Chapter 1

Long-Term Innovation Waves and the Potential Dissonance between Europe and Asia

Lennart Schön

1.1 Introduction

During the last few decades, dramatic events have transformed the global economy. The breakthrough of microelectronics and the diffusion of digital information and communication technology, often referred to as the Third Industrial Revolution, interacted with a new flood in globalization. While the industrial leaders placed their imprint upon the breakthrough period of ICT, globalization and economic growth was increasingly dominated by developments in China and India from the 1990s onwards. These two giant economies attained a new significance in international matters from the turn of the millennium — particularly demonstrated after the Asian financial crisis at the end of the 1990s that saw a retardation in growth in large parts of Eastern and Southeastern Asia but a further acceleration in the Chinese and Indian economies. Contrasts and contradictions in the new global situation were even more acutely expressed in the global crisis that emerged in 2008, which signifies the need for thorough adaptations to new structural conditions and may also indicate a historical turning point into a new trend period.

The main idea of this chapter is to put the present economic situation into a long-term historical perspective and discuss the prospects of new innovation waves over the next decades and their implications for Europe and Asia, with a particular emphasis on the
role of China. These prospects are also put into a more general perspective on structural change as an ingredient in economic growth and as a pertinent question in the present global crisis. In particular, the question is raised whether we are witnessing the awakening of a Chinese giant as a new leading polar in the global economy, overtaking Europe and the USA, or if old leaders will come out of the crisis in a refreshed manner.

In Section 1.2 of this chapter, a historical generalization is presented from the observation of different structural epochs in modern economic history, forming long waves. In Section 1.3 some general implications are discussed regarding economic growth and innovations for the next decades of upswing in a new long wave that may come out of the present crisis. In Section 1.4 two different innovation systems — based on formal science and market-led interaction, respectively — are contrasted in relation to assumed trends in innovation. Comparing economic growth internationally is, however, a rather complicated issue, since changes in both production structures and prices are involved. In Section 1.5 measurements of economic growth over the last two decades are critically assessed, which provides a basis for further analysis of structural change and comparative speed in income development in Europe, Asia and USA. Thereafter, in Section 1.6, prospects over the next decades for innovation and growth in these three major regions are discussed, followed by conclusions in Section 1.7 on global leadership in innovative behavior in a tri-polar world.

1.2 A Framework of Big Waves and Long Waves

In the economic history of the modern world, there is a conception of a long-term pattern of centennial big waves that have been initiated by industrial revolutions (cf. Gordon, 1999). Such revolutions do not occur overnight and do not immediately lead to any marked acceleration in economic growth. Rather, they create, within a couple of decades, a new basis for further growth in the unfolding of the ensuing big wave. Under such a perspective, the Third Industrial Revolution may have marked the beginning of a third big wave that will characterize much of the 21st century. From temporal,
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Technological and geographical perspectives, the industrial revolutions have had the following features\(^1\):

- The First Industrial Revolution took off in the late 18th century with steam engines and the factory system as the major innovations. The revolution was geographically centered in Britain, with strongholds in the regions surrounding the Channel.
- The Second Industrial Revolution accelerated from the late 19th century with the electrical motor and the combustion engine as central innovations in a sophisticated machinery industry and with scientifically-based industries. This revolution had a geographically widened center with Germany and parts of Continental Europe as well as Northeastern USA as leading parties within the evolving North Atlantic Economy.
- The Third Industrial Revolution was a late 20th century phenomenon with the breakthrough of microelectronics and with increased knowledge-intensive interaction between industry and services. Once again, the geographical strongholds widened considerably with Western USA and Japan, around the buoyant Pacific Economy, joining the regions of the old North Atlantic Economy.

Furthermore, there is a pattern within each big wave with two structural epochs of about 40–50 years forming *long waves*. The first long wave comprises the periods of the industrial revolutions and the wave is focused on the technological breakthrough of radical innovations in the production sectors. The second long wave is focused on the wider infrastructural, social and institutional developments that have turned the radical innovations into General Purpose Technologies (Bresnahan and Trajtenberg, 1995), becoming an integral part of the backbone of the social organization. Historically, the second waves have entailed the following enlargement of the radical innovations:

- From the 1850s and 1860s, upswings were directed to the wider construction of railway networks, telegraphs and steam ships combined

\(^{1}\) The model of waves in this chapter builds upon Schön (1998, 2000 and 2009).
with institutional adaptations to enlarged global interaction on all markets. While states became more involved in the infrastructural development at the national level, interaction over markets for goods, capital and labor intensified globally.

- From the 1930s and 1940s (and gaining wider and stronger momentum in the 1950s), upswings saw the wider social diffusion of combustion engines and electrical motors into national systems of infrastructures, concomitant with institutional adaptations to urbanization and to the industrial mass consumption society that had evolved from the beginning of the 20th century.

- If we follow the same pattern in time and context, we can envisage an upswing from the 2010s with the wider diffusion of networks and infrastructure based upon microelectronics (with the Internet as one early expression) integrated with other means of communication, and with institutional and juridical adaptations to these new conditions.

One can further add that these second upswings have created greater scope for diffusion of modernization and economic growth globally based upon reduced transaction costs institutionally and technologically. However, that has also meant the appearance of bottlenecks or new obstacles to growth that have had to be addressed by innovations, both in technology and in institutions. The contemporary menace of global climate change is a dramatic illustration of this point, challenging technology and institutions at a higher level than at earlier junctions in history.

These sequences fit largely to the observation, which Nikolai Kondratieff made in the 1920s, of long waves back to the First Industrial Revolution. Since the time of Kondratieff (1926), much new empirical evidence has amassed and long waves of roughly 40 years have reappeared. Each long wave has been demarcated by international or global crises that have been both financial and structural in character. These crises have been the lower turning points in the long waves. Such crises occurred in the late 1840s, early 1890s, early 1930s and mid-1970s. They were all preceded by decades of increased competition and fierce rationalization, and they were succeeded by decades of decisive
thrusts of long-term investments, enlarging capacity in new trajectories of growth that either brought forward radical innovations or diffused applications of the innovations in transformed structures at a broader plane socially.

So far, the events after the beginning of the 2010s combine the characteristics of prior financial and structural crises and, furthermore, appear according to the time pattern of the long waves. Thus, it is the assumption in this chapter that historical experiences provide relevant perspectives for the future, at a rather general level which is summarized in Figure 1.1.

