading to price volatility). However, the evidence suggests that fundamental factors influencing demand and supply are the primary drivers of recent price trends. In the future, resource markets will be shaped by the race between emerging-market demand that requires increased supply from places with more challenging geology, and technology that can improve access to resources such as 3D and 4D seismic technology for energy exploration, and boosts to resource productivity including action to reduce food waste and improve the energy efficiency of buildings. In the rest of this survey, we examine the drivers of historical energy, materials, and agriculture (food and raw materials) prices, and the factors that will shape future price dynamics.

16 *World energy outlook 2012*, International Energy Agency (IEA), 2012.

Box 1. The role of financial markets

Between 2005 and 2011, the value of commodity-related assets under management increased almost nine-fold to $450 billion, of which more than $100 billion was invested in agricultural commodities.[17] Commodity-related activity on futures markets also grew rapidly. The number of outstanding futures and options contracts on commodity exchanges increased six-fold from 2000 to 2010, and the value of over-the-counter contracts rose 14-fold between 1998 and 2008.[18] While the increasing volume of financial activity in commodity markets is clear, its impact on commodity prices and volatility is subject to dispute.

In energy markets, for example, Kenneth Singleton points to evidence of a statistically significant effect from investor flows on the futures prices of crude oil.[19] However, the IEA questions the role of speculation in shaping oil prices.[20] Similarly, Fattouh et al. (2012) argue that co-movement between spot and futures prices for oil reflects common economic fundamentals rather than the role of financial markets.[21]

In the case of other resources, too, academia is divided on the role of speculation on commodity prices. In its June 2011 *Global economic prospects*, the World Bank said that the empirical evidence linking investment-fund activity and commodity prices is “at best, weak.”[22] However, the Institute for Agriculture and Trade Policy argues that speculation has had a strong influence on food prices.[23] More recently, a major interagency study of agricultural price volatility found that financial investment in commodities may have contributed to an increasing correlation between oil and non-oil commodity prices and that this could have had an impact on the volatility of agriculture prices.[24] The same report concluded that “while analysts argue about whether financial speculation has been a major factor, most agree that increased participation by non-commercial actors such as index funds, swap dealers, and money managers in financial markets probably acted to amplify short-term price swings and could have contributed to the formation of price bubbles in some situations.”

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17 *Financial investment in commodities markets: Potential impact on commodity prices and volatility*, Institute of International Finance, September 2011.

18 Paul McMahon, *Feeding frenzy: The new politics of food*, Profile Books, 2013.

19 Kenneth J. Singleton, *Investor flows and the 2008 boom/bust in oil prices*, Stanford Graduate School of Business working paper, June 22, 2011.

20 *Oil market report*, IEA, September 13, 2011.

21 Bassam Fattouh, Lutz Kilian, and Lavan Mahadeva, *The role of speculation in oil markets: What have we learned so far?* Centre for Economic Policy Research discussion paper number 8916, March 2012.

22 *Global economic prospects*, World Bank, June 2011.

23 *Commodities market speculation: The risk to food security and agriculture*, Institute for Agriculture and Trade Policy, November 2008.

24 *Price volatility in food and agricultural markets: Policy responses*, report including contributions from the Food and Agriculture Organization of the United Nations (FAO), International Fund for Agricultural Development, IMF, Organisation for Economic Co-operation and Development (OECD), United Nations Conference on Trade and Development (UNCTAD), United Nations World Food Programme, World Bank, World Trade Organization, International Food Policy Research Institute (IFPRI), and UN System High-Level Task Force, June 2011.

2. Energy: The race between technology and geology

Prior to the 1970s, real energy prices (including those of coal, gas, and oil) were largely flat as supply and demand increased in line with each other. During this time, there were discoveries of new, low-cost sources of supply, energy producers had weak pricing power, and improvements were made in the efficiency of conversion from energy sources in their raw state to their usable form. In the 1970s, real oil prices increased seven-fold in response to the Yom Kippur War and the subsequent imposition of an oil embargo by the OAPEC. However, after the 1970s oil shock, the prices of all energy commodities declined for several reasons. First, low-cost deposits were discovered. In the case of oil, Saudi Arabia in 1948 discovered its huge Ghawar oil field, which accounted for 60 to 65 percent of all Saudi oil produced until 2000. Second, the pricing power of the Organization of Petroleum Exporting Countries (OPEC) was squeezed as non-members expanded their own (albeit more costly) supply. OPEC's share of global oil production declined from 51 percent in 1974 to 42 percent in 2000 and represents less than 41 percent today. Third, developed countries moved away from using oil to generate electricity. In the United States, for instance, oil's share of electricity generation fell from 12 percent in 1970 to 3 percent in 2000 and to only 1 percent today. Fourth, there was a large decline in demand following the breakup of the Soviet Union and its energy-intensive production system. Finally, governments in developing countries supported lower energy prices by introducing significant consumption subsidies for energy, particularly during the 1970s oil crisis. Today, the value of these subsidies ranges from $300 billion to $550 billion, depending on the oil price.

Since 2000, however, nominal energy prices have increased by 260 percent, or 10.2 percent annually (Exhibit 5). Uranium prices jumped the most—by over 350 percent in nominal terms. Oil and coal nominal prices rose by 293 and 282 percent, respectively, from their 2000 levels. Behind these rising prices was strong growth in demand, the rising cost of non-OPEC supply, and low spare OPEC production capacity between 2003 and 2008. For example, the average real cost of bringing a new well on line doubled from 2000 to 2010—a cost increase of more than 7 percent per annum.[25] According to the IEA, the main sources of rising costs were drilling and oil field services, skilled labor, materials (including steel), and energy, as well as a shift in spending toward more technically complex projects such as deep-water fields and smaller fields where unit costs tend to be higher.[26] More recently, McKinsey analysis shows that the price of jack-ups and drill-ships used by international oil companies increased by 9 and 6 percent, respectively, in 2011 and 2012. Overall, the upstream capital cost index has increased by 4.5 percent in the past year and has more than doubled since 2000. These factors have more than offset technology improvements that helped lower costs in the 1990s.

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25 IHS/CERA Upstream Capital Costs Index (UCCI), Cambridge Energy Research Associates, May 2011.

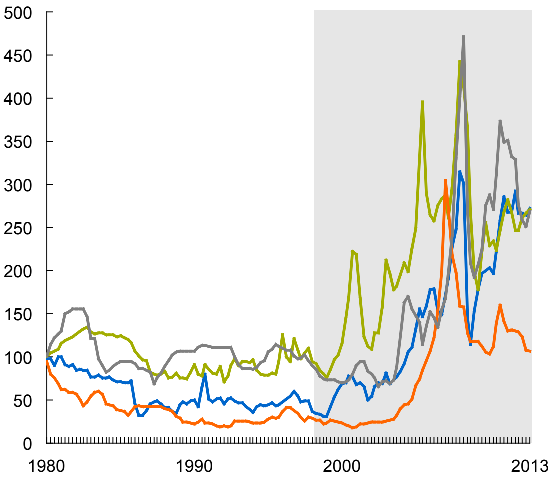
26 *World energy outlook 2008*, IEA, November 2008.

Exhibit 5

In energy, gas prices have increased by the lowest amount over the past decade due to US shale gas production

Energy commodities indexes[1]

Nominal price index: 100 = January 1980



	1Q80–4Q99	1Q00–1Q13	1Q08–1Q13	1Q12–1Q13
Nominal price change (%)				
Oil	-37	293	10	-7
Coal	-30	282	-19	-18
Gas	1	134	-24	10
Uranium	-74	355	-46	-17
Volatility (%)				
Oil	33.8	50.7	23.7	1.3
Coal	20.3	55.5	23.2	4.2
Gas	18.8	31.4	24.5	4.2
Uranium	41.8	70.9	17.8	9.1

1 Each commodity is calculated as a simple average from the data available from different regions—usually the United States, Europe, and Asia.

SOURCE: World Bank; International Monetary Fund; United Nations Conference on Trade and Development; UN Comtrade; McKinsey Global Institute analysis

The dramatic run-up of oil prices in 2008 to more than $140 per barrel was preceded by years of very strong economic and global demand growth. The expansion of supply lagged behind that of demand, and OPEC's spare production capacity was low. The global financial crisis, which started in 2008, led to a significant drop in oil demand and a steep decline in oil prices.

There have also been marked regional divergences in oil prices. Since early 2010, the benchmark US crude oil West Texas Intermediate (WTI) has been trading at a discount to the global benchmark Brent Crude. This discount has been amplified in recent years due to the surge in US shale oil production, which has created a glut of oil around the WTI delivery point at Cushing, Oklahoma, due to the lack of available crude pipeline capacity. The discount has narrowed in recent months as new pipelines have been brought onstream.

The main driver of increasing coal prices has been rapid demand growth. Demand has largely come from India and China, whose economies continued to grow throughout the global financial crisis. This, in addition to widespread supply disruptions, has led to a reshaping of price-setting mechanisms for traded coal as price bargaining power moved from European coal importers to Chinese buyers. Supply was held back by increased labor issues in some countries, bottlenecks at ports, and floods that have forced operations to stop at some mines. According to the Queensland Resources Council in Australia, the state's coal production fell by around 40 million tons due to widespread flooding in 2010 and 2011.

