



Analysis & Trends

The sixth Kondratieff – long waves of prosperity

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Allianz 
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The sixth Kondratieff – long waves of prosperity

From the invention of the steam engine to the internet, the last 200 years the economy has gone through five long (Kondratieff-)waves. Many investors are now asking whether the environment, biotechnology and health sectors serve as the economic engines of the future and put us back on a path of sustainable growth?

From the invention of the steam engine in the 18th century, the railway and the electrification of the 19th century, to the automobile and the development of the information society in the 20th century, the economy has gone through five long waves. Five major economic cycles, characterised by long periods of prosperity which have

generally ended in a major crisis. Many investors are now wondering whether the current financial crisis could mark the beginning of a new cycle of prosperity. Will the environment, biotechnology and health sectors serve as the economic engines of the future and put us back on a path of sustainable growth?

Listening instead of reading: The study is also available as a three-part podcast under: www.allianzgi.de/capital-marketanalysis



Five major economic cycles, characterised by long periods of prosperity which have generally ended in a major crisis.

Summa Oeconomica

- The recent financial crisis could mark a period of upheaval and the beginning of the sixth Kondratieff cycle. Kondratieff lists four main characteristics of changes that lead to a new Kondratieff cycle. All seem to apply to the current financial and economic crisis:
 1. Potential for further exploitation of an old basic innovation is exhausted (cycle of around 40-60 years)
 2. High level of excess financial capital (versus physical capital)
 3. Period of severe recession (period of radical change)
 4. Social/institutional transformations
- In the search for the drivers of the 6th Kondratieff cycle, a distinction should be drawn between two sources:
 - Future megatrends, such as globalisation and demographics, that lead to shifts in demand and
 - Trends and innovations that change the supply structure in the economy, such as environmental technology, biotechnology and nanotechnology or holistic health.
- In the wake of ongoing **globalisation** and world **population growth**, the centre of gravity of the 21st century seems likely to shift increasingly to Asia.
- The path of the developed countries towards a knowledge economy seems already to have been mapped out so that they should play leading roles in the 6th Kondratieff cycle.
- While in the previous Kondratieff cycle the information age led to a tremendous increase in labour productivity, the key to a strong and sustainable economy in the next long cycle seems to lie in an increase in the productivity of resources and energy. Growth will probably continue to be generated from a new mix of economics, ecology and social commitment. A structural change in the economy that we called „**Eco-Trends**“.
- The areas of **nanotechnology and biotechnology** are of interest in terms of increasing the productivity of resources and energy in the 6th Kondratieff cycle. Both of these segments could play major roles in the new structural cycle by using new materials (and/or properties of materials) and new processes to make many sectors more environmentally friendly through the use of fewer resources and less energy.
- In addition to the biotechnology sector, the **healthcare sector** could also be an important engine for economic growth in the 6th Kondratieff cycle. Health is now viewed less as a “condition” than as a resource and less as a cost factor than as a driver for economic growth and employment. As a result of this paradigm shift, the economic significance of the industry is expected to continue to grow.

Kondratieff cycles

A name one encounters again and again when investigating the emergence of long-term (structural) cycles is that of the economist Nikolai Kondratieff. He observed long-term economic fluctuations in cycles of 40 to 60 years (so-called Kondratieff waves). According to his theory, these cycles begin with technological innovations, which then

become the cornerstones of a prolonged economic upturn. Provided, that is, that these so-called basic innovations permeate virtually all sectors of the economy and trigger new bursts of productivity throughout the entire economy. From the industrial revolution at the end of the 18th century until today, there have been five Kondratieff cycles:

Kondratieff cycles	1 st Kondratieff	2 nd Kondratieff	3 rd Kondratieff	4 th Kondratieff	5 th Kondratieff
Period	1780–1830	1830–1880	1880–1930	1930–1970	1970 to today
Invention	Steam engine	Railway, steel	Electrification, chemicals	Automobiles, petrochemicals	Information technology, communications technology
Area of application	Clothing	Mass transportation	Mass production	Individual mobility	Information and communication

Source: L. A. Nefiodow, "Der Sechste Kondratieff" ["The Sixth Kondratieff"], 2006; Table: Allianz Global Investors Capital Market Analysis

These cycles marked times of enormous change, five long cycles in which technological networks transformed entire societies:

- Old industries were replaced by new ones,
- Corporate cultures and processes changed,
- New professions emerged,
- Extended periods of long-term economic growth resulted,
- Typically associated with rising equity markets.

In the most recent long-term cycle, the PC and the Internet have driven radical changes in many aspects of daily life and of work.

The financial markets, which have just brought about the end of a cycle through excessive speculation and inflated asset prices, will serve as the accelerator of the new upturn.

The financial crisis – the beginning of the sixth Kondratieff?

At the beginning of a new Kondratieff cycle, entrepreneurs usually require a considerable amount of capital to buy the steam engine, the (delivery) vehicle or the IT system. Higher interest rates are not an obstacle here, as entrepreneurs increase their earnings by implementing more productive systems. But after many years, the new technology networks begin to offer diminishing returns on investment. As a result, the demand for credit grows more slowly, and (real) interest



rates move toward zero in the end. This was the case in the Panic of 1837, the Long Depression of 1873, the Great Depression triggered in 1929 and the oil crises of 1974 and 1980. And it was also observed in the collapse of the TMT bubble and the recent financial crisis.

Kondratieff lists four main characteristics of changes that lead to a new Kondratieff cycle:

1. Potential for further exploitation of an old basic innovation is exhausted (cycle of around 40-60 years)
2. High level of excess financial capital (versus physical capital)
3. Period of severe recession (period of radical change)
4. Social/institutional transformations

Interestingly, a close examination shows that all four of the criteria marking the process of the reorientation of the economy seem to apply to the current financial and economic crisis:

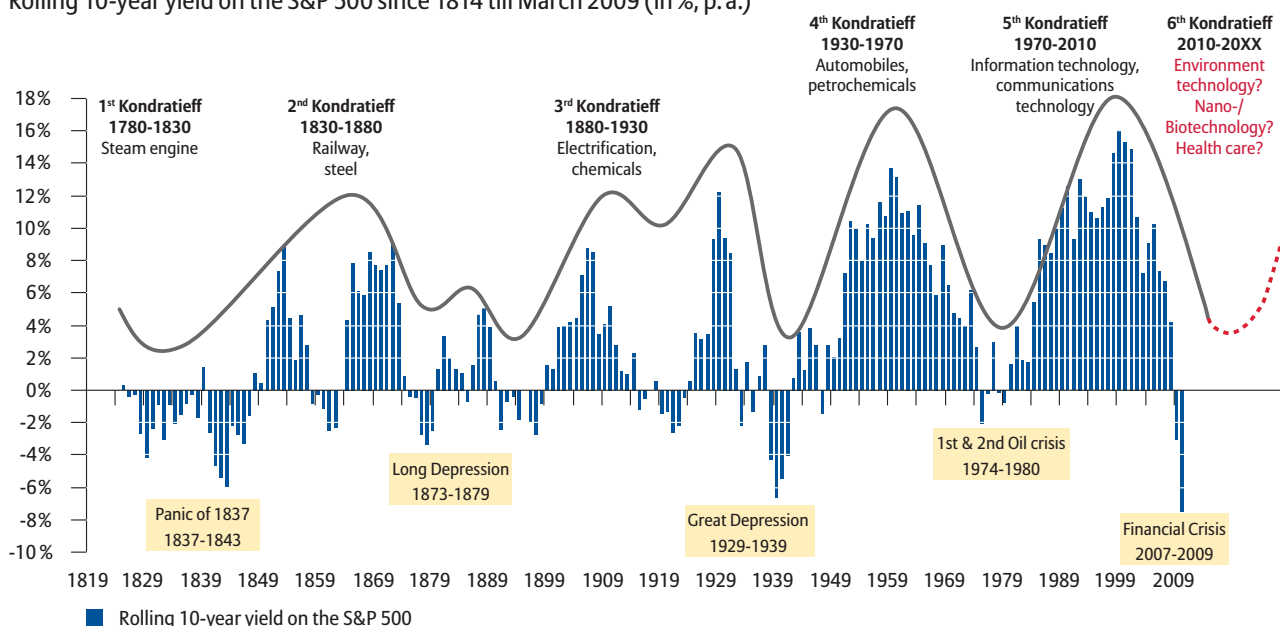
- The surge in productivity that had its origin in the invention of Konrad Zuse's „Z3“ computer in 1941 appears to be slowly coming to an end. Work processes are not made much more productive by an even

faster notebook computer. The Internet has already achieved considerable penetration.