The waves have, furthermore, had a number of common characteristics. Three such characteristics are important for the launching of new innovation trajectories and should be emphasized in the present discussion; namely, shifts in relative prices, diffusion of industrialization to new regions, and new patterns in consumption. These three characteristics are important since they contribute to the creation of platforms for further innovations and structural change and, thus, for long-term economic growth.

The timing of Kondratieff’s observation of long waves in the international price level was largely corroborated by Walt Rostow’s (1978) analysis of relative prices. Rostow indicated trend periods in the relative price of primary to secondary goods with a rising ratio corresponding to the upswing phase of the long wave that fits to shifts in demand for primary goods in periods of long-term investments into new capacity, and to shifts in supply from that capacity when it was fully installed in the later stage of the wave. Thus, the swings in relative prices were provoked by the time lag from investment to production in the primary

<table>
<thead>
<tr>
<th>1790s</th>
<th>1st Industrial Revolution (Steam engines)</th>
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<tr>
<td>1850s</td>
<td>Railways, steam ships</td>
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<tr>
<td>1890s</td>
<td>2nd Industrial Revolution (Motors)</td>
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<td>1930s</td>
<td>Automobiles, electrification</td>
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<tr>
<td>1970s</td>
<td>3rd Industrial Revolution (Micro-electronics)</td>
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<tr>
<td>2010s</td>
<td>Internet, social media</td>
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Figure 1.1: Long-term pattern of innovation waves.
goods sector. Historically, these waves saw an increased demand for raw materials in investment booms and a subsequent but belated widened production capacity, at a time when reduced investments into plants and infrastructure decreased demand for these resources. Such trend periods due to difference in the timing of demand and supply shift are still very important aspects of the waves, even if the relative prices of primary and secondary goods have developed slightly differently in the previous decades than in the Rostowian pattern, largely because of the Chinese expansion (see further below).

Furthermore, in each wave, the global economy was enlarged. Increased investments and expanding new trajectories of growth have stimulated demand in the global economy with the diffusion of modernization and industrialization. New industrializing economies and emerging markets have appeared. For a time, the diffusion of industrialization has stimulated overall demand since the emerging economies have had high investment ratios and deficits in their trade balances; but over a couple of decades, the output from these economies has expanded, leading to increased competition and to downward pressure on prices on large segments of the world market. Imbalances in trade appear more widely and are aggravated by a combination of structural crises and debt crises at the end, resulting in increased pressure towards structural transformation in many economies, both in the center and in the periphery of the world market. The past two decades bear ample witness to this mechanism.

Lastly, at the final stage of the wave, consumption has increased in the center and social patterns have changed more rapidly. The initial technological breakthroughs, with a basis in the production sphere or in infrastructure, have over a couple of decades led to a rich flow of new consumption goods that increasingly have been supplied at falling prices from emerging markets. The combination of technological change and new low-cost producers contributes to a deflationary tendency overall on the markets, which was the original observation by Kondratieff. Entrepreneurial profits are depressed in the center, but real wages are rising — nominal wages are stickier than prices. Thus, such decades as the 1880s, 1920s, 1960s and 2000s have been happy decades in the centers from a consumer point of
view. These consumer booms have been important, moreover, from a long-term perspective since the change in consumer behavior is a necessary experience for furthering the innovative trajectory. Such change in behavior is to a large extent the unforeseeable effect of prior innovations, which basically fits to an evolutionary comprehension of economic growth.

In this evolutionary perspective, structural crises are critical, since during these events a broader spectrum of choice of future trajectories is open within a rather narrow timeframe of opportunities, until the mechanism of path dependency increases over the next wave. In this perspective the present crisis is structural, and raises a number of long-term issues that need to be handled, with indications of a possible shift of future trends.

The historical pattern of waves and structural crises also indicates that the modern society evolves over epochs with a certain stability or inertia, and furthermore, that institutions and structures stay stable over periods of roughly the same length despite the fact that the pace of change in a number of areas is increasing over time. The fact that structures and institutions have seemed to evolve at the same pace over the modern history of the past two centuries indicates that some elements of social and human behavior, fundamental to long-term development, are rather constant. Our time is not different in that respect.

The historical pattern of a widening global economy purveys another experience relevant for the present situation and for present apprehensions in industrialized countries of becoming increasingly marginalized due to Chinese or Asian expansion. The global economy has developed from uni-polar to bi-polar and to multi-polar. Old centers have not disappeared with the emergence of new ones; the precondition to stay in a polar position has been, though, that old centers have been capable of thorough structural transformation in relation to new circumstances.

Two questions, then, are central to the following discussion. Firstly, which economies will be likely to take the lead in the innovative trajectories that will characterize the next long wave? Secondly, within what timeframe will Asia overall — or perhaps we should confine the question
to China as a new giant economy — converge with today’s leading
countries in overall social and economic capacity, measured as GDP per
capita?

1.3 Drivers for Further Growth

Global economic growth in each wave has been characterized by
two mechanisms, namely innovations that shift the technology fron-
tier in production and consumption and catch-up processes with the
leaders in the different sectors. Thus, global growth rates have been
determined by the magnitude of innovative shifts and by the ability
of economies to diffuse innovations widely and to catch-up with
leaders.\(^2\)

Innovations and catching-up have, quite naturally, different
importance in different economies. The closer the economy is to the
frontier of production and consumption possibilities, the more
dependent the economy is upon innovation for further growth,
i.e., upon the ability to turn knowledge and learning into new com-
binations of resources, while the mechanisms of catch-up (which
involve a number of elements such as structural change from agricul-
ture to industry and services, investments in modern social and mate-
rial infrastructures, increase in capital intensity, transfer of technology,
etc.) approach depletion or decreasing marginal returns.

In each wave, a number of new countries have caught up with the
leaders. In that sense, the pool of potential catch-up economies is
diminishing. This does not mean, however, that catch-up will disappear
or even diminish as a mechanism for global growth over the next
decades or the next century. Firstly, new countries are likely to enter the
global scene, increasing competition from below upon all economies,
particularly upon recent latecomers such as China and India. Secondly,
there is still much scope for further catch-up in India and China and
other emerging markets, with a wide gap to leading economies still
existing from technical, economic and social aspects. Thirdly, new scope

\(^2\) On catch-up and forging ahead, see Abramovitz (1989).
for catch-up appears over and over again in modern history since, in the upswing of the waves, some economies are able to open up innovative trajectories and forge ahead by shifting the frontier outwards — in some cases, even catching-up economies of the preceding waves have had the drive to forge ahead, thanks to very strong connections between knowledge creation institutions and production sectors. Such examples were the US and German economies in the late 19th century and the Japanese economy in the late 20th century, at least in some sectors of industry and services.