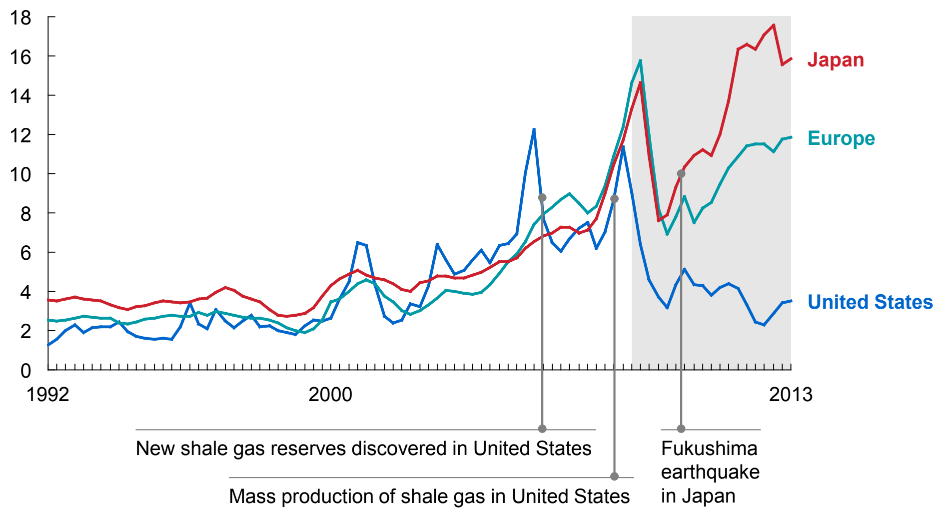
Of all energy prices, that of gas recorded the smallest increase since 2000, albeit with large regional divergences. In the United States, the gas price has fallen considerably since 2008 due to the development of shale gas reserves and the lack of liquefied natural gas (LNG) export terminals, which have resulted in a glut of gas supplies in the domestic market. The production of unconventional natural gas now meets 20 percent of US domestic supply from just 5 percent in 2008.[27] In Japan, gas prices have increased since the Fukushima earthquake and the subsequent shutdown of nuclear capacity pushed up demand for gas. European spot gas prices fell due to the decline in demand during the economic downturn and the abundance of affordable imported coal as the boom in shale gas production in the United States reduced domestic demand for coal and this, in turn, forced Gazprom and other major gas suppliers to offer substantial price concessions under their long-term oil-indexed gas supply contracts (Exhibit 6).

Exhibit 6

Regional gas prices have diverged

Natural gas prices

$ per MMBtu[1]



1 Measure for natural gas volume: MMBtu = million British thermal units. Price shown in nominal terms.
SOURCE: World Bank; International Monetary Fund; United Nations Conference on Trade and Development; UN Comtrade; McKinsey Global Institute analysis

Some key factors will influence future energy-price dynamics:

- **Emerging-market demand.** Incremental world energy demand could swing by up to 15 percent depending on a range of plausible published projections of China's future growth rate and energy intensity (i.e., energy inputs per unit of economic output). We project that China's primary energy demand will grow by more than 2 percent per annum, accounting for more than 40 percent of incremental global energy demand to 2030. We base this projection on growth in China's real GDP of 6.8 percent per year.[28] In most developed countries, per capita energy consumption generally grows consistently until household income hits a threshold of $15,000 to $20,000 in purchasing power parity (PPP) terms. Consumption then typically flattens as economies shift from energy-intensive industries such as manufacturing toward less energy-intensive service industries (Exhibit 7). China's current energy intensity is

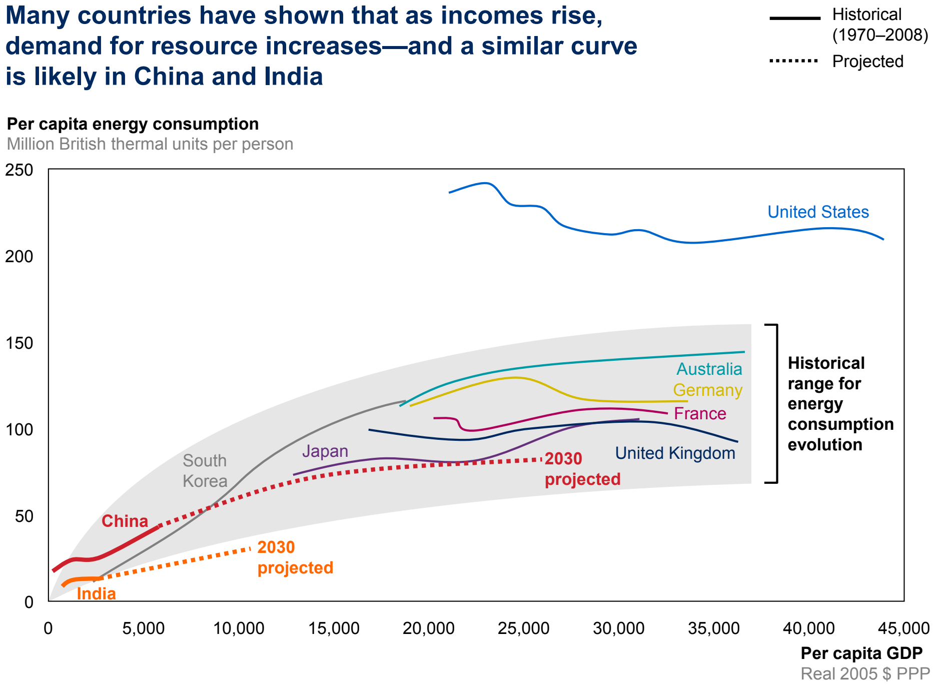
27 "Are we entering a golden age of gas?" *World energy outlook*, IEA Special Report, 2011.

28 This economic growth projection comes from IHS Global Insight. Some economists, including Michael Spence and Barry Eichengreen, argue that China may find it difficult to sustain its fast growth rate as it makes the transition to a middle-income country. See Michael Spence and Sandile Hlatshwayo, *The evolving structure of the American economy and the employment challenge*, Council on Foreign Relations working paper, March 2011; and Barry Eichengreen, Donghyun Park, and Kwanho Shin, *When fast growing economies slow down: International evidence and implications for China*, National Bureau of Economic Research working paper number 16919, March 2011.

around the levels seen in South Korea and Singapore in the late 1980s.[29] We assume that, by 2030, China will reach per capita energy intensity around the level observed in South Korea and Singapore in the late 1990s.

Exhibit 7

Many countries have shown that as incomes rise, demand for resource increases—and a similar curve is likely in China and India



SOURCE: International Energy Agency; IHS Global Insight; McKinsey analysis

- **More challenging sources of supply.** As major oil-rich countries restrict access of international oil companies to low-cost conventional fields, non-OPEC production investments are shifting to unconventional and higher-cost conventional sources of supply such as oil sands and deep-water wells where extraction is more complex. Deep-water offshore oil projects accounted for 24 percent of offshore oil wells in 2009, an increase from 19 percent in 2005.[30] This not only raises the costs and the risk of disruptions to supply but also makes supply even more inelastic. Sanford C. Bernstein, the Wall Street research company, estimates that the marginal cost of oil production has increased by 250 percent over the past decade, rising from just under $30 a barrel in 2002 to a record of $104.5 a barrel in 2012. This has helped to put a floor under energy prices.[31]

- **The technology opportunity.** The unconventional oil and gas boom in the United States demonstrates the potential for new technologies to have a significant impact on the cost of energy (see Box 2, "The global unconventional oil and gas opportunity"). For example, the IEA said in 2012 that the United States could become the world's biggest oil producer by 2017 by continuing to harness its light tight oil (LTO) reserves through hydraulic fracturing or fracking.[32] In addition, past McKinsey research has found

29 We base historical per capita energy intensity on final, rather than primary, energy demand.

30 Colin P. Fenton and Jonah Waxman, "Fundamentals or fads? Pipes, not punting, explain commodity prices and volatility," *Commodity Markets Outlook and Strategy*, J. P. Morgan Global Commodities Research, August 2011.

31 Javier Blas, "Costs rise for 'technological barrels' of oil," *Financial Times*, May 29, 2013.

32 *World energy outlook 2012*, IEA, November 2012.

opportunities such as improving the energy efficiency of buildings to industrial motor systems that could reduce energy demand in 2030 by more than 20 percent.[33] However, significant uncertainty remains about the degree to which technological advancements that improve cost efficiency can offset the rising costs associated with the decreasing quality of reserves, and whether other barriers to new technology development can be overcome. Indeed, while the doubling of upstream costs from 2000 to 2010 can partly be explained by an increase in input costs, Wood Mackenzie data on new oil and gas projects to 2015 suggest that real capital investment per barrel should continue to increase at a rate of 2 percent per annum.[34] Although not covered in this survey, rapid technological advances in renewable energies such as solar and wind could also transform energy markets and have a significant impact on energy prices.[35]

- **Incorporation of environmental costs.** Environmental protection and action to ensure the safety of workers are also driving production costs higher. Extractive technologies have an impact on the environment from carbon emissions to water pollution. However, today's energy costs do not currently reflect many of these secondary effects. One report found that if the health and environmental costs associated with coal in the United States were added to its actual cost, the price of coal from existing plants would rise by 175 percent from 3.2 cents per kilowatt hour to 8.8 cents.[36] For new coal plants, adding in the social and environmental costs would make coal more expensive in some locations than adding new capacity for wind. There are concerns about air and water quality and about land use that are associated with the development of shale gas.[37] The production of shale gas can result in emissions of methane, a greenhouse gas that has roughly 25 times the impact of carbon dioxide over a 100-year time frame and 70 times its impact over a 20-year time frame. There are also concerns about the potential for shale gas to contaminate local drinking water. Fracking uses 100,000 barrels of water per well, and between 30 and 70 percent of that water is not recaptured. When water is returned to the reservoir—flow back—it must be properly treated or disposed of. Worry about the impact on land use largely revolves around wells and their accompanying infrastructure, which can occupy up to almost three hectares per well but whose productivity varies significantly. Horizontal drilling has been shown to be three times as productive per acre as vertical drilling.

