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Growth, Innovation and Natural Resources

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Summary: Key aspects of economic growth and sustainable consumption are highlighted in the context of a modified neoclassical growth model. If we consider the topic of optimum growth in a broader context the notion of efficient specialization – in accordance with relative factor endowment - has to be distinguished from optimum specialization. For most resource rich countries long term economic growth is possible, namely if sufficient investment in research and development plus education is realized in the context of a dynamic open economy. As the exploitation of natural resources is likely to decline in the very long run in many countries – including in Russia – the level of the growth path should be expected to reduce in the steady state. Adequate long term emphasis on innovation dynamics is crucial for sustained growth where innovation should include strong emphasis on renewable energies and energy-efficient technologies. Here international cooperation among countries could be very useful and new joint international projects among countries from different continents indeed should be explored.

Zusammenfassung: In dieser Studie werden wesentliche Aspekte zum Wirtschaftswachstum und nachhaltigem gesamtwirtschaftlichen Konsum im Kontext eines modifizierten neoklassischen Wachstumsmodell behandelt. Berücksichtigt man die Theorie eines optimalen Wachstums im weiten Sinne, so muss der Gedanke einer effizienten Spezialisierung - im Zusammenhang mit einer relativen Faktorausstattung – von einem optimalen Spezialisierungsgrad unterschieden werden. Für die meisten ressourcenreichen Länder ist langfristiges Wachstum dann möglich, wenn genügend Investitionen in Forschung und Entwicklung sowie in Bildung vorgenommen werden. Da langfristig gesehen der Abbau von natürlichen Ressourcen mit langfristig reduzierter Rate erfolgt – auch in Russland – dürfte das Niveau des Wachstumspfades im steady state zurückgehen. Daher ist der Aspekt langfristiger Innovationsdynamik von besonderer Bedeutung für nachhaltiges Wachstum, vor allem hinsichtlich erneuerbarer Energien und energieeffizienter Technologien. Dabei wären internationale Kooperationen zwischen Ländern sehr nützlich und sollten durch neue gemeinsame internationale, kontinentübergreifende Projekte angegangen werden.

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1. Introduction

Long run expansion of real income is a natural goal of societies, and for countries with a medium per capita income (or a low per capita income) economic catching-up with leading economies also is a typical goal. Ultimately, people are not so much interested in a high real income but in a high, stable and safe level of per capita consumption; safe is meant in terms of military security which suggests to place some political emphasis on creating a friendly international network of partner countries – or alternatively, to spend a high share of resources on the military which comes, however, at considerable opportunity costs. Stable consumption is somehow linked to the variance of real income whose modeling requires a stochastic growth model. We disregard uncertainty and risk, respectively, instead we will focus on a rather simple growth model which is a modified neoclassical approach. The analysis presented also puts the focus on the issue of optimum growth, namely that capital intensity which maximizes steady state per capita consumption. Some new ideas are presented here.

Compared to the US, the EU has achieved only modest growth in the 15 years following 1990. Brazil, Russia, India, and China have strongly contributed to global economic growth after 1998, and in 2006 the BRICs indeed have accounted for slightly more than half of global economic growth. High oil and gas prices after 2001 have stimulated growth of output in countries richly endowed with natural resources; this includes not only Russia, Brazil, Mexico and the OPEC countries but also gas producing countries in the former Soviet Union. Russia is the world's largest gas producer and accounted for a share of 26% of global reserves, it reserve to production ratio reached 78 at the end of 2006 which is higher than the global average of 63 (BP, 2007); Russia's role in the oil sector also is important as it accounted for 7% of global reserves, the reserve to production ratio reached 22 in 2006 which was below the global average of 41. Thus Russia can be expected to remain a large producer and exporter of gas and oil for many decades. While there is little doubt that an expansion of the energy sector can contribute to a transitory spurt in economic growth – possibly over several decades – there are doubts whether or not the exploitation of non-renewable natural resources is an ideal basis for long term economic development and growth, respectively.