Thus, the two questions raised in the preceding section of this chapter concern the major mechanisms for global growth. The first question asks what innovations will be central to enable further growth globally and what economies will take the lead in that respect. From the perspective of long-term innovation waves, a leading economy does not have to be the richest economy or the largest economy, but it has to have the capacity to take the lead in crucial innovations over the next decades. Thus, conditions for innovation in Europe and Asia as well as in the USA are certainly central aspects for long-term innovation and for further growth. The second question may be phrased as to whether the very strong catch-up drive behind growth in parts of Asia over the last decades will continue or if it will taper off. The answer is dependent upon what conditions will characterize growth globally and the ability in these economies to change the structures behind growth, in order to meet new conditions.

**Trends in Prices and in Demand for Innovations during the Next Decades**

In the recent wave during the past two decades, the widening of the global economy has been unprecedented in scope due to Chinese and Indian growth. Their growth rates are perhaps not spectacular from a historical point of view, but the numbers are. More than 2 billion people have become actively integrated into the global economy at a path of high annual growth rates. This has meant a fundamental change in the relationship between factors of
production. The increase in the supply of labor has been enormous, while at the same time the pressure on natural resources is augmenting rapidly. Shifts in relative prices between resource-intensive and labor-intensive goods have already appeared during the past decade (in contrast to the earlier Rostowian pattern), but these shifts will most probably be reinforced over the next decade, even if growth rates in India and China will be some percentage points lower. Thus, two major trends may be forecasted, originating in the Asian expansion.

First, the Asian expansion will continue to put a downward pressure on the relative price of labor in large segments of both industry and services — particularly in areas where the labor process is fairly standardized and is suitable for large-scale operations and for catch-up processes. On the other hand, demand pressure will continue to increase, even accelerate, on goods that are intensive in natural resources such as construction materials, energy and food. With further growth in China and India likely, the contribution to total demand for such resources will increase for every year over the next decade or two. This is particularly so, since output increases in this area need long-term investments, which during the construction phase tend to further increase demand for material and energy (cf. the mechanisms of the Rostowian relative price cycle between primary and secondary sectors). Price increases of energy and of natural resource-intensive materials may be further sustained by institutional measures taken to restrict climate change.

Another reasonable trend is that demand will shift towards new services with little material content. This will be particularly pronounced among medium- and high-income earners and thus, on an aggregate social level, in high-income nations. So far, both USA and Europe have been dominant in advancing new consumption patterns. This has been due to factors such as high income levels, a prominent role of consumption in economic growth, and a high degree of openness in societies regarding new trends and variation in habits. With a shift in demand towards more complex or more consumer-oriented
services — and with a less elastic supply of human capital — the relative price of less standardized or more complex services will increase over the next decade.

Prices are important for the formation of value-added and for the distribution of income between economies. Shifts in relative prices are the combined effect of shifts in supply and demand. They may, hypothetically, be inversely related to changes in productivity, in which case the effect of the price change on income is minimal since it would be directly offset by an equivalent volume change per production factor. However, relationships are not that direct in all economies. Rather, one could say that the pressure to increase productivity is particularly strong in areas of falling relative prices (due to increased competition), while the anticipated remuneration to innovation is highest in areas of rising prices (due to increased demand).

This has a bearing on economic growth and income in different regions. Price movements are essential in relation to innovations and to the appearance of development blocks (Dahmén, 1988) or new configurations of complementary activities around important innovations. Major development blocks have some technological innovation at the center which usually provides goods or services at falling prices (through a decisive supply shift), which at the same time leads to an increase in demand for complementary goods or services that are less elastically supplied and thus meet rising prices. It is not certain that a concentration of resources in the innovation area, usually defined as high-tech, leads to a more favorable development in terms of income than allocation to complementary activities (such as a number of services).

The best situation is, of course, if demand shifts and innovative supply shifts are combined. Knowledge and innovations that combat bottlenecks and enhance the supply or reduce the demand of e.g., energy, material or food may be richly remunerated over a period of some decades (until competition in such innovative areas increases again at the ending decades of the anticipated new wave). Knowledge of energy-intensive processes, both in traditional industries and in new areas such as biotech, will be important to meet the challenges. Thus, mergers between the more mature information
technology and the research-intensive biotechnology, which is still awaiting major commercialization breakthroughs, are highly ranked candidates for new development blocks in the next wave. A logical next step in the microelectronic revolution into nanotechnology and its fusion with biotechnology would also replicate the historical development during earlier “second winds” in the big waves. On one hand, the ability to construct smaller and more powerful units of the original radical innovation has been instrumental for the wider application into General Purpose Technologies, which could be applied effectively both in small units and in large social systems. On the other hand, complementary innovations in the area of materials that have dissolved or reduced bottlenecks in the supply of natural resources have been of utmost importance for further global growth. New steel processes as well as new plastics and metal alloys served such functions in the 19th and 20th centuries, respectively.

New trends in consumer behavior may be another important component behind growth, particularly since a coming second wave of the Third Industrial Revolution will very likely have a strong focus on the wider social diffusion and consequences of the microelectronic revolution. Such a trend involves two major preconditions. The first and perhaps most important precondition is that the contemporary rich economies are able to change their structures in relation to new global markets (i.e., taking advantage of relative shifts in prices) and keep increasing their GDP and income at a rate of 1–2 percentages per capita annually. That would sustain the consumer demand into new directions in conjunction with the demand from a rising and numerous middle-class in emerging markets. The second precondition is that consumer demand changes in the direction of more knowledge-intensive and less material-intensive goods and services. Innovative and knowledge-intensive services in a broad spectrum would in that case become a more substantial part of global growth. These perspectives raise a number of questions concerning future innovative trajectories as well as the direction of structural change in different economies.
1.4 Innovation in the Learning Economy

In studies of innovation and innovation systems, two distinctly different mechanisms have been distinguished. On one hand, there is the science- and technology-based innovation process, labeled STI; and on the other hand, there is the experience-based learning process, labeled DUI (Doing-Using-Interacting).