33 *Resource Revolution: Meeting the world's energy, materials, food, and water needs*, McKinsey Global Institute and the McKinsey Sustainability & Resource Productivity Practice, November 2011.

34 Wood Mackenzie oil production database.

35 For a more detailed discussion of renewable energy technological improvements, see *Disruptive technologies: Advances that will transform life, business, and the global economy*, McKinsey Global Institute, May 2013.

36 Michael Greenstone and Adam Looney, *A strategy for America's energy future: Illuminating energy's full costs*, The Hamilton Project, Brookings Institution, May 2011. Note that the coal-fired costs of carbon have been adjusted up from $22.5 per tonne to $30.

37 For a more detailed discussion, see *Resource Revolution: Meeting the world's energy, materials, food, and water needs*, McKinsey Global Institute and the McKinsey Sustainability & Resource Productivity Practice, November 2011.

Box 2. The global unconventional oil and gas opportunity

The use of horizontal drilling and fracking, the technologies used for reaching unconventional reserves such as the natural gas and LTO trapped in rock formations (often shale), is now widespread. Recent MGI research has estimated that unconventional oil and gas could have a direct economic impact totaling $95 billion to $460 billion annually by 2025 in North America, China, Argentina, Australia, and Europe.[38] We estimate the bulk of this impact could come from North America due to the relative maturity of its industry.

The technology for extracting unconventional oil and gas is advancing rapidly, which suggests that production could increase even while costs fall. For example, it may be possible to double the productivity of fracking by using micro-seismic data and well-log data in predictive fracture modeling. Such modeling techniques could cut in half the time it takes to understand the behavior of a basin, enabling companies to scale up production more quickly. Technologies that allow the re-use of water and its treatment could reduce the need for fresh water by as much as 50 percent, saving up to $1 million over the life of a well and helping to address a key barrier to the adoption of these technologies in regions with scarce water.

The development of unconventional oil and gas fields is most advanced in the United States and Canada, but other nations are beginning to develop their reserves. China could be among the biggest producers of shale gas in this group, while Argentina and Australia could be the biggest producers of LTO. To get at China's huge shale gas reserves, in January 2013 the Chinese government awarded exploration rights in 19 areas, and it has entered into an agreement with the US government to share technological know-how.

There are still significant barriers to the growth of unconventional oil and gas in these regions, however. Take Europe as an example. Technically recoverable shale gas resources in the European Union (EU) are estimated at 499 trillion cubic feet, 58 percent of the US level.[39] The experience in the United States, which took 35 years to move from discovery to production, suggests that the development of shale gas is subject to a lengthy learning curve. Europe is only at the start of this process with just 30 exploratory wells drilled since 2005. There are also technical challenges because many deposits appear to be deeper in the EU than in the United States, and those deposits drilled so far have encountered higher clay content. Moreover, land ownership is much more fragmented in Europe than in the United States. Publicly owned below-soil land rights mean that there is less incentive for European residents to support nearby drilling. Public concerns about the environmental impact of shale gas are intense, and bans on the industry are in place in Bulgaria, France, and the state of North Rhine–Westphalia in Germany.[40]

38 *Disruptive technologies: Advances that will transform life, business, and the global economy*, McKinsey Global Institute, May 2013.

39 *World shale gas resources: An initial assessment of 14 regions outside the United States*, US Energy Information Association, April 2011.

40 The shale gas opportunity is discussed in further detail in *Investing in growth: Europe's next challenge*, McKinsey Global Institute, December 2012.

3. Metals: The looming supply challenge

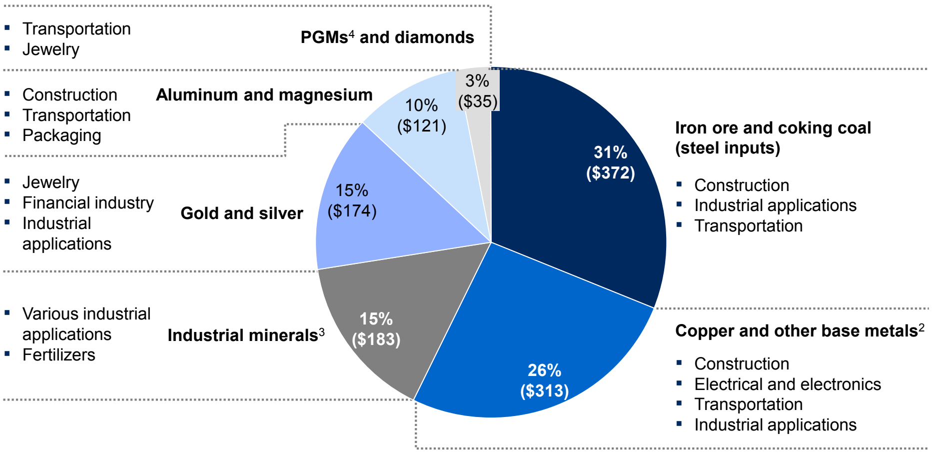
There is a broad range of metals. In the mining industry, the key inputs for the production of steel—iron ore and coking coal—currently account for around 30 percent of revenue in the mining industry (Exhibit 8). The importance of different metals has varied. While steel, copper, and aluminum have always been dominant, other metals such as rare earths are today increasingly in demand (from a low base) due to their use in new consumer electronics, renewable energy, and military applications.

Exhibit 8

The mining industry consists of a large spectrum of commodities serving many industries, with steel accounting for over 30 percent of turnover

Revenue, 2012[1]

100% = $1,198 billion



1 Excludes thermal coal and uranium (which are included in the energy commodities).
2 Refers to metals that oxidize or corrode relatively easily, such as copper, lead, tin, and zinc.
3 Industrial minerals, ferroalloys, and others.
4 Precious group metals.
SOURCE: McKinsey Basic Materials Institute; McKinsey Global Institute analysis

Overall, the real price of metals fell by 0.2 percent (increased by 2.2 percent in nominal terms) a year during the 20th century with some variations. Steel prices were flat while aluminum prices (in real terms) declined by 1.6 percent (increased by 0.8 percent in nominal terms) a year. Where real prices declined, this was due to improvements in technology, the discovery of new, low-cost deposits, and shifts in demand:

- **Technology developments.** Technological improvement has enabled the cost-effective extraction of metals. Aluminum prices dropped sharply in the 1910s because of the commercialization of the low-cost process of refining alumina from bauxite. The development in the 1960s of solvent extraction technology (SX/EW, or the solvent extraction and electro-winning process) has enabled the relatively low-cost processing of copper-oxide resources. Large-scale bulk mining methods and the use of modern bulk carriers in shipping have opened up new resource basins in Australia, Brazil, and Chile.

- **Discovery of low-cost deposits.** This has consistently been a factor behind declining metals prices overall. One example is Chile's Chuquicamata copper mine, which began production in 1915 and is the largest global copper mine in the world measured by cumulative historical production levels. Such significant discoveries have become rather rare since 1995.

- **Demand shifts.** In the 1990s when the Soviet Union broke up, the near curtailment of military spending freed up 80 to 90 percent of local aluminum production capacity, subsequently flooding the world market.[41] Demand for metals from developed countries also stagnated as they began to emerge from the resource-intensive phase of their growth, contributing to lower prices. History suggests that a country's consumption of metals typically grows in line with per capita income until the country reaches a threshold of $15,000 to $20,000 income per capita (in PPP-adjusted dollars) at which time it goes through a period of industrialization and infrastructure building. At higher incomes, growth typically becomes more services-driven, and the per capita use of metals starts to stagnate.[42] There are two important caveats to this general trend. First, countries have different development paths. For example, China has experienced a much stronger urbanization shift than India, which has resulted in greater demand for steel for the construction of buildings and other urban infrastructure (at similar levels of per capita GDP to India's). Second, the mix of commodities that countries demand changes as they develop. Metals such as iron ore tend to attract stronger demand at a relatively low level of per capita GDP, which tends to be the case in the early stages of a country's shift out of agriculture and toward a more urban environment. Other metals such as platinum tend to be "late-cycle" commodities that attract demand at higher levels of per capita GDP.