- Similarly, until 2007, before the outbreak of the financial crisis, there was a substantial surplus of financial capital in the economy. The expansion of the credit (derivatives) economy put too much money into a small segment of the real economy. With the dominance of financial capital over the physical capital (sum of property, plant and equipment) investors sought returns in investment alternatives, which they primarily found in loans on U.S. real estate and in financial derivatives.
- The result was a financial crisis that became a global economic crisis, the likes of which had not been seen since 1930. The 9th of March 2009 was a historic day for investors – in a negative sense. On that day, U.S. share prices as measured by the S&P 500 not only hit their low point, but the 10-year performance of the U.S. equity index, with an average return of -8% p. a., also hit its lowest level in 200 years (see Figure 1).
- Work is now underway on the creation of a new global financial regulatory architecture that is intended to form the basis for a sustainable economic and financial system.

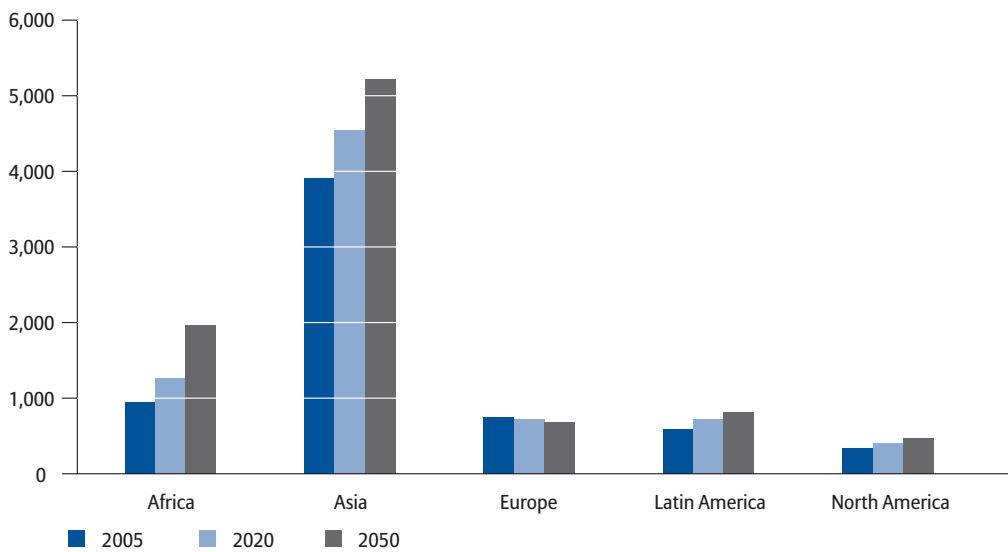
Figure 1: Kondratieff cycles – long waves of prosperity.

Rolling 10-year yield on the S&P 500 since 1814 till March 2009 (in %, p. a.)



Source: Datastream; Illustration: Allianz Global Investors Capital Market Analysis

Figure 2: Global trend: demography.
Population in millions of people



Source: UN, Population Division; Illustration: Allianz Global Investors Capital Market Analysis

The recent financial crisis could mark a period of upheaval as described by Kondratieff. The 6th Kondratieff cycle has probably already begun, but the main and supporting roles seem not yet to have been assigned.

What happens next? What trends could characterise the upcoming 6th Kondratieff cycle? And how will the foundations being laid today shape our life in the 21st century?

Journey into the future – the trends of tomorrow

In the search for the drivers of the 6th Kondratieff cycle, a distinction should be drawn between two sources:

1. Future megatrends, such as globalisation and demographics, that lead to shifts in demand and
2. Trends and innovations that change the supply structure in the economy, such as environmental technology, biotechnology and nanotechnology or holistic health.

These so-called megatrends and basic innovations must have the potential to influence economics, politics and society, and they must also be capable of boosting

productivity in multiple economic sectors at the same time.

Globalisation and demographics: accelerators of change

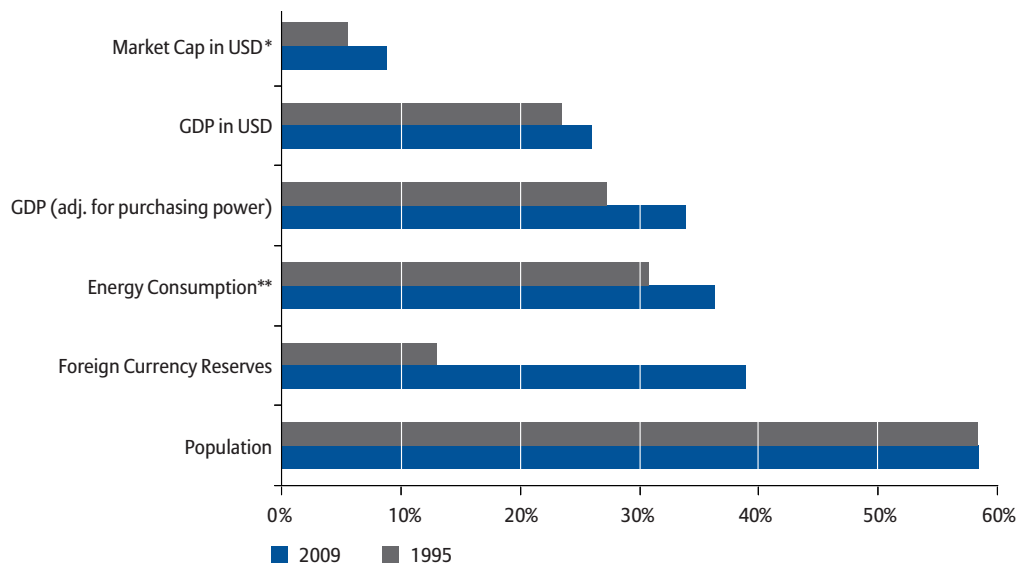
Two candidates for a major role in the next long economic cycle that are expected to result primarily in global shifts in demand have already been identified. Globalisation and demographic change. Both have been having a global impact for some time, but the full scope of their effect will not be seen for years or even decades.

The removal of technological barriers brought about by the Internet has pushed globalisation to an entirely new level. The Internet not only allows goods to be ordered at the press of a button from anywhere on Earth; it also makes the export of services possible. The volume of global trade has now quadrupled since 1987, despite the fact that global economic output (gross domestic product) has only doubled in the same period of time.

While the world is increasingly interconnected, there is also a growing demographic divide. By 2050, the world's population will have grown by about 40% to more than 9 billion people, but populations will shrink and age in half the

A more detailed analysis on the topic of „Demography: a global trend“ is available at <http://www.allianzgi.de/capitalmarketanalysis> under the section Analysis & Trends

Figure 3: Asia's role in the world economy.
Global share of Asia (in %)



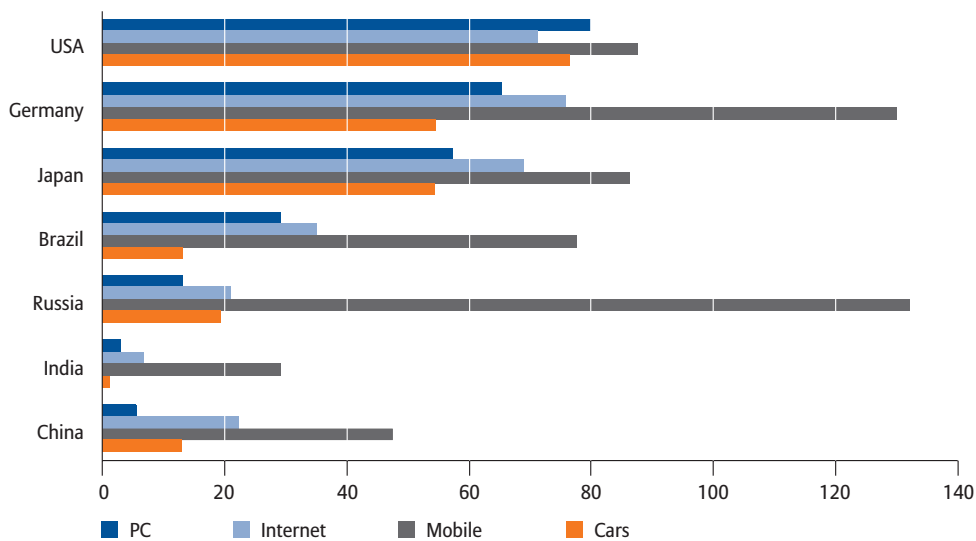
* without Japan; ** Year 2008

Source: MSCI, IWF, UN, BP, Illustration: Allianz Global Investors Capital Market Analysis

world - in developed regions such as Europe and Japan. And in the other half, mainly in emerging countries, the population will continue to grow and will remain relatively young (see Figure 2).