The STI process has been much targeted by research and innovation policy. It is characterized by investments in universities, in research institutes and in R&D, mainly by large firms. It is also characterized by increased interaction between these organizations in National Innovation Systems, and leads to a greater number of trained academics in all organizations.

The STI system is advantageous when it comes to following a certain technological trajectory and exploiting possibilities at the frontier of knowledge through basic research. It is also of great importance for the ability of an economy to import and adopt technology and innovations at an early stage.

The DUI process emphasizes interaction in different respects, between groups of employees within the firm, between employees in different firms and, perhaps most of all, between firms and customers. Innovations come out of learning from experience and from tests of a multitude of ideas. It goes without saying that DUI is more important in innovative areas related to new consumer behavior and to social change.

The structure of DUI processes means that such innovations tend to come out of less hierarchical organizations, built up from rather autonomous groups that are open to communication. Such organizations are more prevalent in open societies. The DUI process is of course still dependent upon a high level of knowledge among employees, particularly upon problem-solving abilities on all levels related to the doing-using-interacting functions.

In reality, the STI and DUI systems are not totally separated from each other or mutually exclusive, since all processes rely upon formal knowledge and science to some extent as well as upon experience and communication. It is, however, held by innovation economists that
the two systems dominate different spheres of the economy and characterize different economies.

These systems played different roles historically, in different stages of economic growth. Thus, it was largely the Second Industrial Revolution that gave rise to formalized STI innovation processes. With the breakthrough of more sophisticated technology at the end of the 19th century, cooperation between universities and industry really took off. During that period, large firms established laboratories for R&D, superseding experience-based trial and error in the sphere of doing-using that had dominated in the First Industrial Revolution. The Third Industrial Revolution, however, created scope for much broader interactive innovation processes within firms, between firms and with consumers, thanks to *inter alia* dramatically reduced transaction costs. Thus, DUI reappeared in a novel form and with a new significance for innovations.

The major trends in growth and in relative prices have different implications for the innovation procedure. On one hand, the increased pressure on natural resources will in turn increase the pressure to advance knowledge in science-based technologies. Thus, innovations in areas such as energy, materials, medicine and food will be highly valued. STI processes will be fundamental in opening up new spheres of knowledge and innovative trajectories, particularly regarding the use of natural resources. On the other hand, shifts in demand to services and to virtual economies will induce innovations related to new consumer behavior, and thus build upon interaction and trial-and-error in a more open, evolutionary manner. Therefore, the broader array of services and consumer goods in future growth will most probably increase the importance of DUI processes.

In both areas, innovation will require that many disciplines cooperate in knowledge creation. Hence, the ability to communicate and coordinate is of utmost importance. While science-based innovations may be met by concentrated efforts that to some, but only to some, extent have a better fit in more hierarchical organizations and societies, the area of DUI innovations is definitely dependent upon an open society with flat organizations and with close connections to experimenting consumers.
1.5 Economic Growth, Structural Change and Purchasing Power

What is the growth rate of GDP in China? How does it compare to European growth rates? These questions are straightforward, but straight answers are more difficult to get, notwithstanding the very prominent role figures of economic growth rates have in every discussion or analysis of performances.

Every measure of economic growth is based upon a set of fixed prices for all goods and services produced, in order to eliminate the effect of inflation or deflation upon the sum of value-added produced in the economy. This may seem a trivial procedure but in fact it is not trivial, especially not when comparisons of growth rates should be made between countries.

In international comparisons of economic growth and levels, two principles are usually combined. Firstly, growth rates are calculated within each country with a set of fixed prices from each country. Thus, the different branches and sectors are weighted according to price relations within the country. Secondly, the level of the time series of GDP is adjusted for each country at one benchmark according to a measure of purchasing power parity (PPP) — i.e., a large set of “world market prices” for all goods and services in GDP is constructed for the benchmark year, and each country’s GDP is recalculated for that particular year. Thus, the level of all series is adjusted at this PPP benchmark, but not the slopes of the series (i.e., the growth rates), which are determined by the domestic calculation.

Since different economies have different structures both in production and in prices, and since there are structural changes both in production and in prices, the use of fixed prices from different points in time will give different growth rates. Such variation is an abomination to the statistician, but varying results may also be an analytical tool to indicate the magnitude and direction of structural change in different economies.

In this section, the rate of economic growth in Asia, Europe and the USA will be adjusted for changes in purchasing power between two points in time, 1990 and 2005. The adjustment will serve a double
purpose. Firstly, adjusted growth rates provide internationally more comparable growth rates in income per capita. Secondly, the size and the direction of the adjustment — upwards or downwards — will indicate the direction of structural change in relation to international price movements.

Nationally calculated growth rates may deviate from the growth rate at purchasing power parities, mainly for two reasons. Firstly, the national price structure is different from the constructed world price structure. This is particularly the case if large sectors of an economy are closed from world trade. In many economies at an early stage of industrialization, there are “traditional” sectors, particularly in agriculture and services, that usually produce at much lower prices than at the world market prices. The opposite may be the case in some industrialized countries that have protected sectors producing at relatively high prices. If growth rates differ much between closed and open sectors — as a general rule, the production volume of a closed sector grows more slowly — these differences in relative prices affect aggregate growth rates. Secondly, prices change over time. With fixed prices, only the volume of goods and services is accounted for, but the purchasing power of an economy is affected if relative prices change in any direction.3

In economic history, a so-called Gerschenkron effect has been identified in industrialization processes, characterized by a rather general phenomenon of falling relative prices and rising quantities of advancing, innovative commodities. During industrialization, such a development indicates increased productivity in modernizing branches. However, it may also indicate increasing pressure from external competition, while the opposite development of prices rising together with rising quantities may indicate a more favorable orientation to demand.

Constructing PPPs covering all economies in the world is labor-intensive and is performed only with rather long intervals. More

3 A third reason for deviations is, of course, measurement errors that may be larger in countries at low income levels than in rich countries. The error is supposed to be unbiased and may affect adjustment in both directions.
recently, PPPs were constructed in 1990 and 2005. One approach to adjust growth rates between these benchmarks is to recalculate the national growth rates according to the annual percentage change in per capita purchasing power from a global supply of goods and services at fixed world prices. The adjustment will be the combined effect of differences between internal and world price structures and of national orientation to segments of relatively rising or falling prices at the world market.