Since 2000, nominal prices of metals have increased by 176 percent total, or 8 percent annually (Exhibit 9). Gold has increased the most, driven predominantly by investors' perceptions of the metal as a safe asset class during the volatility of the financial crisis, production cost increases of more than 15 percent per annum, and very limited discoveries of high-grade deposits. Copper and steel prices (in nominal terms) have increased by 344 and 167 percent, respectively, since the turn of the century (even taking into account recent price falls) because of strong demand from China. China has consumed more steel in the past decade than it did in the previous 60 years.[43]

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41 Kenneth S. Corts, *The aluminum industry in 1994*, Harvard Business School case study, 1999.

42 Martin Sommer, "The boom in nonfuel commodity prices: Can it last?" in *World economic outlook 2006: Financial systems and economic cycles*, IMF, September 2006.

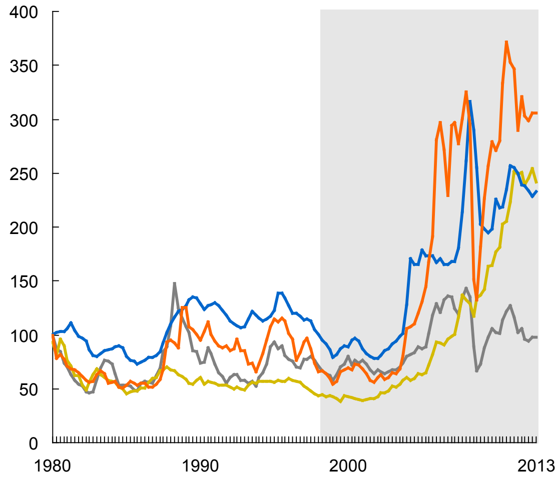
43 *Evolution of the super cycle: What's changed and what may*, Goldman Sachs equity research, April 30, 2013.

Exhibit 9

In metals, aluminum prices over the last decade have lagged behind other categories

Metal commodities indexes[1]

Nominal price index: 100 = January 1980



	1Q80–4Q99	1Q00–1Q13	1Q08–1Q13	1Q12–1Q13
Nominal price change (%)				
Aluminum	-27	27	-27	-8
Copper	-32	344	2	-5
Gold	-53	519	76	-4
Steel	-11	167	9	-3
Volatility (%)				
Aluminum	25.9	24.8	18.6	1.8
Copper	25.9	56.2	22.3	1.1
Gold	18.8	63.8	26.3	2.8
Steel	17.7	37.9	12.8	1.7

1 Subset of metals; see Appendix 1 for full list.

SOURCE: World Bank; International Monetary Fund; United Nations Conference on Trade and Development; UN Comtrade; McKinsey Global Institute analysis

The rise of the aluminum price has been the smallest of any major metal commodity since 2000 at just 27 percent in nominal terms (or 1.5 percent annually) since 2000. Supply of aluminum continues to be abundant due to higher production in China and a considerable global stockpile. China has increased its production of aluminum from just 2.8 million tons in 2000 to 17.8 million tons in 2012 and now accounts for 40 percent of the world's total output (although China's production largely meets domestic demand).[44] A large potential constraint facing China's output of aluminum is the energy-intensive nature of the production process and the fact that China has to import bauxite. The global inventory of aluminum today is at least ten million tons, sufficient to make more than 150,000 Boeing 747 jumbo jets or 750 billion drink cans.[45]

Many observers have pointed to demand from emerging markets such as China as the main reason for the rise in overall prices of metals. However, McKinsey's Basic Materials Institute finds that, while demand from such emerging markets has played a major role, the changing cost of supply has also been an important factor. A combination of geological issues and input cost inflation has put significant upward pressure on prices (Exhibit 10). In the case of gold, more than 45 percent of cost inflation between 2001 and 2011 was due to geological factors that we believe will persist. An additional 30 percent was driven by shortages of inputs including equipment and skilled labor. South Africa used to be the largest gold producer in the world, but today South African gold-mining companies need to mine several kilometers underground to extract reserves, which is much more labor- and energy-intensive. Having said that, there is a link between stronger demand and the higher cost of supply because producers today have to develop supplies in regions where the costs are higher.

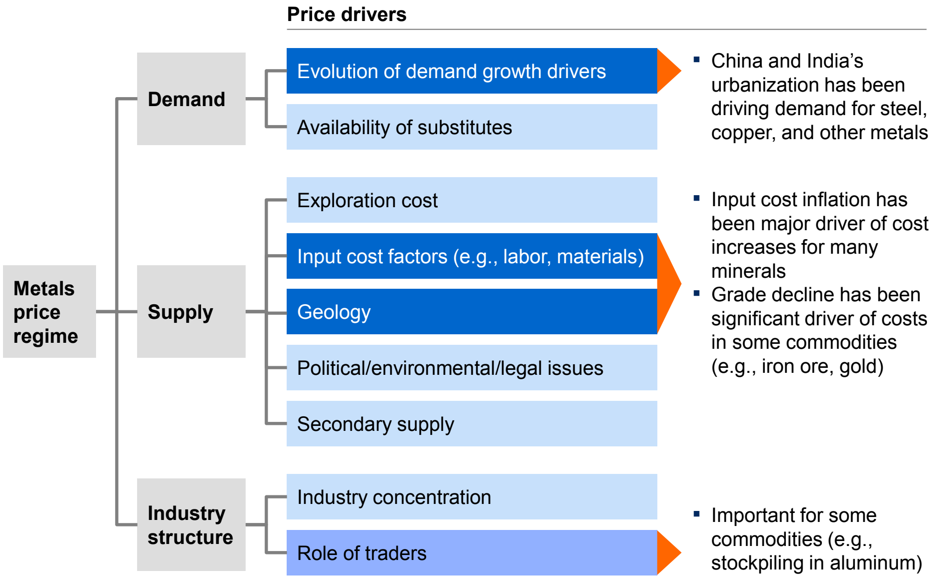
44 Jack Farchy, "Aluminium: Shock and ore," *Financial Times*, October 9, 2012.

45 Ibid.

Exhibit 10

Three drivers are propelling metals prices, with the cost of supply being the key differentiator and geology the main driver

High
Medium
Low



SOURCE: McKinsey Basic Materials Institute; McKinsey Global Institute analysis

Some longer-term trends are already shaping metals markets, including:

- **More challenging access to supply.** The cost of extraction is likely to continue rising because of higher operating expenses in existing mines and the need to access increasingly distant reserves that are frequently of declining quality and/or located in more challenging and risky locations. The depletion rates of existing mines are increasing—for many metals, these rates are now double the rate of demand growth. New reserves are increasingly found in non-OECD countries, often with more challenging geology, regulation, and infrastructure. These challenges are leading to longer lead times for the development of new projects of up to 20 years from conceptual planning to the startup development of a mine. Almost half of new copper projects are in countries with a high degree of political risk.[46] New projects are increasingly challenging in environmental terms and geologically complex, which also drives up the cost of projects. All these factors exacerbate mismatches between demand and supply, and this is leading to more volatility in prices. Price volatility can undermine the social contract between extractive companies and governments. If governments feel they are not obtaining their fair share of a project's revenue when prices spike, there is pressure to renegotiate contract terms. In addition, volatility can deter private-sector investment, thereby increasing government pressure on extractive companies to make better use of existing licenses. Data from the Royal Institution of International Affairs (Chatham House) show that instances of arbitration have increased along with rising oil, metals, and mineral prices since 2000.[47] Finally, due to the increasing size of extractive projects, extractive companies have

46 *Resource Revolution: Meeting the world's energy, materials, food, and water needs*, McKinsey Global Institute and the McKinsey Sustainability & Resource Productivity Practice, November 2011.

47 Bernice Lee, Felix Preston, Jaakko Kooroshy, Rob Bailey, and Glada Lahn, *Resources futures*, Chatham House, December 2012.

a highly visible role in the economies in which they operate, and, for this reason, expectations are higher about, for instance, the number of jobs their operations create and the tax revenue they generate. Historically, petroleum projects have been on a huge scale relative to the size of the economies where they are taking place, but this is also now true of some mining projects. A recent report from Citigroup profiled 400 new mining projects that would require capital of more than $500 billion if all were to go ahead.[48] These increased expectations can place further pressure on the social contract between governments and extractive companies.

- **The funding gap for new projects.** There has recently been a spate of large project write-downs in the mining sector (for example, Rio Tinto's $3 billion write-down on its Mozambique coal project and Anglo American's $4 billion write-down of its Minas-Rio iron ore growth project in Brazil), and this had led investors to focus more on projects that offer strong cash returns and deter them from projects in risky locations. At the same time, the large scale of new projects has made it difficult for junior miners to develop them. As a result, potentially less capital is available for new projects and this could have a significant impact on long-term supply capacity.

- **The skills challenge.** Labor accounts for a large share of rising costs. Mining companies are in increasingly intense competition with each other to find people with the right skills and are having to pay premium wages to attract them. Local labor shortages often occur because mine developments are increasingly in thinly populated areas or countries with small populations, and it is not uncommon for mine workers to earn five to ten times the national average.