Two other long-term developments can be assumed on the basis of these two megatrends:

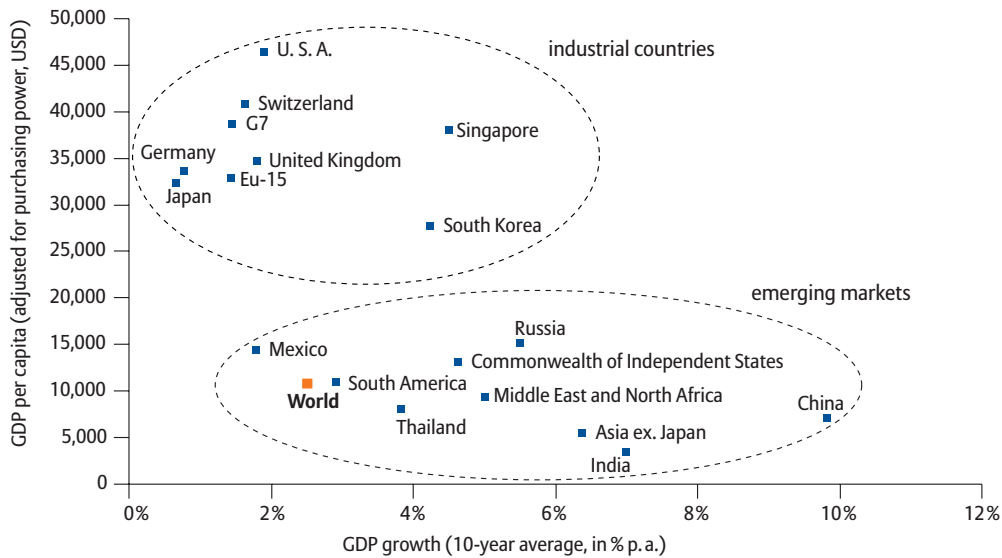
Figure 4: Emerging markets still have IT productivity reserves.
Owners/users per 100 inhabitants



Source: International Telecommunication Union, 2009; UN Statistical Yearbook, 2008;
Illustration: Allianz Global Investors Capital Market Analysis

Figure 5: Emerging countries continue to gain ground.

GDP per capita (adjusted for purchasing power, USD) vs. GDP growth (Average 1999 till 2009, in % p.a.)



Source: Datastream; Illustration: Allianz Global Investors Capital Market Analysis

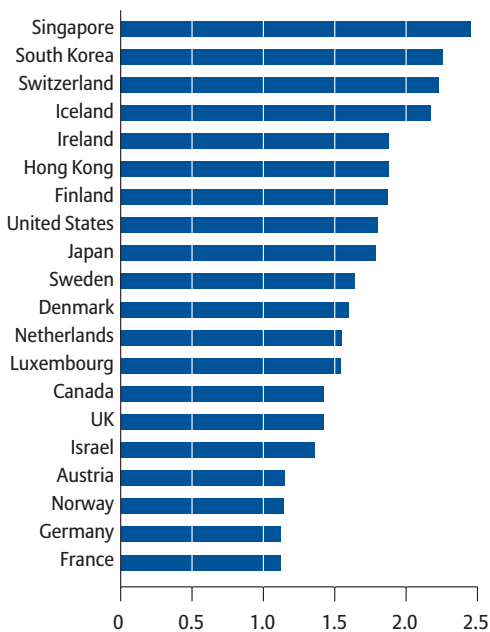
Asia - the centre of gravity in the 21st century

In the wake of ongoing globalisation and world population growth, the centre of gravity of the 21st century seems likely to shift increasingly to Asia. With a population of almost 4 billion people, Asia not only represents around 60% of the world's population, but it holds nearly half of all foreign exchange reserves and now generates about 32% of global value creation, adjusted for purchasing power (see Figure 3). According to estimates by the Asian Development Bank, Asia will account for about 50% of global output by 2050 and China will likely have surpassed the U.S. and Europe in this area. Emerging markets in the middle of the 5th Kondratieff cycle still appear to be tapping into the productivity reserves of information technology. One indication of this is the fact that in China only 5 in 100 inhabitants own a PC and only 22 in 100 have Internet access, while the figures in India are just 3 and 7, respectively. In the U.S. and Germany, in contrast, the penetration rate for PCs stands at 80 and 69, respectively, per 100 inhabitants and 71 and 76, respectively, for Internet access (see Figure 4).

Growing prosperity – a study by the World Bank estimates that by 2030 China and India will make up about 44% of the global middle class – is expected to slowly close this gap. The World Bank assumes that low-income countries will grow twice as fast as high-income countries in the coming decades.



Figure 6: Developed countries still have a „pioneering advantage“. Global Innovation Index (2009).



Source: Boston Consulting Group, Global Innovation Report 2009;
Illustration: Allianz Global Investors Capital Market Analysis

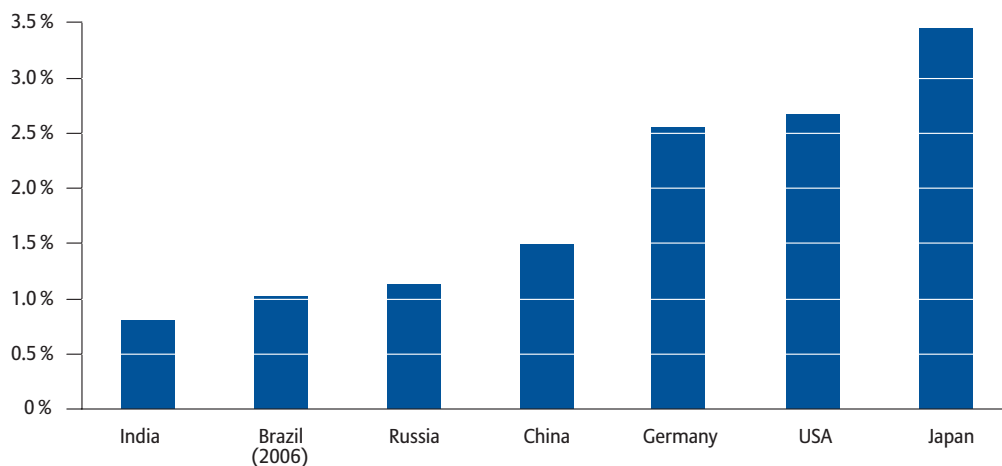
A more detailed analysis on the topic of „Asia on the move – gravitational centre of the 21st century?“ is available at <http://www.allianzgi.de/capitalmarketanalysis> under the section Analysis & Trends

As a result, the demand for commodities in the emerging markets is not only increasing quantitatively because of their rising populations; there is also “qualitative” growth: consumption becomes more commodities-intensive as prosperity increases. At the same time, the supply is limited, meaning that commodities will become an increasingly scarce resource.

Developed countries: nucleus of the 6th Kondratieff cycle?

While the growth in prosperity in the emerging markets has not been very broad thus far, the developed countries seem to have progressed much further along the learning curve of the information age. As mentioned above, the penetration and use of PCs and the Internet is already extensive and the potential for the further exploitation of this basic innovation seems to have been largely exhausted. One indication of this is the fact that with higher per capita incomes, the productivity gains and growth rates in the established countries are significantly lower than in the emerging markets. This means that productivity – measured in terms of economic output per worker – in emerging countries has increased substantially. For example, China has seen output rise fourfold in this period and India has recorded a twofold increase. GDP growth for the group of emerging countries in the last 10 years (1999

Figure 7: Developed countries: research is emphasised. Expenditure on research and development as % of GDP



Source: UNESCO 2008; Illustration: Allianz Global Investors Capital Market Analysis

to 2009) reflects this trend: growth in these countries amounted to over 5% p. a. on average, while the economic output of developed countries grew relatively slowly, around 2% p. a. (see Figure 5).

Although the share of exports of the emerging countries in the field of high technology has grown significantly in recent years, the developed countries still have an important pioneering advantage in many areas. Two examples:

- The top 20 of the Global Innovation Index – an indicator produced by the Boston Consulting Group which measures the innovation strength of countries – contains only developed countries (see Figure 6).
- Developed countries are placing even greater emphasis on the area of research and development. For example, Japan, the U.S. and Germany spend the equivalent of about 2.5% of GDP on research and development, while emerging countries like China, Russia, Brazil and India invest no more than 1.5% of GDP in this area (see Figure 7).