In Table 1.1, the traditional, domestically determined growth rates for a number of countries in Western Europe and Asia and for USA are presented together with growth rates adjusted for changes in purchasing power between the PPP benchmarks of 1990 and 2005.

The result is very striking. In traditional measures, using domestic price relations to quantities in the calculation, the difference between Asian and European growth rates is indeed large — excluding Japan, the Asian average rate is more than three times the European rate, and including Japan it is twice the European rate. When growth rates are adjusted for purchasing power parities in 1990 and 2005, however, a rather different picture emerges. All European countries increase their growth rates, some quite substantially. On the whole, one may hypothesize a positive demand effect, i.e., a European orientation to areas with increasing relative price. In the Norwegian case it is presumably to a large extent a contribution from oil, while the substantial German and Dutch effects are reached without such natural resources. There may also be a “reverse” effect from slow-growing and highly priced domestic service sectors, which may reduce growth rates in traditional calculations.

One may also notice that Europe compares very favorably with the USA in the PPP-adjusted growth rates. A slight American lead over Europe is turned into a decisive American lag. This is noteworthy for

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4 The procedure is to recalculate the 1990 GDP for every country in 2005 price level but with 1990 global PPP structure according to this formula: \(\text{(Country share of world GDP 1990 in 1990 PPP)} \times \text{(World GDP 1990 in 2005 PPP)}\) and then calculate the difference in growth rates between series with the adjusted and non-adjusted base year of 1990.
a number of reasons. The American lag had already appeared by 2005 
(i.e., before the financial crisis), over a period encompassing the much 
praised “roaring nineties” in the USA. Rhode and Tonniolo (2006) 
argue that American growth in the 1990s gave rise to European fears 
of a new technological and economic gap opening up to the USA, 
which inter alia was a motivation for the Lisbon strategy in the 
European Union. Furthermore, the USA is the only rich country that 
has a negative effect from the purchasing power adjustment of the 
growth rate. Hypothetically, this reduction may be due either to a re-
latively large share of domestically low-paid and slow-growing services 
that have been “up-weighted” by international prices or, more posi-
tively, to a large IT sector with falling prices. Actually, American 
growth figures of the 1990s were boosted by the use of so-called hedo-
nic prices of IT equipment to a much larger extent than in Europe — 
i.e., calculation methods increased production volumes in relation to

Table 1.1: Annual growth rates in GDP per capita 1990/1994–2005/2010 in a number of Asian and European countries and in the USA. Traditional growth rates and PPP-adjusted growth rates.

<table>
<thead>
<tr>
<th>Region/country</th>
<th>Traditional</th>
<th>PPP-adjust.</th>
<th>Region/country</th>
<th>Traditional</th>
<th>PPP-adjust.</th>
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<td>Germany</td>
<td>1.3</td>
<td>2.4</td>
</tr>
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<td>India</td>
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<td>2.2</td>
<td>UK</td>
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<td>S. Korea</td>
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<td>Ireland</td>
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<td>Taiwan</td>
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<tr>
<td>USA</td>
<td>1.8</td>
<td>1.6</td>
<td>Europe</td>
<td>1.6</td>
<td>2.3</td>
</tr>
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Source: Calculations from the Conference Board.
Note: Europe = Austria, Belgium, Denmark, Finland, France, Germany, Greece, Iceland, Ireland, Italy, Netherlands, Norway, Portugal, Spain, Sweden, Switzerland, UK. Asia = Bangladesh, Cambodia, China, Hong Kong, India, Indonesia, Japan, Malaysia, Pakistan, Philippines, Singapore, South Korea, Sri Lanka, Taiwan, Thailand, Vietnam.
the technical capacity of the equipment, which deviated from the value-added produced in a sector with rapidly falling prices. Overall, the adjustment of the American growth rates rather depicts an economy with increasing structural weaknesses, which contributed to accelerating deficits in the period preceding the financial crisis.

The Asian cases are generally the opposite of the European cases and follow a logical pattern. Thus, the effect of the PPP adjustment is clearly correlated to the income level or to the stage of industrialization. Only two small and commercially developed city-states—Singapore and Hong Kong—have substantial positive adjustment effects comparable to the European level. Of the major Asian economies, only Japan and Taiwan have positive effects at all from PPP adjustment, but in both cases the effect is very small. In Korea, the effect is only slightly negative, while the effect is strongly negative in all other Asian countries, in some cases catastrophically so. This pattern may be interpreted as an effect of the two reasons for deviations discussed earlier—firstly, that poor countries have large traditional sectors with slow or even negative growth at per capita basis that are given much greater weight in the PPP calculations than in the internal calculations, and secondly, that much of the volume growth in new industrializing countries is in sectors with falling prices, such as the provision of goods and services that are standardized and open to low-price competition.

Among the rising giants, the adjustment effect is particularly strong for India. This indicates that the modern sector is still very narrow in this overwhelmingly rural country, with much slower growth in the agricultural sector where the positive effects of the “green revolution” may be waning. The negative adjustment effect is substantial also in China, but much weaker than in India. Even the PPP-adjusted Chinese growth rate is very respectable, if not outstanding. One reason why the adjustment effect is so much weaker in China than in India may be that growth in China is broader-based with more upgrading undertaken, but it may also be due to a large and increasing share of domestic production of raw materials, notably of coal, at rising prices that counteracts negative influences from falling prices of manufactured goods and slow growth in extensive traditional sectors.
These calculations give further emphasis to the importance of consecutive structural changes and of social and regional broadening of modernization as part of economic growth and development.

1.6 Growth and Innovations in Three Continents

In this section, the three major economic regions — USA, Europe and Asia — will be revisited with prospects for further economic growth and, in particular, for leadership in the next wave of innovations.

USA a Leader in the Next Wave?