- **The emerging-market demand question.** China and other emerging markets are likely to drive metals demand. We expect demand for steel to increase by more than 75 percent from 1,316 million tons in 2010 to 2,312 million tons in 2030, primarily driven by increasing demand from China, India, and other emerging markets (Exhibit 11). Three sectors could account for 80 percent of global growth in steel demand. The construction sector could generate 50 percent of demand growth as urbanization continues in China and India. In these two economies alone, we project that 750 million more people than today could be living in cities in 2030. Per capita floor space is likely to rise as incomes increase, and steel intensity will probably increase as more high-rises are built. Every year, China could add floor space totaling 2.5 times the entire residential and commercial square footage of the city of Chicago. India could add floor space equal to another Chicago annually. The machinery and engineering sector could account for around 20 percent of global demand growth as the industrial sectors of emerging markets, particularly China, expand. Finally, the transport sector could be responsible for around 10 percent of global growth in the demand for steel, reflecting the increasing penetration of cars in emerging markets. China's economy is such a dominant factor in the overall growth of emerging markets that a slowdown in its growth rate or an accelerated reduction in resource intensity would have a marked negative impact on the mining sector (in terms of resource demand). Our estimates show that, under different plausible assumptions about growth in

48 *Generation next: A look at future greenfield growth projects*, Citigroup equity research, June 20, 2011.

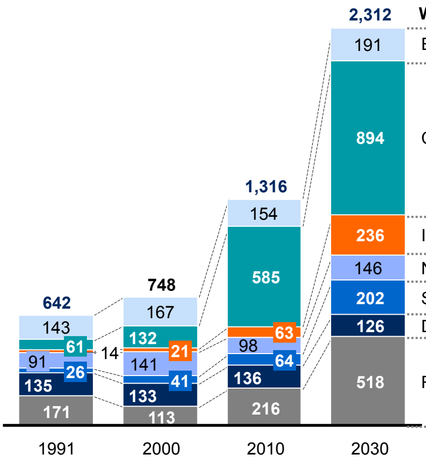
China's future steel demand, global steel demand could vary by more than 22 percent.

Exhibit 11

Global steel demand is expected to increase by more than 75 percent from 2010 to 2030, driven by emerging markets

Finished steel demand

Million tons



Demand growth and regional contribution to growth

% of incremental demand

	1991–2000	2000–10	2010–30
World	106	568	996
Europe	22.3	-2.2	3.7
China	66.9	79.9	31
India	6.8	7.3	17.3
North America	46.8	-7.5	4.8
South America	14.5	4	13.9
Developed Asia	-1.9	0.4	-1
Rest of the world[1]	-55.2	18.1	30.4

1 Includes the Commonwealth of Independent States, Middle East and North Africa, sub-Saharan Africa, and Oceania.
NOTE: Numbers may not sum due to rounding.
SOURCE: McKinsey analysis; McKinsey Global Institute analysis

- **New forms of demand.** Renewable technologies and electric vehicles are also likely to drive demand for some metals. For example, the strong penetration of new vehicle technologies could drive a 120- to 200-fold increase in demand for neodymium and lithium.[49]

- **Incorporating environmental externalities.** The mining industry could face increasing pressure from regulators to pay for inputs such as carbon and water that are currently largely un-priced. A carbon price would have the most direct impact on coal producers (discussed in the energy section of this survey) but would also have an indirect impact on other operators through increases in the cost of energy inputs. Pricing water could have a dramatic impact on costs—and constrain output—given that 32 percent of copper mines and 39 percent of iron ore mines are in areas of moderate to high water scarcity, according to Trucost. Analysis by McKinsey and Trucost shows that pricing water to reflect its "shadow cost" (i.e., the economic value of the water if put to its best alternative use) could increase iron ore costs by 3.3 percent across the industry. A price of $30 per tonne of carbon emissions could increase the cost of iron ore by 2.5 percent. Goldman Sachs has estimated that a hypothetical $10 per tonne carbon tax would have reduced profits of mining companies by around 2 percent in 2011.[50] In water-scarce regions, some operators could face increased costs of up to 16 percent from the combined costs of water and carbon emissions.

49 *Resource Revolution: Meeting the world's energy, materials, food, and water needs*, McKinsey Global Institute and the McKinsey Sustainability & Resource Productivity Practice, November 2011.

50 *Evolution of the super cycle: What's changed and what may*, Goldman Sachs equity research, April 30, 2013.

- **Disruptive demand-side technologies and recycling.** There is a large opportunity to curtail future demand for metals through technology that increases the efficiency with which we use metals, and through increased recycling. Past McKinsey research has found potential to address up to 13 percent of 2030 steel demand through, for example, higher use of high-strength steel.[51] Even more impact on demand could be achieved through the adoption of the "circular economy" concept that aims to reduce, re-use, and recycle resources. A circular economy is an industrial system that is restorative or regenerative by intention and design. It replaces the "end-of-life" concept with restoration; shifts toward the use of renewable energy; eliminates the use of toxic chemicals, which impair re-use; and aims for the elimination of waste through the superior design of materials, products, systems, and within this, business models.[52] Take the example of washing machines. Over a 20-year period, replacing the purchase of five 2,000-cycle machines with the lease of one 10,000-cycle machine would also yield almost 180 kilograms of steel savings. In total, the Ellen MacArthur Foundation estimates that more than 100 million tons of iron ore use could be avoided by 2025 if the circular economy were to be broadly applied in the steel-intensive automotive, machining, and other transport sectors that account for about 40 percent of demand. The opportunity to boost recycling is significant. Strong demand for metals over the past decade that has led to high resource prices means that a significant amount of scrap metal is available. Recycling of precious metals has more than doubled since 2005.[53]

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51 *Resource Revolution: Meeting the world's energy, materials, food, and water needs*, McKinsey Global Institute and the McKinsey Sustainability & Resource Productivity Practice, November 2011.

52 *Towards the circular economy: Economic and business rationale for an accelerated transition*, Ellen MacArthur Foundation, 2012.

53 *Evolution of the super cycle: What's changed and what may*, Goldman Sachs equity research, April 30, 2013.

4. Agriculture: Falling yield growth hits prices

Food prices (in real terms) fell by an average of 0.7 percent (increased by 1.7 percent in nominal terms) a year during the 20th century despite a significant increase in food demand. Demand for grain, for instance, increased by 2.2 percent per annum from 1961 to 2000. Declining food prices were not due to large increases in the use of cropland—in fact, use of cropland for grains increased by just 0.1 percent a year during this period.[54] Instead, prices fell because grain yields increased at a rapid rate of 2.1 percent per annum between 1961 and 2000, largely as a result of greater use of fertilizers and capital equipment, and the diffusion of improved farming technologies and practices. In the latter part of that period, however, the rate of yield growth decelerated—potentially a sign of things to come. From 1961 to 1970, yields grew at 3.0 percent per annum but then increased at a rate of only 1.1 percent from 1990 to 2000. When we take into account mix effects in which lower-yielding crops are substituted for those with higher yields, growth in cereals yields slowed even more significantly to just 0.4 percent a year from 1991 to 2000.

There are three major reasons for the deceleration in progress on agricultural yields. First, yields in developed countries have begun to converge with "best practice" yields—where agro-ecological conditions and the prevailing level of technology constrains further yield growth. For large-scale farms, there appear to be diminishing marginal returns to additional inputs. Second, investment in R&D aimed at increasing attainable yields has been declining. Third, a range of political, infrastructural, and supply-chain bottlenecks has limited the spread of best practice in agricultural techniques to other countries.

A combination of falling yield growth, increases in demand for feed and fuel, supply-side shocks (due to droughts, floods, and variable temperatures), declines in global buffer stocks, and policy responses (e.g., governments in major agricultural regions banning exports) has contributed to a rapid rise in nominal food prices of almost 120 percent (or 6.1 percent annually) since the turn of the century (Exhibit 12).

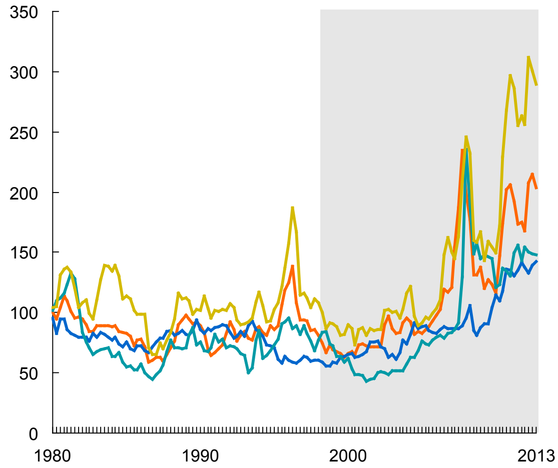
54 Although demand for cropland grew slowly, the impact of changes in land use was still significant. Annual growth of 0.1 percent implies an expansion of cropland of 146 million hectares from 1961 to 2000. This figure underestimates the degree to which land use changes as cropland has shifted due to urban expansion, growth in mining and energy extraction, and some land degradation. From 1980 to 2000, tropical regions added about 100 million hectares of pasture and arable land, about 80 percent of which came from the clearing of primary and secondary forests. Considering all crops, global demand increased by 2.3 percent per annum, land use expanded by 0.7 percent a year, and yields increased by 1.6 percent. See Holly K. Gibbs et al., *Tropical forests were the primary sources of new agricultural land in the 1980s and 1990s*, proceedings of the National Academy of Sciences, volume 107, number 38, September 21, 2010.