The quantity of natural resources which could be exploited in the long run often are much larger than simple extrapolation of reserve-consumption ratios suggest since technological progress in exploration and exploitation of such resources can be high; this holds particularly since increased long run scarcity of natural resources imply a relative rise of global resource prices which in turn make advanced exploration and exploitation technologies profitable. The effective reserves thus can increase over time – possibly for many decades. Technological progress (which could be endogenously modeled in the context of new growth approaches) thus helps to effectively reduce the depletion rates of resource sites; an alterative view is that progress enlarges over time those resource sites in terms of reserves. However, at some future point there will be a declining exploitation ratio and backstop technologies have to be considered more seriously.

At the beginning of the 21st century it is remarkable that global consumption of fossile energy resources in a given year is equivalent to the "creation" of such resources in one million years in the past. Resource rich countries as well as major energy importers among advanced OECD countries have become increasingly interested in the issue of raising energy efficiency and resource efficiency in the 1990s; partly as a response to the signature of the Kyoto protocol and the fear of global warming: eg the British government – facing a medium term decline in oil production as well as new global challenges - has emphasized a new framework for sustainable consumption and production (DTI/DEFRA, 2003; STERN, 2006). The Italian environmental agency also has considered new options for a sustainable use of natural resources in Italy (CASCONE ET AL. 2006). The efforts of leading OECD countries in energy innovation could dampen the global long run increase in global energy consumption, however, given the enormous growth dynamics in China, India and many other Asian and African and Latin American countries the global demand for energy and natural resources could increased for many decades.

In Western Europe sustained growth has become an important topic, namely in the sense of raising the growth rate as was emphasized in the EU's Lisbon Agenda with its focus on an expansion of the digitally networked knowledge society (internet users density see figure 9). As regards the Euro zone, the relative income gap vis-à-vis the US increased considerably in the last two decades of the 20th century. In 2006 and 2007, however, Euroland's growth seemed to match that of the US and even to temporarily overtake it – with good prospects for enhanced growth in the medium term. Interestingly, the number of jobs created in the period 1999-2006 reached more than 10 million and thus exceeded the number in the US (EUROPEAN COMMISSION, 2007, p.3). In the EU, Germany suffered from rather low growth in the decade after the German unification boom 1991-93; Italy also has had rather modest growth rates, which raises in both countries the issue of structural change, productivity growth and output growth. By contrast, France, Spain, Ireland, Greece and Finland have recorded rather high growth rates; the UK and Sweden also recorded sustained growth over the decade following 1995. Among the eastern European accession countries Hungary, the Czech Republic, the Slovak Republic and Poland have experienced relatively strong growth in the decade following 1995 after systemic transformation and economic opening up as well as EU membership in 2004. Russia has experienced high growth in the decade after the crisis of 1998 into which the economy fell not least due to poor advice of the IMF who had argued in favor of introducing fixed exchange rates which, of course, is totally in contrast to the optimum currency literature – in particular the KENEN criterion which says that only countries with a diversified export basis should have fixed exchange rates.

At the beginning of the 21st century, the US is the only superpower and the dominant global source country of foreign direct investment. For a few decades it is unclear whether the world economy will be characterized by stability: the US might engage in a quasi-imperial overstretch, as it is the only superpower; the rise of new challengers might also generate impulses for instability. China which already has become a leading regional Asian power, is likely to become a long term rival of the US. The subsequent table (ignoring military power) gives a few key figures for large economies in the world.

The US leads with a share of about 1/5 of global GDP – on the basis of purchasing power parity figures. China already has come close to the economic size of Euroland in 2001-05. Russia's share in world GDP is growing gradually.

Table 1: Role of Large Economies in the Global Economy (% of global total)

	GDP				Merchandise Trade				Stock Market Capita-lization
	At PPP exchange rates		At market exchange rates		Exports		Imports		
	1971-75	2001-05	1971-75	2001-05	1971-75	2001-05	1971-75	2001-05	2001-05
United States	22.5	20.5	27.9	30.1	15.7	11.6	15.6	19.7	44.4
Euro area[1]	21.3	15.7	20.2	21.9	21.2	18.5	21.2	16.9	15.3
Japan	8.0	6.7	7.5	11.6	8.5	7.4	7.9	5.8	9.4
United Kingdom	4.3	3.1	3.7	4.9	6.9	4.7	7.9	5.6	7.5
China[2]	3.0	14.0	2.6	4.6	1.2	7.2	1.3	6.2	1.9
Canada	2.1	1.9	2.7	2.4	5.7	4.4	5.5	4.0	2.8
Mexico	1.7	1.8	1.3	1.8	0.5	2.7	0.8	2.9	0.5
Russia*	-	2.4	-	1.3	-	1.6	-	1.3	-
Korea	0.6	1.6	0.3	1.7	0.7	3.1	0.9	2.7	1.1
India	3.5	5.7	1.7	1.6	0.7	1.0	0.8	1.2	0.8
Brazil	2.7	2.7	1.2	1.5	1.3	1.2	1.9	0.9	0.8