The leading US economy seems, to some extent, very fit to meet many of the challenges of our time. The USA was the leading economy in both the Second and the Third Industrial Revolutions. Thus, it has shown great potential in both STI and DUI processes of innovation. The present challenges facing the USA, however, are to a large extent of a different character than advancing new radical innovations. Basically the challenges are more social in character, with the adaptation of institutions to a number of new imbalances. In that sense, the situation has greater similarities with the crisis of the 1930s, which placed a heavy transformation pressure on US politics. At the beginning of the 2010s, the challenge is to come to grips with the imbalances that have emerged in relation to foreign markets and to natural resources due to a too-lavish consumption. While on one hand, the political and economic US hegemony has weakened in the face of growing competition, on the other hand, the US demand for resources has stayed at a high level both from consumers and from the global political apparatus. In particular, the American lifestyle — developed over two centuries with an extremely rich supply of natural resources — is at stake. An innovative change in the direction of economizing with natural resources, above all with energy, would represent a new American leadership, involving as well rearmament of the social and material infrastructures. It is still an open question whether such an American response to global questions will materialize within the next decade.
Rather low rates of PPP-adjusted economic growth over the past few decades may indicate structural conditions that raise more problems. That the USA forged ahead to global leadership in the 20th century was to a large extent based upon the combination of rich domestic resources and a wide integrated market that opened the way for standardization and mass production technologies at an early stage. Globalization and IT certainly enhanced some comparative advantages for US companies in the 1990s, but at the same time competition increased in the field of standardization. Furthermore, with the technologies of the Third Industrial Revolution, quality and flexible customized production have come to the fore — traditions that have been stronger developed in Europe.

**European Innovative Leadership?**

The European economy clearly faces new possibilities but also challenges of adaptation to a new competitive world and of catching up in new areas. The Lisbon strategy addressed some of these challenges, mainly arising from the new growth trends that appeared in the USA in the 1990s, by advocating enhanced knowledge intensity in Europe with a more rapid shift to an economy driven by innovation and services. It also entailed a number of European cooperative efforts in typical STI systems of knowledge creation and innovation, such as the enormous venture into the ESS center in Lund, Sweden.

A new European handicap to the integrated United States of America emerged out of the Third Industrial Revolution with the potential of large-scale service integration that became very visible with the expansion of the Internet and globalization in the 1990s. Hence, one of the major political challenges confronting Europe is within services, where markets to a large extent are fragmented nationally, despite decades of increased integration. Transformation pressure is augmented upon national social systems that were strengthened following the crisis of the 1930s — particularly in small open economies such as in Scandinavia and the Netherlands that once took the lead in the 1930s recovery.
Conditions for innovation and growth are, however, very different in different parts of Europe. This is due both to macroeconomic circumstances and economic structures at large, but also to differences in systems of innovation and learning organizations. Conditions for economic growth have shifted radically over the last few decades, as shown by the annual growth figures in Table 1.2, and new trends may be perceived from the 1990s.\(^5\)

The overall picture of European growth is clear. In the post-war period of high growth rates, there was a strong convergence with

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<th>Northwestern Europe</th>
<th>Continental Europe</th>
<th>Southern Europe</th>
<th>Eastern Europe</th>
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<tr>
<td><strong>Annual percentage growth in GDP per capita</strong></td>
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<td>1951/1955–1971/1975</td>
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<td>4.0</td>
<td>4.9</td>
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<td>2.3</td>
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<td>1991/1995–2006/2010</td>
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<td>1.4</td>
<td>1.8</td>
<td>3.6</td>
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<thead>
<tr>
<th>GDP per capita in international dollars of 1990 price level</th>
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<tbody>
<tr>
<td>1951/1955</td>
<td>6828</td>
<td>5406</td>
<td>3377</td>
<td>2315</td>
</tr>
<tr>
<td>1971/1975</td>
<td>11851</td>
<td>12095</td>
<td>8942</td>
<td>5057</td>
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<tr>
<td>1991/1995</td>
<td>16995</td>
<td>17460</td>
<td>14250</td>
<td>4823</td>
</tr>
<tr>
<td>2006/2010</td>
<td>24028</td>
<td>21495</td>
<td>18673</td>
<td>8317</td>
</tr>
</tbody>
</table>

*Sources:* Maddison and the Conference Board.

*Note:* Northwestern Europe: Ireland, Great Britain, the Netherlands, Denmark, Norway, Sweden, Finland and Iceland; Continental Europe: Austria, Belgium, France, Germany and Switzerland; Southern Europe: Portugal, Spain, Italy and Greece; Central and Eastern Europe: Poland, Czech Republic, Slovakia, Hungary, Yugoslavia, Bulgaria and Romania.

\(^5\) These growth rates are not PPP-adjusted, mainly because no benchmarks prior to 1990 are available. One may also add that the effect of PPP-adjustment for the last period is rather similar over the European regions; it is positive in the range of 0.6–0.9 percentage points annually.
rapid growth in the economically more backward regions of Southern, Central and Eastern Europe. The whole of Europe was catching up with the USA, while European integration got rid of the fragmentation that had hampered modernization of industry. There was also a strong internal catch-up with the more affluent Northwestern Europe region. During the crisis-stricken decades of the 1970s and the 1980s, growth rates slowed down and the catch-up process withered, both externally to the USA and internally in Europe. Since around 1990, however, a new pattern has emerged. Growth rates have increased in Northwestern Europe and in Central and Eastern Europe, while there was a further deceleration of growth in Continental and Southern Europe. Thus, growth accelerated in the richest and the poorest regions of Europe — divergence and convergence co-existed.

These differences in growth performance over the last decades may be discussed in relation to changing structural conditions to meet the innovative waves of IT and globalization that took off in the 1990s. In particular, work organization and systems of innovation changed, but with different characteristics in different parts of Europe. In Lorenz and Valeyre (2006), a matrix of different systems of work organization with regard to learning processes and innovations is applied to characterize the EU-15 countries.

The analysis is made from a scheme of four types of work organization: (a) discretionary learning characterized by high level of problem solving in work with high complexity in problems and high level of discretion or latitude for the initiative of the individual employees; (b) lean production with high level of problem solving in work but with lower complexity in problems and with low level of discretion or latitude for the initiative of the individual employees (thus, the initiative is more with central administration); (c) taylorism characterized by low level of problem solving and very low level of discretion for the individual employees; and (d) traditional handicraft organization with low levels of learning and complexity.