Exhibit 12

In food, all major commodities have experienced large price increases since 2000

Food commodities indexes[1]

Nominal price index: 100 = January 1980



	1Q80–4Q99	1Q00–1Q13	1Q08–1Q13	1Q12–1Q13
Nominal price change (%)				
Wheat	-37	208	-13	16
Corn	-22	223	39	10
Beef	-33	117	59	0
Rice	-42	138	14	3
Volatility (%)				
Wheat	17.7	40.0	21.5	10.5
Corn	20.0	47.5	26.2	8.3
Beef	14.3	26.4	19.1	2.8
Rice	24.3	48.2	16.3	2.0

1 Subset of food; see Appendix 1 for full list.

SOURCE: World Bank; International Monetary Fund; United Nations Conference on Trade and Development; UN Comtrade; McKinsey Global Institute analysis

Within food crops—particularly corn and to a slightly lesser extent wheat and soybean—prices surged in the latter half of 2012 as US farmers endured their worst drought in 56 years and as a combination of heat waves and floods across Australia, Western and Eastern Europe, Russia, and Latin America created challenges for 2012 harvests. Other crops, such as palm oil and sugar, did not have the same increases in the latter part of 2012 as production levels continued to be high and strong stock levels tempered price increases.

Beef prices (in nominal terms) increased by 117 percent but poultry and pork prices by somewhat less. World meat consumption continues to grow at one of the highest rates of any agricultural commodity. Production costs have been increasing due to high feed prices and energy-related inputs including transport and cold supply chain costs, as well as increasingly stringent food safety, environmental, and animal-welfare regulations covering, for instance, traceability, housing, and transportation.[55]

Fish prices have also increased significantly since 2000. In 2009, fish accounted for about 16 percent of the global intake of animal protein and 6 percent of all protein consumed.[56] The United Nations Food and Agriculture Organization (FAO) estimates that global fish production grew at an average 3.2 percent a year between 1961 and 2009, outpacing the increase of 1.7 percent per year in the world's population.[57] Global per capita food fish supply increased from an average of 9.9 kilograms in the 1960s to 18.4 kilograms in 2009. However, achieving sufficient supplies of fish to meet demand is becoming increasingly challenging. An estimated 30 percent of the world's fish stocks are currently considered

55 *OECD-FAO agricultural outlook 2012–2021*, 2012.

56 *The state of world fisheries and aquaculture 2012*, FAO, 2012.

57 Ibid.

overexploited and an additional 50 percent considered fully exploited.[58] As a result, wild fisheries production since the late 1980s has largely stagnated.

Aquaculture is beginning to dominate the supply of fish. In 1970, aquaculture accounted for just 4 percent of total seafood supply but now accounts for 46 percent of supply.[59] Despite the growth of aquaculture, fish prices overall have increased rapidly due to the rising price of fishmeal, fish, and other feeds, and the fact that catching fish in the wild is more challenging.

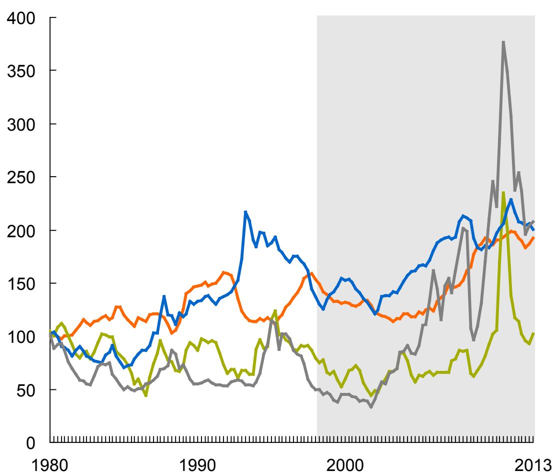
Since the turn of the century, nominal non-food agricultural commodity prices have risen by between 30 and 70 percent (2.1 and 4.1 percent annually) in the case of timber, cotton, and tobacco (Exhibit 13). Volatility in overall non-agricultural commodity prices has been more than 17 and 58 percent higher during the past decade than it was in the 1980s and 1990s, respectively. Since 2000, the largest price increase has been in rubber at more than 350 percent, the principal driver being constraints on supply at a time of surging demand. On the supply side, Thailand, Indonesia, and Malaysia, the three major world producers accounting for roughly two-thirds of the world output of rubber, formed the International Tripartite Rubber Organisation in 2001 with the aim of managing production in such a way as to maintain orderly growth in the market and guarantee a minimum price to their domestic producers (Vietnam joined in 2007). In addition, adverse weather conditions, including severe floods, have disrupted production in major producing countries. Upward pressure on prices also came from surging penetration of vehicles in emerging markets, particularly China, which has boosted demand for rubber for vehicles tires (more than 60 percent of natural rubber is used for tires).[60]

Exhibit 13

In non-food agricultural raw materials, rubber prices have increased much more rapidly than other resources

Raw materials commodities indexes[1]

Nominal price index: 100 = January 1980



	1Q80–4Q99	1Q00–1Q13	1Q08–1Q13	1Q12–1Q13
Nominal price change (%)				
Tobacco	30	46	30	0
Timber	52	31	-3	-3
Cotton	-50	70	18	-11
Rubber	-55	359	15	-18
Volatility (%)				
Tobacco	14.0	20.3	7.9	2.0
Timber	31.1	16.7	6.3	1.4
Cotton	19.4	43.8	41.0	4.7
Rubber	26.3	62.5	34.2	8.4

1 Subset of commodities; see Appendix 1 for full list.

SOURCE: World Bank; International Monetary Fund; United Nations Conference on Trade and Development; UN Comtrade; McKinsey Global Institute analysis

58 *The state of world fisheries and aquaculture*, FAO, 2010.

59 Ibid.

60 *Medium-term prospects for agricultural commodities: Projections to the year 2010*, FAO, 2003.

Among the longer-term trends starting to shape agriculture markets are:

- **Emerging-market demand.** A projected 35 percent increase in food demand to 2030 is expected to come largely from the developing economies of China, India, other Asian countries, and the continent of Africa. This strong demand is likely to be driven by increasing calorie consumption, rising populations, and increasing consumption of meat that requires more land per calorie to produce. In India, we expect calorie intake per person to rise by 20 percent over the next 20 years, and China's per capita meat consumption could increase by 40 percent to 75 kilograms (165 pounds) a year (and still be well below US consumption levels). Dietary trends also could have an impact on demand for cropland and prices. In contrast, shifting just 20 percent of the world's 2010 calorie consumption from meat to fish would save about 60 million to 80 million hectares of cropland.[61] This would be roughly equivalent to three to four times the landmass of the United Kingdom and around 30 to 45 percent of new cropland required to 2030. While switching to fish might theoretically offer large environmental benefits, we should note that some aquaculture production also has an impact on the environment through, for instance, the clearing of mangroves. In addition, aquaculture may increase pressure on the supply of agricultural inputs for feedstocks such as soy.

- **Climate and ecosystem risks.** Productivity lost due to land degradation and climate change could require an additional 30 million to 75 million hectares by 2030 if significant increases to crop efficiency on remaining land cannot be achieved. Serious land degradation affects more than 20 percent of the world's arable land. There are many causes of such degradation, including the pollution of land and water resources, soil nutrient mining, and soil salinization.[62] Soil salinization highlights the link between resources. The over-extraction of groundwater leads to a lowering of the water table. In coastal areas, this can allow the intrusion of marine water, increasing the salinity of the water table. The severity of the degradation varies, and with it the extent of yield loss. We account for land degradation by calculating the amount of new cropland needed to compensate for an overall loss of productivity. We estimate this at 30 million hectares. Different studies offer a wide range of estimates for the impact of climate change on agricultural yields, from a loss of 27 percent by 2050 to an increase of 22 percent. One recent study estimated that global temperature rises are already having a significant impact on cereals yields.[63] Different assumptions on carbon dioxide fertilization are a major source of disagreement in these estimates.[64] In view of the wide

61 This assumes that incremental fish production would come from aquaculture.

62 *The economics of desertification, land degradation, and drought: Toward an integrated assessment*, IFPRI, 2011.

63 Between 1980 and 2008, a recent study found global production of corn and wheat to be 3.8 percent and 5.5 percent lower, respectively, as a result of the warming of the global climate compared with a reference case without climate change. See David B. Lobell, Wolfram Schlenker, and Justin Costa-Roberts, "Climate trends and global crop production since 1980," *Science*, volume 333, number 6042, May 2011.

64 Carbon dioxide fertilization describes the effect that increased concentration of carbon dioxide in the atmosphere has on crop yields. Its effect is subject to much debate. Some claim it will have a positive effect, while others cite recent studies showing the effect to be minimal due to other constraints such as the availability of nitrogen and phosphorous. See Gerald C. Nelson et al., *Climate change: Impact on agriculture and costs of adaptation*, IFPRI, 2009; and Christoph Müller et al., *Climate change impacts on agricultural yields*, Potsdam Institute for Climate Impact Research, 2010.

range of estimates, we make a conservative, median assumption of a zero to 2 percent negative impact on yields by 2030. This could result in additional demand for cropland of as much as 45 million hectares.[65] In addition to this, as we have noted, 30 percent of all fish stocks are now overexploited (beyond their maximum sustainable limits), and an additional 50 percent are fully exploited (at or close to those limits), putting pressure on wild-catch fisheries. Past McKinsey research has highlighted the potential benefits—as well as the challenge—of moving to a more sustainable model for fisheries.[66]

- **Urban expansion.** The global phenomenon of urbanization could encroach on an additional 30 million hectares of cropland, leading to a loss of an estimated two million hectares per year, about three-quarters of that being agricultural land.[67] As a result of this trend, agriculture is shifting to increasingly marginal lands with poorer soils and weak infrastructure.