1 Excluding intra-euro area trade, 2 Data in 1971-75 columns are for 1976-80

Source: IMF (2007, pp. 122/123); * 2007 for Russia; according to World Development Indicators

Whether Russia can restore its old superpower status in the medium term is doubtful and depends to some extent on sustained economic growth – in 2003 the per capita income of Russia was close to that of Mexico, and such a low income is certainly not an economic basis for being a political superpower in the narrow sense (given Russia's geopolitical position, however, the country certainly is a leading global power, although its potential will be fully exploited only once it is more active in international organizations such as the WTO, the BIS or the OECD). However, Russia might achieve high long term growth and this in turn could be crucial for its political weight. A major problem of Russia's growth in the decade after 1998 concerns the fact that the energy sector has played a key role for economic growth. To some extent growth driven by the energy sector is normal in a country richly endowed with natural resources and the energy sector could play an important role for economic expansion: both through the sectoral growth and via associated impulses for other sectors on the one hand, on the other hand via the easing of

the current account constraint and opportunities to import capital equipment and knowledge from abroad. At the same time one should not overlook the risk that lack of modernizing the manufacturing sector based on "home-grown" entrepreneurship and innovativeness will bring about a specialization which will be difficult to correct in the medium term and long run; at least to the extent that path-dependencies could strongly restrict ability to create a broader industrial sector with technology-intensive and knowledge-intensive production.

In the decade after 1998 economic restructuring and gains from trade have contributed to economic growth. After 2001 high relative oil prices – and high gas prices – have stimulated investment in the natural resources sector which in turn has enormous backward linkages and forward linkages. One may assume that about 1/3 of economic growth is determined by the energy sector in Russia in 1998-2007.

The US represented about 30% of global GDP at the beginning of the 21st century if we focus on figures at market exchange rates (figures for the US are expressed in $, figures for the Euro area in Euro and then converted at the current exchange rate into US dollars, figures for China are expressed in Yuan and then converted into US dollars….; then the shares of individual countries in world GDP are calculated). However, the US share in world GDP is lower within the PPP concept: it is 1/5 of the world economy's gross domestic product if one uses purchasing power parity figures – that is if one controls for differences in the price of nontradables across countries (e.g. the price of a hair cut in China is lower than in the US and so are rents for apartments: adjusting for such international differences allows to compare income figures of individual countries). The output share of the – hypothetical – Euro area in the early 1970s was close to that of the US, while at the beginning of the 21st century it was 5 percentage points behind that of the US (20.5%), whose growth performance had been much higher in the 1990s than in the Euro area. At the beginning of the 21st century, the share of Japan in global output is 7%, the share of the UK is about 3%. China has increased its share in three decades by roughly ten percentage points and stood at 14% in the period 2001-05. Canada, Mexico and Korea each account for about 2%; India was close to 6% and Brazil as well as Russia close to 2.5% at the start of the 21st century.

In the following analysis we will briefly look at the theory of economic development and growth, respectively; the distinction between the level of the growth path and the trend growth rate itself is emphasized here. As regards the perspectives for long term economic growth the neoclassical growth model considered suggests that the growth path adopted in the period 1998-2007 – much emphasizing a strong and expanding role of the natural resources sector – is not sustainable. If one takes into account the true savings rate of Russia, namely official savings plus private spending on education minus the depletion rate of natural resources (and the emission ratio) the level of the growth rate will decline in the long run. This, however, does not rule out a high growth rate of output in the medium term.