Adaptation to new conditions of growth in the 1990s was most significant in Northwestern Europe, according to Lorenz and Valeyre (2006). Structural change in private enterprise was combined with
new economic policies. Thus, macroeconomic measures, such as tax reforms, were undertaken in order to increase flexibility and labor supply. Even new political constructions were launched to meet the needs of both flexibility and social security, such as the Danish flexicurity in the 1990s. As regards work organization, the Scandinavian countries and the Netherlands took the lead in Europe as well as worldwide in developing discretionary learning processes within companies. The hierarchic Taylorist or Fordist model gave way for an organization where more responsibility was allocated to employees who were expected to solve problems on their own and where knowledge creation and learning developed in a more interactive form both within the company and with customers. With this structural change, the innovation process of the DUI type was strengthened. These countries also performed very well with two critical and complementary investments — in IT equipment and English. They were able to adapt to the new conditions of globalization at an early stage. Apart from being comparatively successful in the ICT sector, economies such as the Netherlands, Denmark and Sweden were also well-advanced in more complex knowledge-based innovation areas such as biotechnology. In Norway, economic growth was not only related to oil resources but also to non-R&D-based innovation underlying the exceptional productivity performance of the private services sector (OECD, 2008). Once again — as in the 1930s — small open economies in the northwest of Europe showed apt reactions to the structural challenges of the early 21st century.

The two other countries in Northwestern Europe — Great Britain and Ireland — were certainly well-prepared in respect of the complementarity between IT and English as well. Ireland could furthermore profit from educational reforms undertaken in the 1960s, enhancing supply of well-educated labor from the 1980s, while Great Britain took advantage of global expansion in services. Work organization in these two Anglo-Saxon countries differed, however, from Scandinavia and the Netherlands. It was characterized more by lean production in the Japanese sense with a work organization that was more structured or bureaucratic and with more narrowly defined tasks of problem solving, i.e., with less complexity for the
employee. In general, learning processes in the Anglo-Saxon countries were weaker and more concentrated to the upper layers of the hierarchy.

In continental countries such as Germany and Austria, work organization was close to the Scandinavian or Dutch type with more discretionary learning processes undertaken by the employees. In France, on the other hand, work organization was closer to the British or Irish type with a more standardized labor process. The weak economic performance of this group of countries may partly be seen in relation to greater difficulties in adapting to new conditions of growth — not least with the strong complementarity between global services, IT and English. It was also the result of the economic strain that arose in the 1990s from the German unification. The very pronounced positive effect of PPP-adjustment of German growth rates indicates, however, a strong structural transformation to new conditions in the world market that partly may have come out of the unification and the further integration with liberalized Central European countries.

Deceleration in growth was similarly very marked in Southern Europe. In this region, structural difficulties were furthermore augmented over the period into the 2000s. Favorable catch-up conditions were to a great extent exhausted, while competition from expanding economies in Eastern Europe and from China became more intense. Above all, however, work organization in all these Southern countries was still either Taylorist in character or traditional with low knowledge intensity. This probably made them more vulnerable to the new low-price competition in manufacturing. One may envisage a rather high structural threshold into a new phase of more innovative and integrated learning processes, in combination with severely restrictive economic policies over a period of time to come to grips with large deficits.

The expansion in Central and Eastern Europe was very much of a catch-up character, driven largely by strong growth in manufacturing industries in countries with traditions in this area such as Poland, Czech Republic, Hungary and Slovakia, now open to the market economies. Very high PPP-adjustments of growth rates indicate positive structural changes in all these countries. These former planned
economies certainly have scope for further catch-up — showing growth figures over the last decade in manufacturing exports of machinery, vehicles and other equipment that are close to the Chinese performance — but they will probably be rather weak players in terms of innovations over the next decades.

Overall, the indications of structural change in Europe in relation to new market conditions with traditions of customizing rather than standardization as well as political willingness, at least, to tackle some of the major problems confronting further global growth may give Europe, or some European countries, an important role for leadership in technological and institutional innovations of the 2010s.

**Asian Dynamics and Structural Change**

The spectrum of Asian economies is very wide in terms of income and economic development. There is much scope for further dynamics with catching-up countries at different levels. There are also strong pressures for structural change in this process. At the top, there are economies such as Japan, South Korea and Taiwan at income levels comparable to or close to the OECD average with similar situations as many European countries, confronted with new competition and in need of structural transformation. In the midst, there are the catch-up giants of China and India that will have a strong impact on both the Asian and the global economy in the near future. And below, there are countries and regions in Southeast and South Asia that are candidates to become new low-cost and high-growth industrializing economies, among them the next-to-giant economy of Indonesia.

High-growth countries such as South Korea and Taiwan have, in many respects, been very successful in terms of technology and productivity. Substantial efforts have been put into education, organization and technological upgrading of the economy. The rise of competition from new low-cost countries, not least China, increases the need for further upgrading and the creation of greater variety in more complex systems. Work organization and systems of innovation suffer, however, from some weaknesses that are rather common to the newly industrializing countries in Asia. Concentration to the ICT
sector is very high and furthermore, it is concentrated to process rather than product innovation, often in close cooperation with advanced industrial customers (Edqvist and Hommen, 2008). Structural transformation in relation to new market conditions increases the need for greater variety and greater discretion and cooperation beyond the lean production concept. Thus, there is a need to shift from catch-up to creative innovation systems. In the case of Korea, however, the continued reliance upon large chaebols creates lock-ins that may place obstacles on such a restructuring (OECD, 2009).

The ensuing discussion of Asian innovation systems will concentrate on the Chinese perspectives, since China’s future path will be very significant for global development. In an absolute sense and at the macro level, China has clearly advanced to a position close to the global frontier in terms of total gross domestic expenditure on R&D (GERD), second only to the USA and Japan. In relative terms, the Chinese level is certainly much lower than in most OECD countries, but its R&D intensity has increased rapidly, with R&D expenditures rising from 0.6 to 1.4 percent of GDP between 1995 and 2006.

China’s innovation system still has a number of weaknesses, though. The OECD review (2008) of the Chinese innovation system concluded that some “framework conditions for innovation are insufficiently conducive to market-led innovation, especially those relating to corporate governance, financing of R&D and technology-based entrepreneurship, and enforcement of intellectual property rights”. It also concluded that there was a too-great separation between knowledge producers and potential users and regions of science parks, which appear as “a very large number of ‘innovative islands’ with synergies insufficiently developed between them, limiting spillovers beyond them”. Overall, conditions are very much characterized by massive resources channeled into catch-up, and are far from those of discretionary learning and DUI processes that characterize north-western Europe.