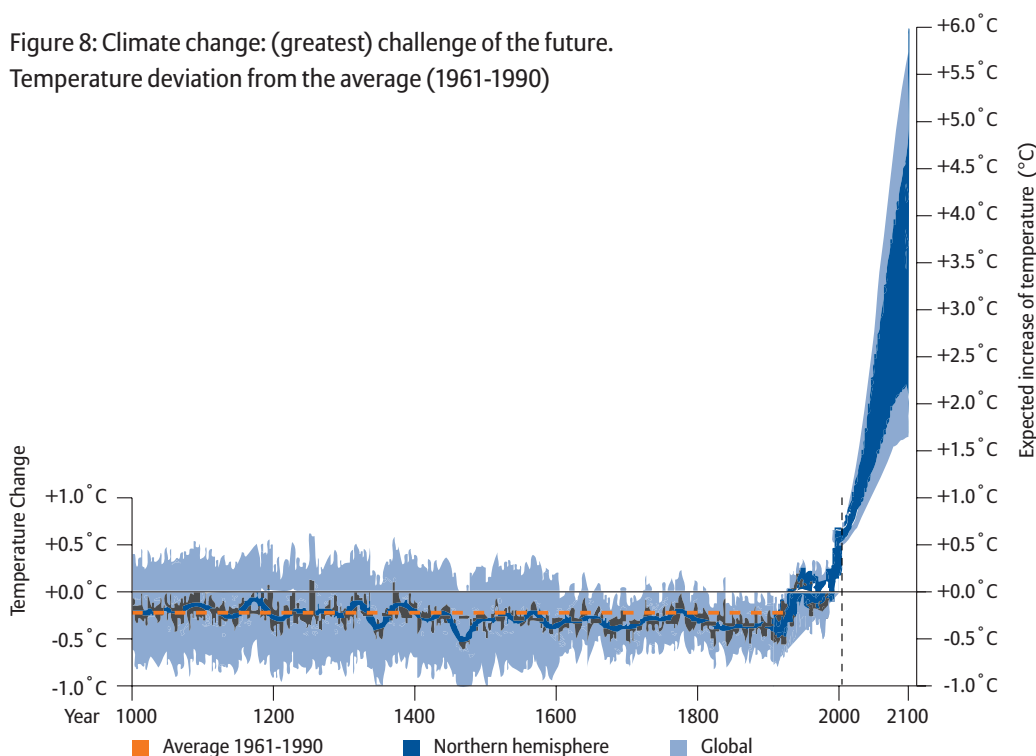
Because competitive pressure seems likely to increase rather than decrease with rising globalisation and demographic change, it seems likely that the 6th Kondratieff cycle will begin in the developed countries. For the established developed countries, there seems to be only one solution: to further expand the share of knowledge in the creation of value.

While the megatrends globalisation and demographics will boost demand primarily in emerging countries, particularly in Asia, during the transition from the 5th to the 6th Kondratieff cycle, the path of the developed countries towards a knowledge economy seems already to have been mapped out. Investors are now wondering which basic innovations and which sectors could serve as the drivers on the supply side and thus continue to play leading roles in the 6th Kondratieff cycle?

“Eco-Trends” – greening the economy

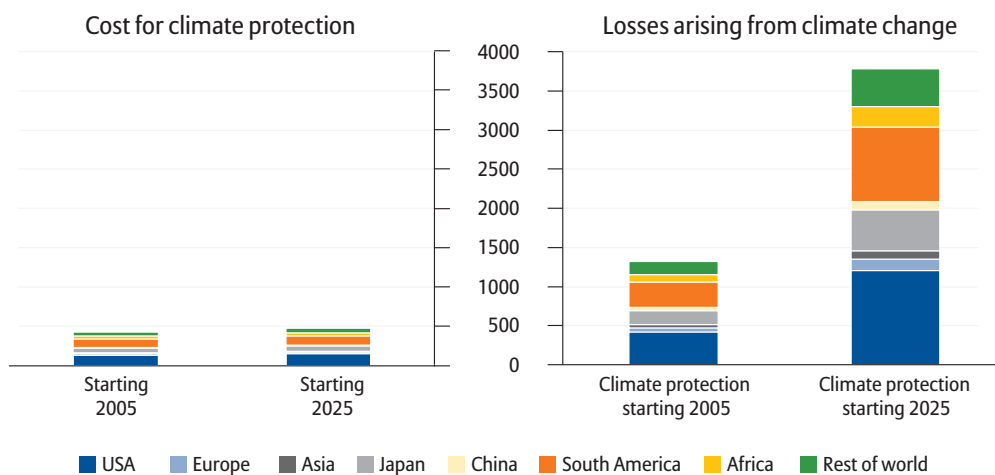
While in the previous Kondratieff cycle the information age led to a tremendous increase in labour productivity, the key to a

Figure 8: Climate change: (greatest) challenge of the future.
Temperature deviation from the average (1961-1990)



Source: IPCC/WG1, Climate Change 2001/2007, Illustration: Allianz Global Investors Capital Market Analysis

Figure 9: Ecology and economics are converging. Estimated cost of climate protection and damages caused by climate change (worldwide, in billions of U.S. dollars).



Source: Deutsches Institut für Wirtschaftsforschung (DIW); Illustration: Allianz Global Investors Capital Market Analysis

A brief analysis of the topic of „Eco-Trends“ is available at <http://www.allianzgi.de/capitalmarketanalysis> under the section Analysis & Trends

strong and sustainable economy in the next long cycle seems to lie in an increase in the productivity of resources and energy. This is because under the new conditions imposed by globalisation, demographic change, climate change, scarce resources and greater awareness of the environment and of responsibility on the part of consumers, growth will probably continue to be generated from a new mix of economics, ecology and social commitment. A structural change in the economy that we called „Eco-Trends“.

This makes the environmental market a hot candidate for a major role in the 6th Kondratieff cycle.

Climate – a scarce resource

Unlike just a few years ago, the debate about climate change no longer revolves around the questions of whether it exists at all and who culprits are. The facts are now well known:

- The years 2001 to 2007 were all among the 10 warmest years on record since 1880 (see Figure 8).
- Sea levels rose by 19.5 cm from 1870 to 2004.
- According to a 2008 study by the Global Carbon Project, CO₂ emissions grew four times faster from 2000 to 2007 than in the previous decade.
- Extreme weather events like hurricanes and floods have increased disproportionately in recent years.

Based on the assumptions of „RECIPE“ (Report on Energy and Climate Policy in Europe), a joint study by the WWF together with the Allianz Group, without measures to protect the climate CO₂ emissions would increase to 2500 gigatonnes (Gt) by 2050 and

push global temperatures up by seven degrees over pre-industrial levels. The „Stern Review“, which examined the economic cost of climate change, concluded that without further climate protection measures, climate change would reduce global economic output in 2050 by an estimated 5% to 20%. According to estimates by the German Institute for Economic Research (DIW), even if climate change measures were to be taken starting from 2025, the global damage caused by climate change would increase to around USD 3.8 trillion by 2050. If investments in climate change measures in the amount of just USD 500 billion were to be made today, the economic costs of global warming could be reduced to just USD 1.3 trillion (see Figure 9).

Preliminary conclusion: the environment is becoming an increasingly scarce resource. It now has a „price“, i.e. the consumption of the environment is becoming a cost and scarcity factor. The trade in CO₂ emission rights is one piece of evidence that environmental costs are being increasingly internalised, i.e. polluters are being asked to pay their own way.

The environment gets a price tag

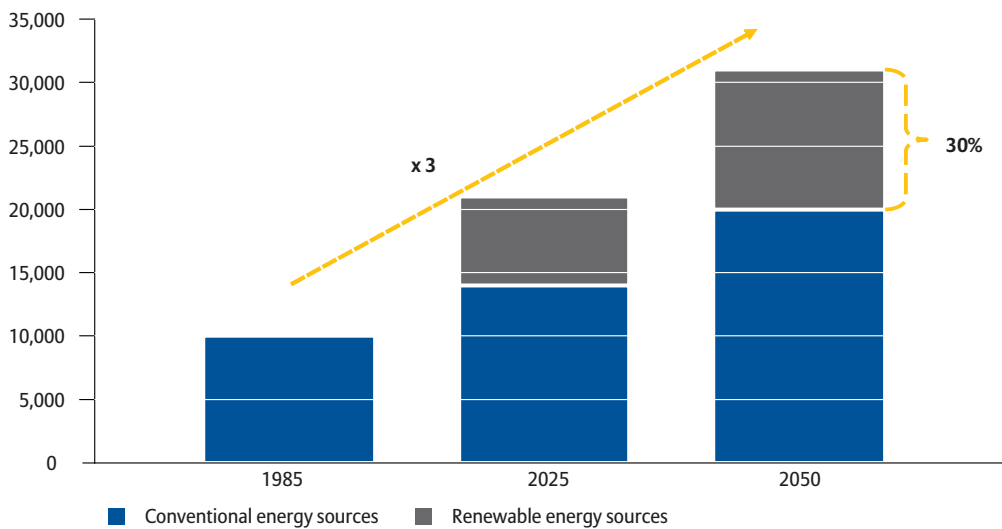
As the consequences of climate change may increasingly become a business risk, around 6,000 companies and 475 large institutional investors, with combined total assets of around USD 55 trillion, have now joined together in the Carbon Disclosure Project (CDP). They not only make use of uniform standards for the measurement of emissions and of climate change considerations in their analysis of securities, but also urge businesses to develop their own climate protection strategies and to reduce their emissions.

All these factors – the introduction of CO₂ emission rights, rising commodity prices and climate change as a business risk – contribute to putting a price tag on the consumption of the environment. The environment is increasingly becoming both a cost factor and a risk factor, resulting in the need to increase global value creation in the productivity of resources and energy and to practise sustainable management. At the same time, this trend also provides opportunities for growth.



Figure 10: Sustainable energy consumption with renewable energy.