2. Basic Reflections on Economic Growth

Long term economic growth of output and per capita income are important from a policymaker's perspective, but it is not an end in itself. In a normative perspective, one may argue that

- long term output growth should be sustainable so that the relevant output figure is not gross domestic product but net domestic product. In our analysis we will, however, emphasize that net domestic product – as usually defined in the Systems of National Accounts – is not an adequate output category, rather one should focus on "net-net income" (net-net income and net-net savings refers to a broader concept of depreciations; see below);
- basically people are interested in long term per capita consumption which leads to the topic of optimum growth theory, namely to achieve that capital intensity K/L (with K and L denoting capital and labor, respectively) which maximizes per capita consumption C/L (C denoting real consumption) in the steady state

In a nutshell, long term growth is linked to supply-side dynamics and the macroeconomic production function for output Y, respectively, where the latter can be summarized as

(1) $Y = Y(K, L, H, A, N, T, \Omega, M/P, E, \Phi)$

where input variables K, L, H, A, N, T, Ω, M/P, E, Φ stand for capital, unskilled labor, skilled labor, technology, infrastructure capital, the use of telecommunications, technological specialization, real money balances (M is the stock of money, P the price level; m=: M/P), energy and the "institutional capital", respectively. In a broader perspective one may emphasize some standard features of growth accounting and some more recent insights:

- While capital K, labor L (and H) and the level of technology A – proxied, for example, by the number of patents – are standard variables in growth theory, the role of infrastructure capital N is not fully clear in the literature as the empirical evidence is mixed when authors look for a direct impact of N on output. However, an essential part on the output effect of higher N certainly is linked to growing trade and the associated improvement in diffusion of knowledge and enhanced specialization. The institutional variable Φ also is likely to cause some problems in institutional analysis as its supply-side effects could be mainly occurring in an indirect manner, e.g. by raising the output elasticity of some or all factors. Moreover, an efficient set of institutions (say, concerning elements of the legal system) could also be factor-augmenting – e.g. an efficient legal system will allow firms to avoid complex and recurrent legal conflicts which allows in the overall economy for the employment of fewer people as lawyers and bodyguards but more people in the direct production of output.
- As regards L+H the demographical factor partly will influence its development over time. With respect to K, H and A accumulation is necessary so that this takes time and investors willing to accumulate. A knowledge capital stock can be accumulated through expenditures on research and development (R&D): Here both

private R&D expenditures and government R&D expenditures are crucial as are government subsidies for private sector R&D, namely to the extent that there are positive external effects of private R&D. If accumulation of R&D capital is not explicitly modeled – as an exception see e.g. WELFENS/JUNGMITTAG (2001) – the role of R&D is reflected in the residual of empirical growth accounting models: in the so-called total factor productivity which summarizes not only the R&D impact but also other elements relevant for the expansion of output.

- Recent empirical findings for Germany have also pointed to a significant role for the use of telecommunications, which obviously signifies knowledge diffusion effects (WELFENS/JUNGMITTAG, 2002). For other industrialized countries a similar result should be expected.
- To the extent that increasing trade in intermediate products within global multinational production networks contributes to higher global output it is important to consider the growing role of offshoring (production in foreign subsidiaries) and international outsourcing (KLODT, 2007; KLEINERT, 2004). There might be positive static and dynamic scale effects as well as network effects (dynamic growth effects on the demand side as in the case of the use of telecommunication networks) related to the size of regional integration clubs.
- In an institutional perspective membership of Russia in international organizations is quite important since this amounts to an institutional anchor: membership in WTO and OECD therefore is quite important – these institutions also stand for new opportunities for Russia to contribute to shaping regulations and rules in important areas such as telecommunications, electricity and railways (WELFENS/YARROW/GRINBERG/GRAACK, 1999; LANE/ODING/WELFENS, 2003; GRAHAM/ODING/WELFENS, 2005).
- The energy sector offers input which is crucial for specializing in energy intensive industries and it also is important for exports for resource rich countries. The more Russia would like to develop a specialization in the field of technology and knowledge intensive products the more important will be government policies which encourage R&D and higher education. The specialization of Russia on the EU15 market in the decade after 1993 is strong in resource intensive products and in resource & scale intensive products (positive modified RCAs; RCA is revealed comparative advantage). For a transition period it seems realistic to expect that profits from the energy sector will stimulate innovation dynamics – in particular in the energy sector which partially is both capital intensive and technology intensive. If Russia were to switch to a more knowledge and technology intensive production it would have to achieve a positive modified RCA (sectoral export-import ratio of Russia relative to EU15 export-import ratio in the EU15 market) and also rising export unit values (EUVs) in science based products in scienced based product and differentieted goods. The present situation is characterized by the following graphs.