Given the strong orientation in the catch-up process to manufacturing for foreign markets, such weaknesses of institutions for market-led innovation are understandable. It is also quite natural
that Chinese R&D is mostly dedicated to experimental product development while expenditure in basic research has been low. Furthermore, patenting has been dominated by foreign firms in China, while exports of high-technology goods have been strongly, and increasingly so, dominated by foreign-owned companies or by joint ventures with foreign companies.

In a wider perspective, Chinese economic growth will be highly dependent upon reactions to the present crisis. In the upswing from the crisis, China will face the need for profound structural transformation. On one hand, international price development will probably turn negatively for the Chinese specializations hitherto, with price increases in the primary and tertiary sectors and with a further relative price decrease in the secondary sector of manufacturing. This will be particularly the case if industrialization maintains its global momentum and spreads to new regions of low-cost labor. Furthermore, consumer demand for Chinese exports from the American and European markets may weaken due to policies to get rid of current imbalances, not least in the USA but also in parts of Europe. On the other hand, internal pressure for transformation will probably increase; particularly if the present global crisis is prolonged and if the two main driving forces over the last 15–20 years — investments and exports — are faltering. Demand for social reforms and regional balance within China will increase, which is a situation similar to the one that confronted industrial countries in the crisis of the 1930s.

These issues are targeted by the Chinese leadership in the 12th five-year plan, taken in March 2011. The intention is for China to give up its position as a global factory with export-driven growth, by performing a structural shift to service sector growth, based to a large extent upon domestic demand. These reforms will raise consumption and wages. Higher wages and social expenditures will strengthen internal growth forces and increase pressure towards structural change, since profits will decrease within those companies that have been a mainstay in growth so far. Productivity will have to be raised further, particularly when confronted with competition from new low-cost countries or regions. The profit squeeze from falling prices and rising costs is already felt in “hot” regions in southern China,
where firms have moved to adjacent low-cost countries in Southeast Asia — such mobility has been part of the Asian dynamics since the 1950s. This is a transformation pressure for structural upgrading that all industrial countries have to confront and react to. A number of much smaller Asian countries have done so in a rather orderly fashion and very successfully since the 1960s, while industrialization has been diffused to new countries. The new five-year plan is clearly intended to meet the needs of profound structural reforms.

Such reforms are necessary in order to achieve the overarching goal of keeping the nation intact. Structural change is, however, a problematic issue in many ways. For one thing, such shifts generally lead to periods of slow growth and unemployment, since old engines are choked before new ones really get to full steam. A slow-down may increase social and political pressure on the regime. For another thing, reforms to strengthen consumption and regions in Western China will at the same time work against strong groups in Eastern China that have become prosperous and established interests over the last decades. Social contradictions of this kind pose particular challenges to the political leadership in an economy that is both market-driven and planned. In particular, it raises the question of the political power to implement the reforms. What instruments does the leadership have to carry through reforms in a very wide and multi-layered economy such as China, where much of the initiative over the past decades has been handed over to those who had much to gain from the previous policy but little to win from the new one? It may take more than five years to realize the basic structural shift in Chinese growth.

The prospects for the effect on R&D and innovative capacity are mixed. Reforms may, on one hand, reduce the surplus for R&D investments in the short run but, on the other hand, they may improve the degree of market-orientation in R&D and innovation in the longer run. Above all, a successful realization of the five-year plan may create scope for somewhat lower but sustained growth rates in China over the next wave. This would at the same time undoubtedly have benign effects upon the stability of the global economy, reducing the pressure from present imbalances between China and USA.
A very last question with regard to China: How long will it take for China to reach the level of Western Europe in terms of per capita income? If one assumes that China and Western Europe continue on the PPP-adjusted paths that characterized the last 15 years, the answer is comparatively simple. With a differential in annual growth rates of roughly 4 percentage points, it will take 40 years — that is over the span of the next long wave!

1.7 Innovations and Institutional Change in a Tri-polar World

If global growth is to continue at an average rate of 1–2 percent per capita over the next decades with a further diffusion of industrialization, there is a need for innovations in areas of natural resource bottlenecks and for a concomitant shift in consumption into less resource-intensive goods and services. Innovations and shifts will take some time to mature and, in the meantime, trends in relative prices and competition will have a strong effect on the world economy and on needs to restructure. Such pressure will be hard not only for established industrial countries but also for new giants such as China and India. In this perspective, innovation, diffusion and structural transformation will be integral parts of a new long wave from the 2010s, and the national trajectories for the next decades are very much dependent upon abilities to meet the present structural crises. The impact from the rising Asian giants will most certainly continue to grow over the next wave, but they will hardly oust the present polar structure; rather, they will add new dimensions to the global economy.

Pressure towards structural change is particularly augmenting in the leading centers of USA and Europe, confronted with fundamental trend shifts, structural imbalances and acute debt crises in the early 2010s. In USA, the traditional lavish consumption lifestyle is put under heavy transformation pressure in conjunction with rather poor economic performance over the last decades. While political tensions increase within USA, the global American hegemony since the mid-20th century is weakening in a world that turns tri-polar. Thus, adaptation to new conditions is a profound challenge to the USA.
The European situation is very mixed. Long-term trend shifts towards complex services and customization favor some traditional European qualities; while at the same time widespread debt crises put the institutional structure of monetary and financial integration into jeopardy. Catching-up countries — such as Greece, Spain and Ireland — are caught in a financially fragile position with grave public deficits and with an economic structure open to low-cost competition in many fields, despite reasonably high growth rates over the last decades. The outcome of the crisis may be a deeper financial and political integration in Europe, or the reverse — a break-up of the monetary integration.

Northern Europe stands out as a strong region both in terms of economic structures and financial position. Just as important as innovative technological change are institutional changes that combine social security with structural flexibility in an increasingly urbanized and integrated global economy. In this area, a number of small and open economies in northwestern Europe have been comparatively successful over the last couple of years, strengthening their position both within Europe and internationally.

Institutional and technological leadership into the next long wave is not a question of being the richest economy or the largest economy, but rather, being able to meet and grapple with the major challenges. In an evolutionary perspective of long-term economic development, successful innovations come out of variety, and strong variants of institutional adaptation may appear in surprisingly small economies, as was the case in northwestern Europe from the 1930s. History may repeat itself in some fashion, but in the longer term it is necessary that large economies also follow suit.

References