- **Energy (biofuels and energy infrastructure).** Energy drives higher demand for land. Breaking that down into its constituent parts, we find that biofuels could be responsible for two-thirds of the energy impact on land demand, and other energy sources the remaining one-third. The FAO has predicted that the global production of bioethanol and biodiesel, heavily concentrated in Brazil, the United States, and the EU, is projected to almost double by 2021. By 2021, the FAO forecasts that biofuels could consume 34 percent of sugarcane production (up from 23 percent today), 16 percent of vegetable oil production, and 14 percent of coarse grain production.[68] McKinsey estimates suggest biofuels could require the equivalent of an additional 15 million hectares of land by 2030.[69] Other energy sources, such as the construction of dams, could require an additional ten million hectares of cropland. In combination with demand for biofuels, we estimate that energy will account for more than 10 percent of incremental demand for cropland in 2030.

- **Productivity opportunities.** Increasing the productivity of agricultural systems could reduce demand for land by almost 30 percent by 2030.[70] Opportunities to raise productivity include improving crop yields on

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65 A 2 percent reduction in yields assumes that any gains from improving climate in certain areas or increased fertilization are more than offset by worsening climate (e.g., higher volatility in rainfall, higher temperatures) globally. The global reduction of crop production caused by loss of productivity will need to supplemented by production from areas with future potential for cropland expansion, as many of the current agricultural cropland areas have extremely low potential for such expansion (e.g., in the United States, the EU, and East and South Asia). Because around 90 percent of future cropland expansion is projected to take place in Latin America and sub-Saharan Africa, whose yields will be about 35 percent lower than the global average, the world will require 15 million more hectares than the zero to 30 million hectares it needs to make up because of lost productivity due to climate change.

66 *Design for sustainable fisheries: Modeling fishery economics*, McKinsey Sustainability & Resource Productivity Practice, September 2011.

67 Shlomo Angel, Stephen C. Sheppard, and Daniel L. Civco, *The dynamics of global urban expansion*, World Bank, September 2005.

68 *OECD-FAO agricultural outlook 2012–2021*, 2012.

69 The land directly put into production to grow the crops for biofuels would be around 25 million hectares, as 30 to 80 percent of biomass input for biofuel production is fed back to livestock feed. However, there would also be a reduction of about ten million hectares in the amount of cropland required to produce feed crops.

70 *Resource Revolution: Meeting the world's energy, materials, food, and water needs*, McKinsey Global Institute and the McKinsey Sustainability & Resource Productivity Practice, November 2011.

commercial and smallholder farms—particularly in sub-Saharan Africa, where significant yield gaps exist—and reducing food waste in the value chain, which can be as high as 20 to 30 percent even before allowing for food waste at the point of consumption. There is a large opportunity to reduce food waste both in high-income economies where supply chains are more efficient and middle- and low-income economies with less advanced supply chains. In the case of fruit and vegetables, roughly 50 percent of all produce grown is wasted.[71] Given the embedded energy in the production, consumption, and distribution of food, energy savings from reducing food waste are potentially large. For example, roughly 17 percent of energy use in the United States is linked to the production, distribution, and consumption of food.[72] Reducing food waste globally could save $340 billion a year by 2030.[73]

71 *Global food losses and food waste: Extent, causes, and prevention*, FAO, 2011.

72 Amanda D. Cuéllar and Michael E. Webber, "Wasted food, wasted energy: The embedded energy in food waste in the United States," *International Journal of Environment, Science and Technology*, volume 44, number 16, August 15, 2010.

73 Ibid.

Appendix 1: Background to the MGI Commodity Index

To improve our understanding of commodity price trends, we have developed an index of 43 key commodities broken into four sub-groups: energy, metals, food, and non-food agricultural raw materials. We weight commodities within each sub-group based on their share of global export values. The one exception to this is food where, given the high share of production that is used for domestic consumption, an export-based index would not be appropriate. Instead, we use a total (price-weighted) consumption index to weight the importance of different food commodities. This gives us four sub-indexes. Finally, we take an average of the four sub-indexes to create the composite MGI Commodity Index. We do not weight the four sub-indexes by their share of export values, given energy's disproportionate share of global trade.

The four commodity sub-groups have the following sub-indexes:

- **Energy.** Oil, coal, gas, and uranium.
- **Metals.** Steel, copper, aluminum, tin, nickel, silver, lead, zinc, gold, rock phosphate, potassium chloride, platinum, and tungsten.
- **Food.** Cocoa, coffee, tea, oils, groundnuts, soybeans, barley, wheat, rice, corn, bananas, oranges, beef, lamb, pork, poultry, fish, shrimp, and sugar.
- **Non-food agricultural raw materials.** Tobacco, timber, cotton, hides, rubber, wool, and sisal.

This index builds in three ways on the previous MGI Commodity Index discussed in the 2011 MGI and the McKinsey Sustainability & Resource Productivity Practice report *Resource Revolution: Meeting the world's energy, materials, food, and water needs*.[74] First, it includes a broader range of resources, covering 43 commodities (compared with 28 commodities in the 2011 report). The price data come from a variety of sources, including the World Bank, the IMF, and UNCTAD. Data on trade volumes come from the United Nations' Comtrade database. Second, we have tried to capture geographical price movements for those commodities (specifically for oil and gas), where there are sometimes large discrepancies in price movements between markets. In particular, we use proxies for prices in Europe, North America, and Asia to reflect these different price movements. Third, we have switched from annual price data to quarterly price data, so we can examine the evolution of commodity prices at a more granular level. The more limited availability of time series data that meet these requirements means that our analysis begins from 1980, as opposed to 1900 in the earlier report (with the exception of Exhibit 1, which is based on annual data).

74 *Resource Revolution: Meeting the world's energy, materials, food, and water needs*, McKinsey Global Institute and the McKinsey Sustainability and Resource Productivity Practice, November 2011.

Despite these changes, the overall results are very consistent with those shown in the 2011 report. In particular, we still observe the spike in resource prices and the increased volatility in prices over the last decade. However, there are some differences. The use of quarterly price data means that we observe greater variance in resource prices, particularly during the financial crisis, which is somewhat obscured with the use of annual data. Also, unlike our approach in the 2011 report, with the exception of Exhibit 1, we do not deflate the index for changes in overall inflation levels, as the focus in this survey is not on the evolution of the real cost of resources but rather their nominal price movements. The result of this is that the price decline between 1980 and 2000 is more muted than that seen in the index in the Resource Revolution report.

There are a few important points to note about the index:

- **Portfolio weightings.** Within the four sub-indexes, the weightings used are total world export values (or consumption values in the case of food) from 2010. A potential source of bias in the results arises out of the fixed weights for these commodities over the period analyzed, but historical data were insufficient to introduce annual weightings for export values. For the overall index, we used a simple arithmetic average. If we based this average on market values, this would change the index significantly, because three commodities—steel, oil, and timber—would tend to dominate. To capture the effects across the sub-indexes, we also used a simple arithmetic average, not one weighted for market values.

- **Inflation adjustments.** The long-term resource price trends shown in Exhibit 1 are deflated using an index that accounts for inflation in the prices of manufactured goods exported by the G-5 countries (the United States, the United Kingdom, Japan, France, and Germany), weighted by share of exports. Inflation measures have been criticized for failing to account for quality improvements in goods (which implies that the quality-adjusted price change may be lower), re-weightings of consumer and business consumption in reaction to price changes (meaning that the overall price increase on consumer and business budgets may be lower due to adjustment of buying decisions), or the introduction of new goods.[75] It is difficult to control for the first of these, but this is unlikely to change the overall message of the index, which indicates a rapid increase in prices since 2000. The conclusions of the index would change only if we could establish that the rate of quality improvement of a given good has increased significantly compared with historical growth rates during this period, and that seems unlikely. The failure to capture fully shifts in business and consumer consumption to lower-priced goods means that the index potentially shows a steeper decline in 20th-century prices than businesses actually experienced. However, this, too, is unlikely to affect the finding that there has been a trend break in the price index since the turn of the century. For the rest of the analysis shown in this survey, the price movements are shown in nominal price terms.

- **Exchange-rate adjustments.** The index uses current prices in US dollars for the relevant period (e.g., 1990 prices based on the 1990 exchange rate). This approach allows us to compare price levels and changes across different regions and commodities at a specific point.

75 John E. Tilton and Peter Svedberg, “The real price of nonrenewable resources: Copper 1870–2000,” *World Development*, volume 34, number 3, 2006.