Expected development of electricity production from conventional and renewable energy sources by 2050



Source: World Energy Council; Illustration: Allianz Global Investors Capital Market Analysis

The global economic system has already taken environmental protection, resource conservation and corporate social responsibility on board in many areas – particularly in the industrialised countries. Consumption, primarily in the developed countries, now takes place under a completely different set of assumptions about ecological criteria and sustainability. For example, U.S. sales of hybrid cars rose approximately fourfold between 2004 and 2008, and over 80% of Britons recycle paper and glass. In emerging countries such as China, there were, for example, around 51,000 protests against environmental pollution in 2006. But even in other economic sectors, consuming with a clear conscience seems to be a growing engine for growth. The market for organic food is booming, as are „green“ investments and fair-trade products.

Given all these developments, the 6th Kondratieff cycle now seems to have taken root. This makes it unsurprising that trend researchers view sectors that are crucial to sustainable development and human health as having particularly strong potential.

“Green tech” – a growth market

New forms of energy have become increasingly important. In particular, the share of renewable, CO₂-neutral energy sources on the global energy market is expected to continue to increase. The global demand for energy is rising in step with world population growth – where an increase of 40% by 2050 is expected – while conventional energy resources such as oil and gas are limited. The World Energy Council estimates that global electricity production will double by 2025 and triple by 2050. The global share of renewable energy sources is expected to rise from its current level of approximately 7% to about 30% by mid-century (see Figure 10). The World Energy Council estimates the market for renewable energy in 2010 at USD 635 billion. By 2020, it is expected to grow to USD 1.9 trillion.

High-tech industry is also expected to benefit significantly from the green transformation of the markets, because the demand for renewable energy, advanced environmental technologies, sustainable water management, recycling and more efficient propulsion technologies is rising. The

Smart Grid

Behind the smart grid are power grids that, in addition to conventional electric power transmission, allow the bidirectional flow of power and (electrical) data communications. The decentralised production of energy – primarily renewable energy – in a growing number of households and businesses is making the efficient management of the energy system increasingly important. More and more consumers are using solar, wind or geothermal power plants to become electricity producers themselves. The goal of this new technology is to make power generation, distribution and consumption on the energy market of the future as efficient as possible. The smart grid has three core components:

1. Smart metering: an intelligent electricity meter which allows the measurement of consumption and production via data transmission over the Internet. This makes it the cornerstone of the smart grid. Smart meters also allow variable prices to be charged for electricity, depending on the overall demand and network utilisation.
2. Grid intelligence: the name for the power grid infrastructure and the associated control equipment. This virtual power plant creates an efficient balance between production and consumption in the „energy web“.
3. Utility IT: intelligent data management systems, which automatically control billing and the storage of customer data and parameters of power line networks.

The smart grid is also referred to as the “Internet of energy” or the “energy web”. There are already some examples of the way it will be used in the future:

- The production of energy in the desert of North Africa or on a wind farm on the high seas requires intelligent power distribution networks that distribute electricity whose production is sometimes irregular directly to the source of consumption.
- If the North Sea winds are blowing at night, when consumption naturally decreases and electricity is generally cheaper, a wide variety of storage devices, including batteries for electric cars and trains, could be charged or thousands of washing machines could be activated.
- In summer, when hundreds of thousands of photovoltaic systems all across the country are feeding electricity into the grid at the same time, intelligent controls ensure that power plants can be shut down or their output reduced, as necessary.

This makes the market potential of this new technology appear very promising. The European energy platform Smart Grids estimates that EUR 390 billion will have to be invested in Europe by 2030 to provide comprehensive smart grid coverage. EUR 300 billion of this amount will be put into the renewal and expansion of the electric power infrastructure, and EUR 90 billion into electricity transmission. Cisco Systems, one of the largest networking providers in the world, expects to record a turnover of USD 20 billion per year in the smart grid segment beginning in 2013 and assumes that the energy web will be 100 times bigger than the Internet.

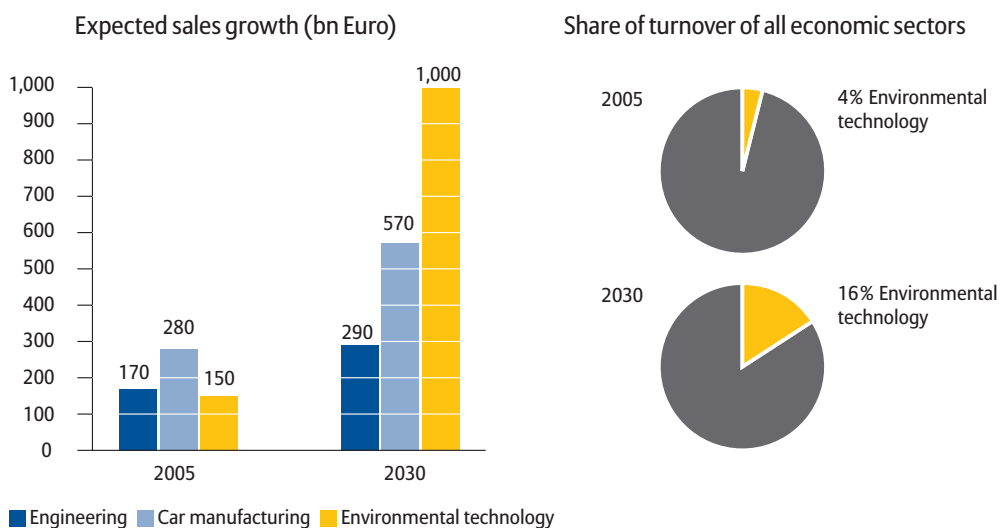
Energy-efficient smart grids that reduce the consumption of resources thus represent an important technology in the ongoing greening of the economy.

Source: Smart Grids European Technology Platform, Siemens AG, Wikipedia

dovetailing of the 5th Kondratieff cycle with the 6th Kondratieff cycle, i.e. the connection of the area of information technology with the „green markets“ is likely to continue to increase. For example, tremendous growth prospects are foreseen for the „**Smart Grid**“, known as the „Internet of energy“. The decentralised production of energy – primarily renewable energy – in a growing

number of households and businesses is making the efficient management of the energy system increasingly important. Current measurement and management via the Internet, as well as virtual power plants, which create a balance between production and consumption in the „energy web“, are likely to play a significant role in the future of the energy markets.

Figure 11: Green energy: an enormous and growing market.
Sales growth and share of turnover of all economic sectors in Germany

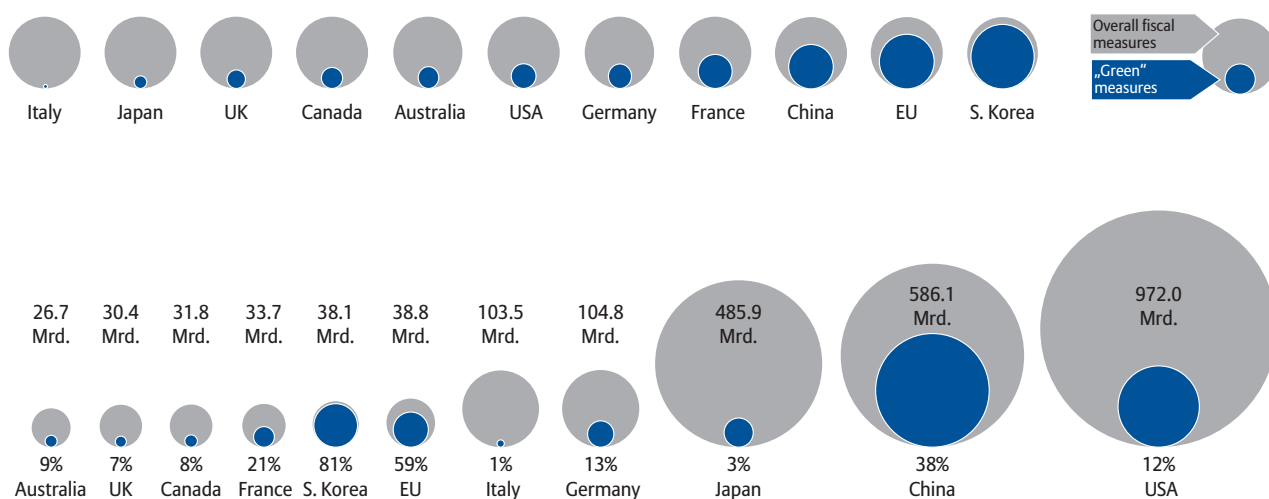


Source: BMU, 2006, Zukunftsinstitut; Illustration: Allianz Global Investors Capital Market Analysis

The „green-tech“ markets will likely leave traditional industrial sectors far behind. For example, analyses by the DIW, Fraunhofer ISI and Roland Berger Strategy Consultants carried out on behalf of the Federal Environment Ministry show that by 2020 environmental technology will be of greater

significance for the German economy than the automobile industry. The environmental technologies segment will quadruple to 16 percent of total German economic output by 2030, with sales expected to total EUR 1 trillion (see Figure 11).

Figure 12: „Green“ fiscal packages.
Shares of fiscal measures for environmental protection



Source: Financial Times, RCM, Allianz Global Investors.