Figure 1: RCAs of Russia in the EU15 Market

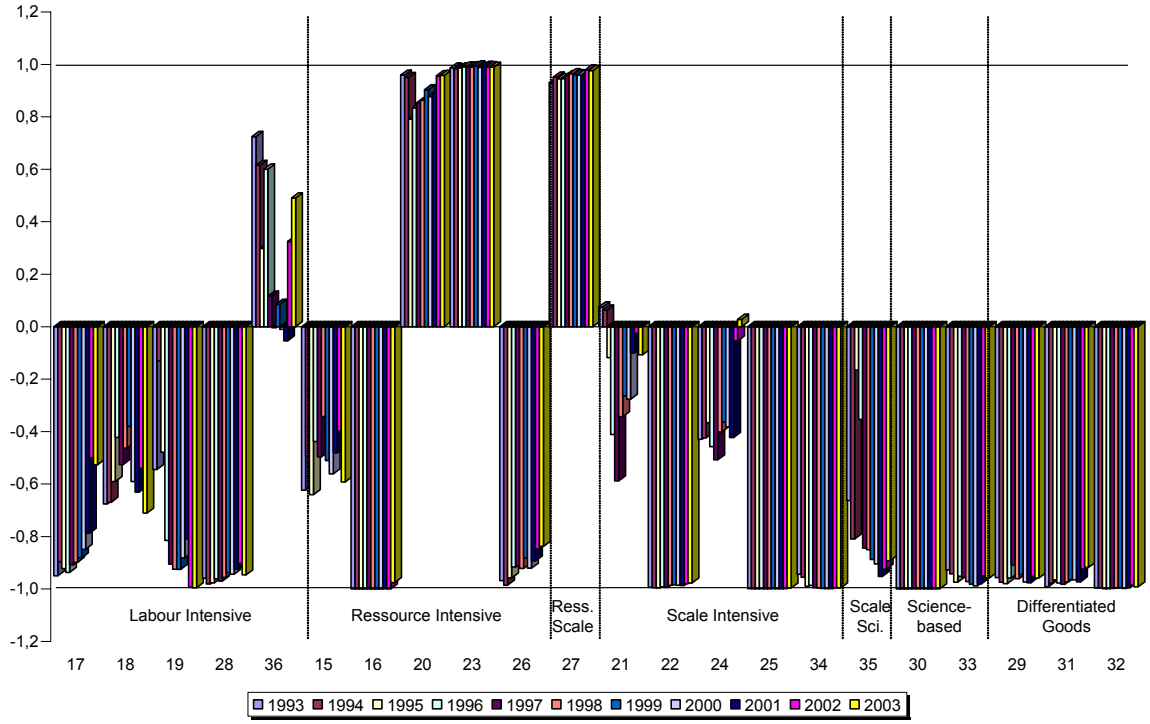
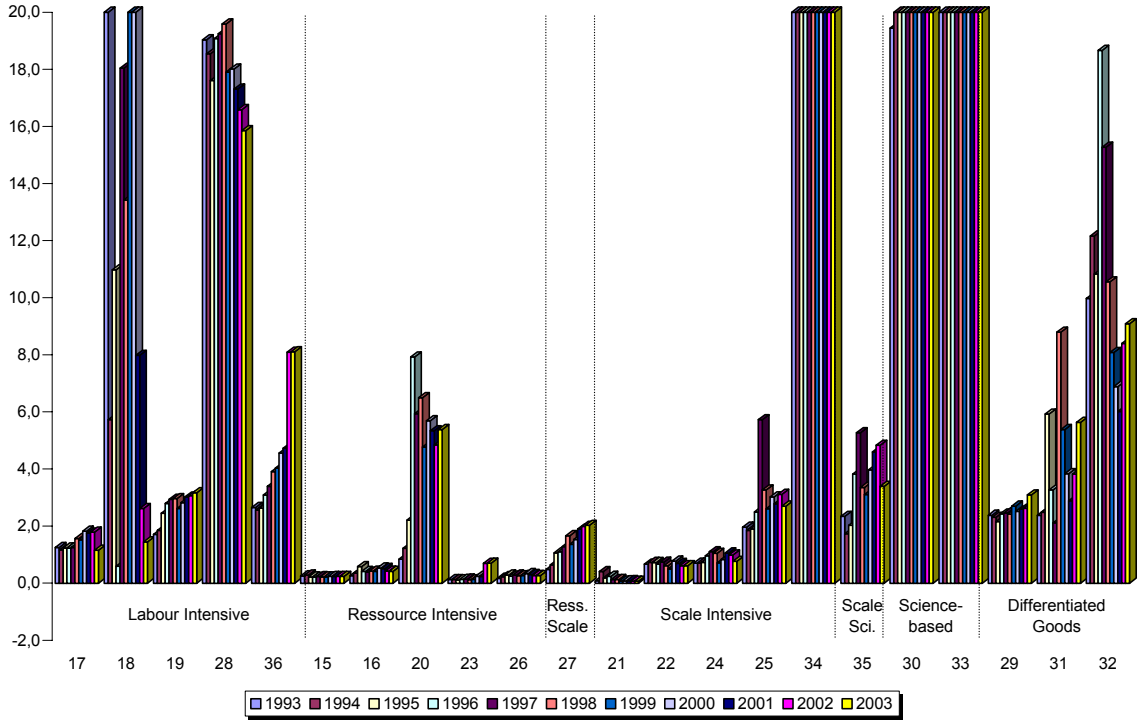