Appendix 2: Resource price tables

Exhibit A1
Energy

	Crude oil (Europe)	Crude oil (Asia)	Crude oil (United States)	Coal	Natural gas (United States)	Natural gas (Europe)	Natural gas (Japan)	Uranium
Nominal price change (%)								
1Q80–4Q99	-37	-38	-38	-30	75	-40	-34	-74
1Q00–1Q13	294	321	344	282	33	244	271	355
1Q08–1Q13	10	17	18	-19	-60	9	52	-46
1Q12–1Q13	-7	-5	-7	-18	42	3	-3	-17
4Q12–1Q13	3	2	1	7	3	1	2	-1
Volatility (%)								
1Q80–4Q99	33.7	34.7	36.8	20.3	22.1	25.2	25.0	41.8
1Q00–1Q13	50.8	52.4	54.0	55.5	42.0	45.6	49.9	70.9
1Q08–1Q13	23.7	25.3	24.5	23.2	48.8	21.7	24.0	17.8
1Q12–1Q13	1.3	1.5	0.8	4.2	18.5	2.7	5.8	9.1

SOURCE: World Bank; International Monetary Fund; United Nations Conference on Trade and Development; UN Comtrade; McKinsey Global Institute analysis

Exhibit A2
Metals

Nominal price change (%)

	Aluminum	Copper	Lead	Tin	Nickel	Zinc	Gold
1Q80–4Q99	-27	-32	-46	-61	15	47	-53
1Q00–1Q13	27	344	285	339	163	99	519
1Q08–1Q13	-27	2	-21	33	-40	-15	76
1Q12–1Q13	-8	-5	7	5	-12	1	-4
4Q12–1Q13	0	0	3	12	2	4	-5

	Silver	Platinum	Steel	Rock phosphate	Potassium chloride	Tungsten
1Q80–4Q99	-84	-47	-11	-4	11	-70
1Q00–1Q13	561	171	167	302	222	117
1Q08–1Q13	70	-13	9	-26	6	-9
1Q12–1Q13	-8	2	-3	-12	-19	0
4Q12–1Q13	-8	2	2	-6	-9	0

Volatility (%)

	Aluminum	Copper	Lead	Tin	Nickel	Zinc	Gold
1Q80–4Q99	25.9	25.9	24.0	40.5	40.7	26.2	18.8
1Q00–1Q13	24.8	56.2	54.5	58.4	54.3	49.6	63.8
1Q08–1Q13	18.6	22.3	18.8	23.8	24.9	17.6	26.3
1Q12–1Q13	1.8	1.1	5.6	9.2	2.4	3.1	2.8

	Silver	Platinum	Steel	Rock phosphate	Potassium chloride	Tungsten
1Q80–4Q99	59.9	21.8	17.7	12.6	17.7	47.6
1Q00–1Q13	74.1	41.3	37.9	88.8	70.3	46.1
1Q08–1Q13	38.3	18.2	12.8	46.9	31.1	3.8
1Q12–1Q13	4.6	4.3	1.7	3.0	7.9	0

SOURCE: World Bank; International Monetary Fund; United Nations Conference on Trade and Development; UN Comtrade; McKinsey Global Institute analysis

Exhibit A3
Food

Nominal price change (%)

	Cocoa	Coffee	Tea	Oils	Oranges	Soybeans	Barley	Wheat	Rice	Corn
1Q80–4Q99	-70	-48	20	-18	16	-27	7	-37	-42	-22
1Q00–1Q13	145	59	59	139	160	177	225	208	138	223
1Q08–1Q13	-11	0	24	-17	-24	10	10	-13	14	39
1Q12–1Q13	-6	-24	10	-10	9	21	11	16	3	10
4Q12–1Q13	-10	-3	-4	-2	-2	-8	-4	-5	0	-4

	Ground-nuts	Bananas	Beef	Lamb	Pork	Poultry	Fish	Shrimp	Sugar
1Q80–4Q99	-3	-10	-33	4	-28	79	-42	35	-34
1Q00–1Q13	63	87	117	-22	46	74	267	-35	51
1Q08–1Q13	-19	12	59	-43	49	27	61	20	1
1Q12–1Q13	-51	-11	0	-22	-6	10	44	36	-24
4Q12–1Q13	-4	-2	2	9	1	4	6	25	-5

Volatility (%)

	Cocoa	Coffee	Tea	Oils	Oranges	Soybeans	Barley	Wheat	Rice	Corn
1Q80–4Q99	28.4	31.6	19.0	18.5	17.1	16.0	23.2	17.7	24.3	20.0
1Q00–1Q13	35.7	46.0	26.5	38.0	27.6	39.5	38.5	40.0	48.2	47.5
1Q08–1Q13	14.0	22.6	10.2	20.1	15.9	16.0	24.5	21.5	16.3	26.2
1Q12–1Q13	5.8	6.9	2.3	5.2	8.3	9.4	3.9	10.5	2.0	8.3

	Ground-nuts	Bananas	Beef	Lamb	Pork	Poultry	Fish	Shrimp	Sugar
1Q80–4Q99	28.6	20.5	14.3	17.1	35.6	21.1	16.3	16.5	23.9
1Q00–1Q13	41.2	30.1	26.4	15.4	19.3	14.8	40.8	24.9	23.9
1Q08–1Q13	31.6	8.0	19.1	19.0	18.4	5.6	18.0	12.3	17.2
1Q12–1Q13	31.9	2.2	2.8	5.6	2.8	2.8	10.1	15.4	7.9

SOURCE: World Bank; International Monetary Fund; United Nations Conference on Trade and Development; UN Comtrade; McKinsey Global Institute analysis

Exhibit A4
Non-food agricultural raw materials

	Tobacco	Timber	Cotton	Hides	Rubber	Wool	Sisal
Nominal price change (%)							
1Q80–4Q99	30	52	-50	62	-55	-32	-15
1Q00–1Q13	46	31	70	12	359	169	130
1Q08–1Q13	30	-3	18	31	15	32	27
1Q12–1Q13	0	-3	-11	11	-18	-10	-3
4Q12–1Q13	3	-2	10	0	2	8	-8
Volatility (%)							
1Q80–4Q99	14.0	31.0	19.4	26.0	26.3	24.3	17.0
1Q00–1Q13	20.3	16.7	43.8	16.6	62.5	37.6	26.6
1Q08–1Q13	7.9	6.3	41.0	22.8	34.2	29.1	23.8
1Q12–1Q13	2.0	1.4	4.7	1.1	8.4	5.0	5.0

SOURCE: World Bank; International Monetary Fund; United Nations Conference on Trade and Development; UN Comtrade; McKinsey Global Institute analysis

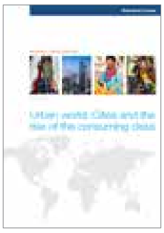
Related MGI and McKinsey research

McKinsey Insights iPad app (September 2013)

This new app provides mobile access to the latest perspectives from McKinsey, MGI, and *The McKinsey Quarterly*. Our articles and reports address the most challenging issues facing senior leaders around the world, spanning countries, industries, and all business functions to examine leadership and corporate strategy to organization, technology, marketing, and operations. The app is available from the Apple App Store.

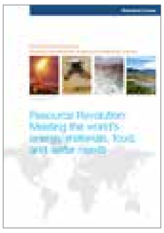
Urban world tablet app for iPad and Android (May 2013)

An unprecedented wave of urbanization is driving the most significant economic transformation in history, as the center of economic gravity shifts decisively east. MGI's new tablet app offers an intuitive sense of this new urban world, showcasing GDP, population, and income levels for more than 2,600 cities worldwide in 2010 and 2025. The app is available from the Apple App Store and Google Play.



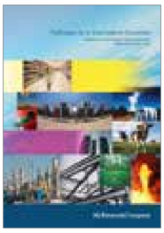
Urban world: Cities and the rise of the consuming class (June 2012)

This finds that the 600 cities making the largest contribution to a higher global GDP—the City 600—will generate nearly 65 percent of world economic growth by 2025. However, the most dramatic story within the City 600 involves just over 440 cities in emerging economies; by 2025, the Emerging 440 will account for close to half of overall growth.



Resource Revolution: Meeting the world's energy, materials, food, and water needs (November 2011)

Meeting the world's resource supply and productivity challenges will be far from easy—only 20 percent of the potential is readily achievable, and 40 percent will be hard to capture. There are many barriers, including the fact that the capital needed each year to create a resource revolution will rise from roughly $2 trillion today to more than $3 trillion.



Pathways to a low-carbon economy: Version 2 of the global greenhouse gas abatement cost curve (McKinsey & Company, January 2009)

This report includes an updated assessment of the development of low-carbon technologies and macroeconomic trends, and a more detailed understanding of abatement potential in different regions and industries. It also assesses investment and financing requirements and incorporates implementation scenarios for a more dynamic understanding of how abatement reductions could unfold.

The case for investing in energy productivity (February 2008)

MGI research finds that the economics of investing in energy productivity—the level of output we achieve from the energy we consume—are very attractive. This detailed report assesses the additional investment and key actions needed to capture the productivity potential. Additional annual investments in energy productivity of $170 billion through 2020 could cut global energy demand growth by at least half while generating average internal rates of return of 17 percent. Such outlays would also achieve significant energy savings and cuts in greenhouse gas emissions.

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