Box: Colour theory of biotechnology

Biotechnology is defined as the application of knowledge from biology and biochemistry in technical or technically useful fields. As biotechnology is a very broad term, a differentiation is made concerning the areas of application:	Red biotechnology:	medical/pharmaceutical
	Green biotechnology:	agriculture, plant biotechnology
	White biotechnology:	Biotech products/industrial processes
	Blue biotechnology:	products from the sea
	Grey biotechnology:	waste management
	Brown biotechnology:	engineering/environmental and biological technologies
	Yellow biotechnology:	production of foodstuffs and raw materials

Source: German Association of Biotechnology Industries (DIB)

Industrial policy goes green

Renewable energies are also much on the minds of policy makers, which is likely to give the field of environmental technology an additional boost. The European Union has set a target of receiving 20% of its energy supply from renewable sources by 2020. China is seeking to meet at least 15% of its energy needs through renewable energy by 2020. Moreover, the worldwide fiscal measures to support the economy, totalling more than USD 2 trillion, have a significant green orientation. The share of environmental protection measures contained in the fiscal stimulus packages is as high as 81% (South Korea). Following the change of government, the U.S. is also planning an extensive environmental programme. At least 12% of the stimulus package will go to climate-friendly projects, which represents a total investment of approximately USD 120 billion (see Figure 12).

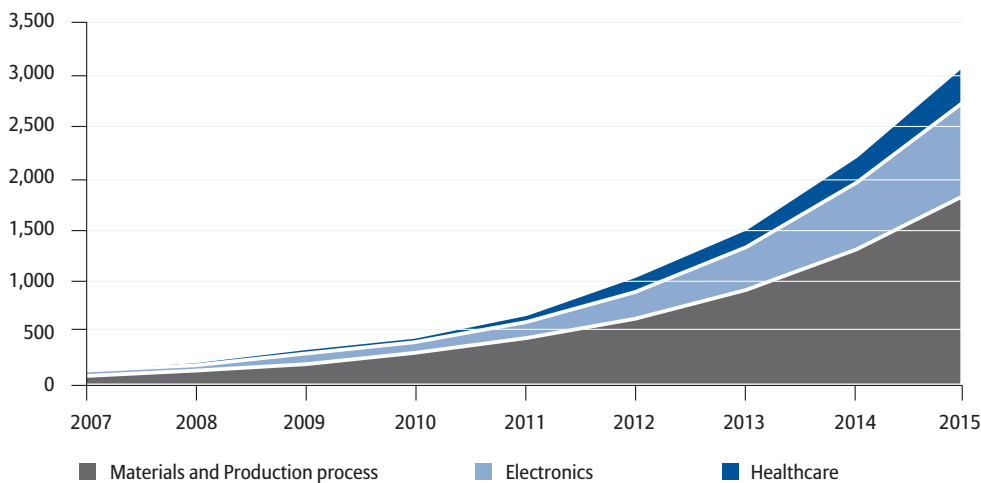
While the environmental protection aspect is, of course, key, forward-looking investors should think about how they can benefit from these long-term ecological and economic trends.

**Megatrend:
very small structures**

The areas of nanotechnology and biotechnology are of interest in terms of increasing the productivity of resources and energy in the 6th Kondratieff cycle. Both of these segments could play major roles in the new structural cycle by using new materials (and/or properties of materials) and new processes to make many sectors more environmentally friendly through the use of fewer resources and less energy.

The contribution of **nanotechnology and biotechnology** to the economy is still small, but they are exactly what is needed to accelerate progress. As interdisciplinary technologies that find application in other areas, such as environmental, electrical and medical engineering, their significance is likely to continue to increase. There are already several applications in everyday life: for example, nanotechnology has resulted in stain-resistant textiles and paints as well as miniature drug depots for chronic illnesses and retractable flat-panel displays (OLED). Biotechnology has also become an integral part of our lives. The technology has, after all, been around for 5,000 years – when yeast was first used for fermentation in the production

Figure 13: Nanotechnology: small structures – big impact.
Global market volume of nano-optimised products (in billions of USD)

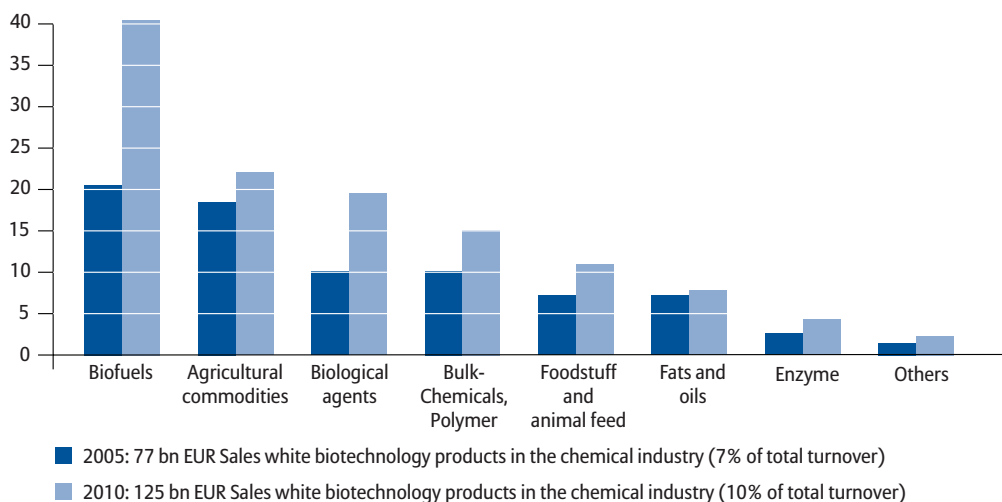


Source: LUX Research; Illustration: Allianz Global Investors Capital Market Analysis

of bread and beer. Although biotechnology can often not be seen directly, it is used in a variety of medical products (e.g. vaccines), in industry (e.g. degradable plastics), in agriculture (e.g. biological pesticides), in food (e.g. cheese) and in environmental engineering (e.g. sewage treatment) to name just a few examples (see colour theory in the biotechnology box).

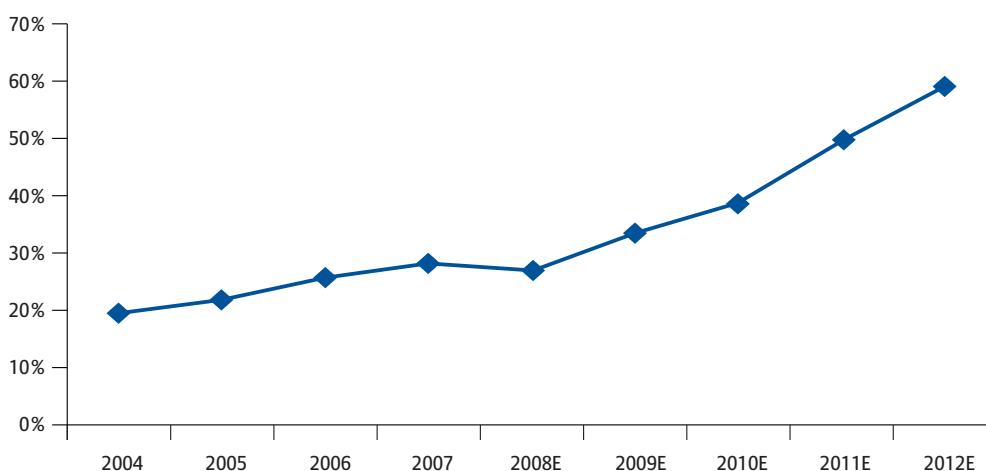
Global sales of nano-optimised products already stand at USD 147 billion (2007). And according to market forecasts by Lux Research, total market volume is expected to increase to about USD 3 trillion in 2015, which would correspond to an annual growth rate of 46%. The greatest potential is considered to lie in the field of materials and production technology (with an increase from USD 97 billion in 2007 to USD 1.7 trillion in 2015) (see Figure 13).

Figure 14: White biotechnology – a growth industry.
Global sales of white biotechnology products (in billions of EUR)



Source: Dr. Garthoff; "White Biotechnology", 2008; Illustration: Allianz Global Investors Capital Market Analysis

Figure 15: Biotechnology – companies are maturing.
Global percentage of profitable biotech companies (in %)



Source: Barclays Research, Illustration: Allianz Global Investors Capital Market Analysis

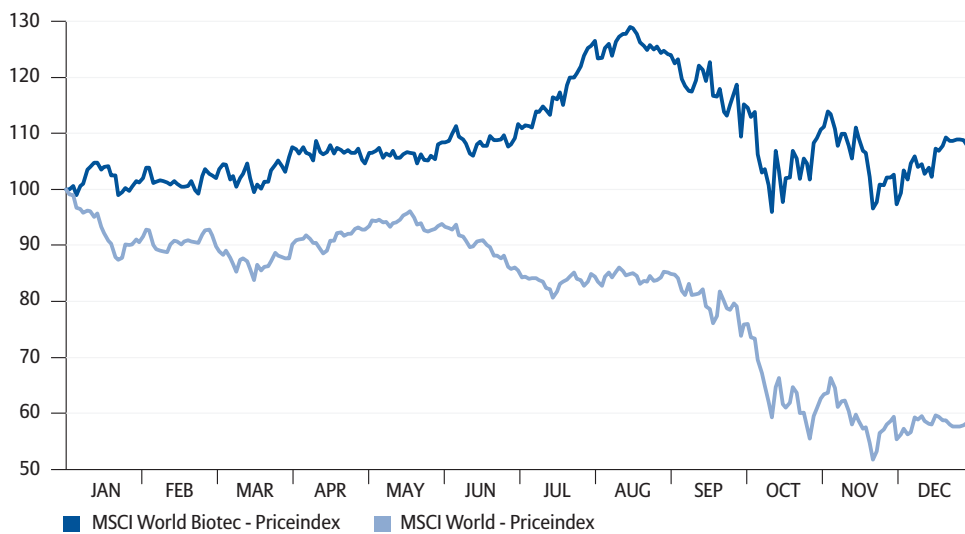
The global sales volume of listed biotechnology companies already stands at nearly USD 90 billion, which represents 17% of the pharmaceutical sector (source: Ernst & Young). Astonishingly, even in the financial crisis, sales in this sector defied the general trend to grow by 12% in 2008. With the increasing conversion of industrial processes to biotechnological processes, industrial (white) biotechnology alone is expected to increase from EUR 50 billion to around EUR 300 billion in ten years.

At the same time, the biotechnology and pharmaceuticals sectors are also investing more in research and development than other industries. According to a survey by the European Commission (R&D Scoreboard), the EUR 71 billion invested in research and development worldwide in the biopharmaceutical sector puts it ahead of the technology/hardware/equipment sectors.

While there are not yet many large-cap companies in the nanotechnology sector, investors who wish to focus on the megatrend of very small structures, would be advised to invest in the biotechnology sector, where companies seem to be steadily maturing. Evidence for this is the fact that in 2004 only 20% of all publicly-traded biotech companies generated a profit, while by 2007 this figure already stood at 30%. In the U. S., the overall sector reached profitability for the first time in 2008. According to estimates by Barclays Research, the worldwide percentage of profitable biotech companies is expected to grow to around 60% by the year 2012 (see Figure 15). It is no surprise, then, that established pharmaceutical companies are also showing increasing interest in the biotechnology sector. According to a study by Ernst & Young, the total value of mergers and acquisitions (M&A) in the biotech sector in the U. S. exceeded USD 28.5 billion in 2008. Adjusted for the mega-transactions from previous years, this is a new record. In Europe, the total value of M&A transactions climbed to USD 5 billion.

Figure 16: Biotechnology – resilient during the financial crisis.

2008: performance of MSCI World vs. MSCI Biotechnology (1 January 2008 = 100)



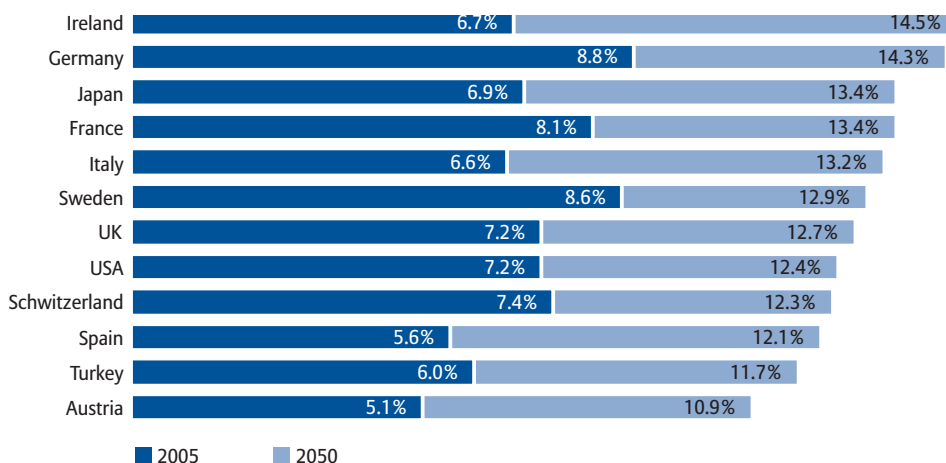
Source: Datastream, Illustration: Allianz Global Investors Capital Market Analysis

The rising profitability and demand in this sector is also reflected in share prices. Biotechnology stocks have recently proven themselves to be incredibly resilient in times of crisis. While stocks plummeted by about 40% worldwide in 2008 in the wake of the financial crisis, the industry index MSCI Biotechnology recorded a gain of around 10% (see Figure 16).

The area of very small structures, with the sectors of nanotechnology and biotechnology, is not yet capable of serving as a locomotive for the global economy. But in view of the high level of spending on research and development in this area, the major growth potential and the broad penetration of these interdisciplinary technologies, both of these fields may become megatrends and thus become drivers of the 6th Kondratieff.

Figure 17: Healthy ageing: spending in the healthcare sector rises.

Health care spending (as % of GDP)



Source: OECD, 2006; Illustration: Allianz Global Investors Capital Market Analysis

Megatrend: holistic health

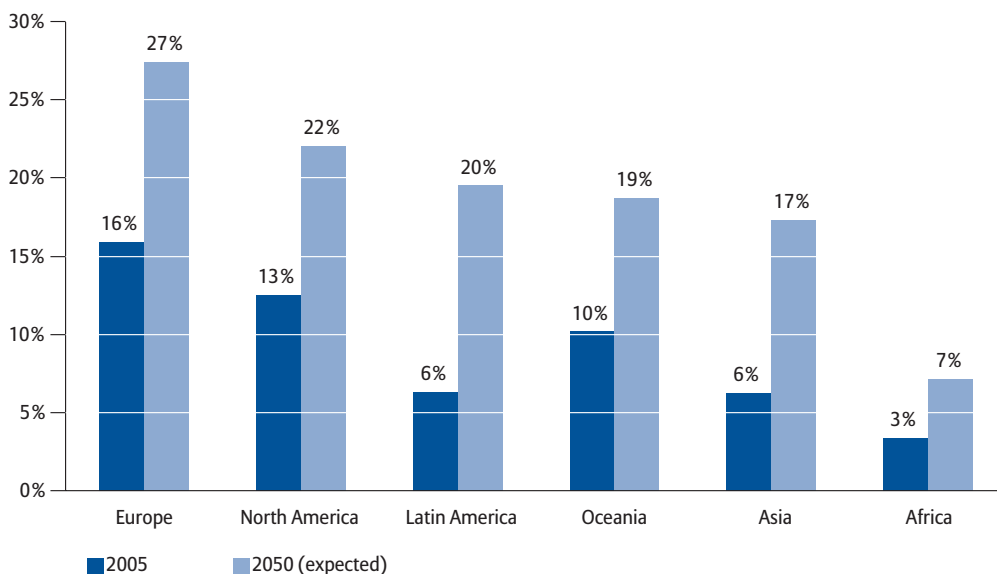
In addition to the biotechnology sector, the **healthcare sector** could also be an important engine for economic growth in the 6th Kondratieff cycle.

Health is now viewed less as a “condition” than as a resource and less as a cost factor than as a driver for economic growth and employment. As a result of this paradigm shift, the economic significance of the industry is expected to continue to grow.



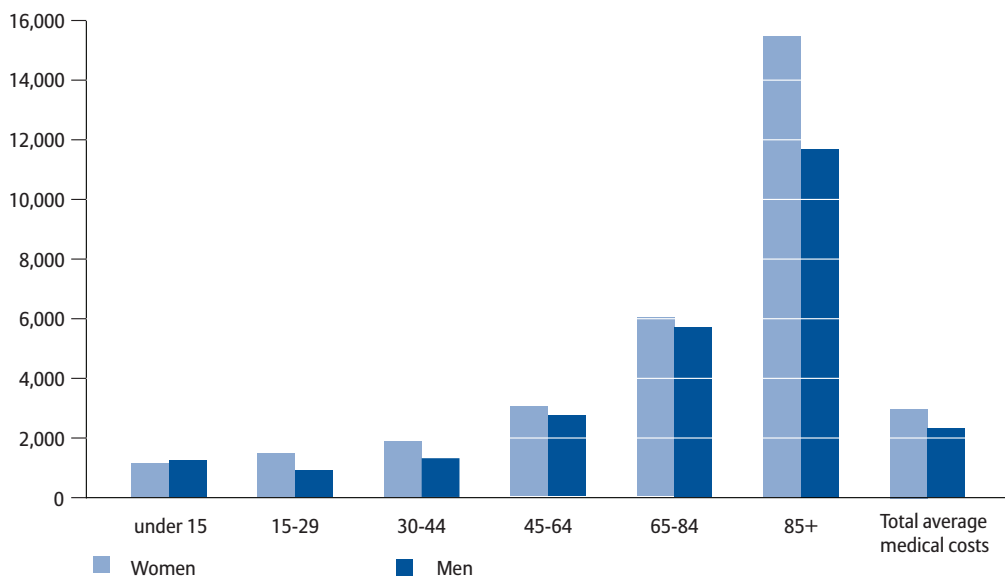
In 2005, spending on healthcare comprised between 5% and 10% of GDP in OECD countries. The OECD estimates that spending in this sector will rise disproportionately to GDP growth until 2050 and in some countries will account for up to 15% of economic output (see Figure 17). The sales of listed pharmaceutical companies alone totalled around USD 770 billion in 2008 (source: IMS Health). And new and expanding markets and product worlds are expected to develop around the concept of „holistic health“, in the sense of physical, psychological, environmental and social health.

Figure 18: The healthcare market is benefiting from „double ageing“.
Percentage of population over 65 years of age by region (2005 and 2050)



Source: UN Population Report 2008, Illustration: Allianz Global Investors Capital Market Analysis

Figure 19: Living longer – with chronic diseases.
Medical costs per age group (in EUR p. a.)



Source: Gesundheitsberichterstattung des Bundes, „Gesundheit und Krankheit im Alter“, 2009;
Illustration: Allianz Global Investors Capital Market Analysis

These are the main driving forces that are expected to further boost growth in the healthcare sector:

1. **Global demographic change** is likely to result in a changing and rising demand for health services.

- First, the world population is expected to grow by more than 2.5 billion over the next 50 years, an increase of nearly 40%. The need for healthcare, however, will not only increase quantitatively as the **global population rises**; „qualitative“ growth will also take place: the World Bank estimates that low-income countries will grow twice as fast as the high-income countries in the coming decades. The consumption of higher-quality health services increases together with prosperity. For example, the per capita consumption of health services in the United States was about USD 1,500 in 2008, while the figure was only about USD 200 in China and India.

- At the same time, healthcare spending will also rise as a result of the **increased longevity** of the population in developed countries – it rises around 3 months every year – as well as the growing percentage of people over 65 years of age. For example, the proportion of the population over 65 in Europe is expected to rise from around 16% in 2005 to over 27% in 2050 (see Figure 18). This gives the concept of the „old continent“ an entirely new meaning. But the ageing process on the other continents is also irreversible. In Asia, for example, the proportion of pensioners is expected to rise from its current level of about 6% to just over 17% in 2050. As a consequence, the demand for drugs and medical procedures is likely to grow. Chronic and acute diseases increase as people age, meaning that healthcare spending will grow disproportionately: a 45- to 64-year-old German consumes an average of around EUR 3,000 worth of health services in a year, while a 65- to

84-year-old consumes just under EUR 6,000 annually and the figure for those over 85 years of age is nearly EUR 12,000 (see Figure 19).

2. **Progress in medical technology** offers improved chances for healing and longer lives – even with chronic illnesses. New growth markets in the areas of diagnosis and therapy are being created through closer integration with other fledgling technology sectors such as biotechnology and nanotechnology. For example, it is already possible to place drugs directly in the bloodstream using nanorobots. And in the area of biotechnology, targeted vaccines and antibiotics can be produced through the use of enzymes. Another new market is improved diagnostics through the exchange of data on bodily functions over the Internet.
3. Particularly in the ageing affluent societies of the developed countries, a change in values can be seen as people move more towards self-managing their healthcare and more active physical fitness. In addition to the curing of diseases, the focus in the healthcare market is increasingly shifting to **health maintenance**. As a result, the healthcare market is likely to grow even more differentiated and develop from a regulated supply market to a demand market. New services and products are expected to be created in the areas of healthy foods (organic food, „functional food“), personal health, health counselling, prevention and wellness.

4. The health sector is becoming **increasingly commodified**. First, a trend is evident in which health services providers are modelling themselves more and more on private sector businesses. But it will not be just economic principles, such as efficiency, that will shape the medical value chain: those causing healthcare costs will also increasingly be required to make a contribution. There are already some examples of this latter trend, such as higher premiums for smokers and compensation payments from the tobacco industry. At the same time, the sector is becoming more and more liberalised. And finally, patients are turning into consumers, whose needs are at the forefront. For example, healthcare has become a major focus of marketing in the food and sporting goods industries



Conclusion

It is clear even now that existing technologies and materials will reach their technological limits. Whether megatrends on the demand side, such as globalisation and demographics, or megatrends on the supply side, such as environmental technology, the areas of very small structures or holistic health: all have the potential not only to trigger long-term productivity increases for the global economy, but also to influence society as a whole. New products and services are likely to open up new demand, which would initially be focussed in the developed countries.

Although the main and supporting roles in the 6th Kondratieff cycle have not yet been clearly assigned, the roots seem already to have taken hold. The TMT bubble and the recent financial crisis may mark the beginning of the 6th Kondratieff cycle. A cycle in which prosperity will probably come in long waves.

The period of upheaval following the financial crisis is not likely to come to an immediate end. However, long-term investors would be well advised to use the current crisis as an opportunity to get in early on the 6th Kondratieff wave.

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Box: Megatrends and their beneficiaries

Megatrend	Beneficiaries
Globalisation	Knowledge-intensive services with close proximity to corporations: - Logistics - IT services/ security - HR consulting and continuing education
Demographics	Healthcare and health maintenance services: - Pharmaceutical industry - Biotechnology - Care services/care facilities - Financial services for pension and health care
Eco-trends	Markets connected with the environment: - Renewable energy - Energy efficiency/ consulting - Water Treatment/ Desalination facilities - Recycling technologies
"Very small structures"	Companies from the sectors - Biotechnology - Nanotechnology
"Holistic health"	Products and services for „health maintenance“ - Medical technology - Healthcare consulting - Wellness market - Organic products and functional food

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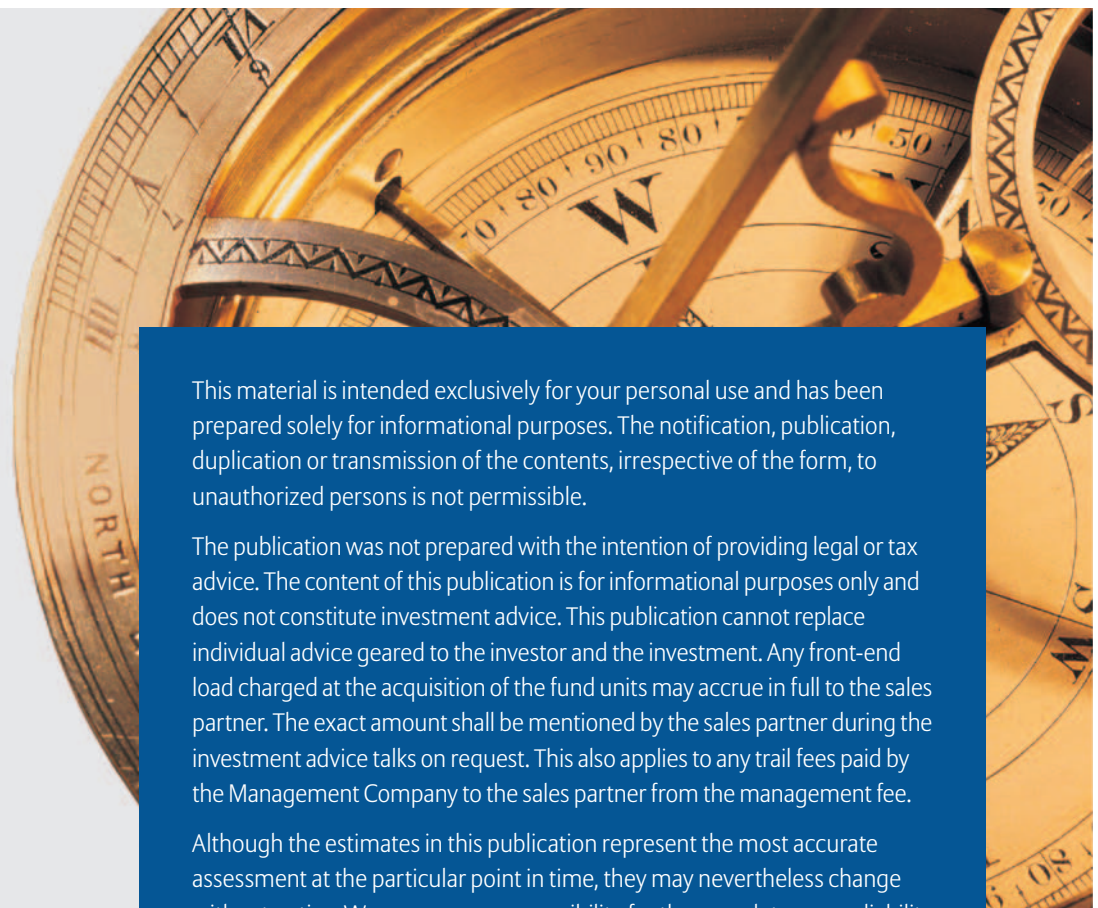
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