Figure 2: EUVs of Russia in the EU15 Market



- From a theoretical perspective, one should emphasize that real money balances should have a positive effect on output as the use of money allows one to save information and transaction costs; in a monetary growth model it has been shown that under certain parameter conditions the stock of real money m (m=: M/P) indeed can raise the equilibrium capital intensity so that the so-called Tobin-paradox of having a lower capital intensity in monetary economy than in a barter economy is avoided (WELFENS, 2007); also it has been argued that institutions matter for the level of productivity and hence long run development of per capita income. Finally, one may argue on the basis of theoretical and empirical arguments that trade is relevant for the expansion of output (JUNGMITTAG, 2006). COE/HELPMAN (1995) have shown that foreign research and development (R&D of trading partners) positively affects total factor productivity. BALDWIN/SEGHEZZA (1996) have presented similar evidence and shown that this trade-related spillover effect is particularly strong for EU countries – thus network effects, embodied technology or dynamic effects of import competition might matter here. HENREKSON/TORSTENSSON/TORSTENSSON (1997) also present empirical evidence for EU countries and EFTA countries that the growth rate of GDP is positively influenced by regional integration. VANHOUDT (1999) puts the focus on EU countries and does not find an EU-related growth effect. JOHANSSON (2001) finds in his study of four large EU countries a positive link between imports and growth – with intra-EU-imports showing a stronger effect than extra-EU imports.

One may consider value-added as a two-stage production process where the production of intermediate products and services (which include banking services) is assumed to use money as an input factor – once that the economy switches from a barter economy to a monetary economy. The switching from a barter economy to a monetary economy and hence introduction of money in a non-inflationary economy has two consequences, namely to reduce production costs of intermediate products and to reduce information costs on the demand side.

In the EU countries the role of an increasingly knowledge-based production has been emphasized. As regards the European Commission and the European Council, the topic of EU growth is clearly emphasized in the EU Lisbon Agenda of 2000, which aims at making the EU the most competitive knowledge-based economy in the world by 2010. In this context, diffusion of new knowledge and technological progress are quite important. The number of patent applications (ideally stock figures) at the USPTO shows that the US is well ahead of Europe, and this holds even if we would correct for the home bias in application figures/patents granted.

Table 2: Patents Granted to USA, Germany, France, UK, Italy, Spain, Sweden, China and Russia at the US Patent Office

	2003-2005 Average
Germany	10411
USA	82267
UK	3410
France	3371
Italy	1534
Sweden	1311
China	368
Spain	282
Russia	173

Source: USPTO

Figure 3: Patent Applications at the USPTO per 1000 Inhabitants

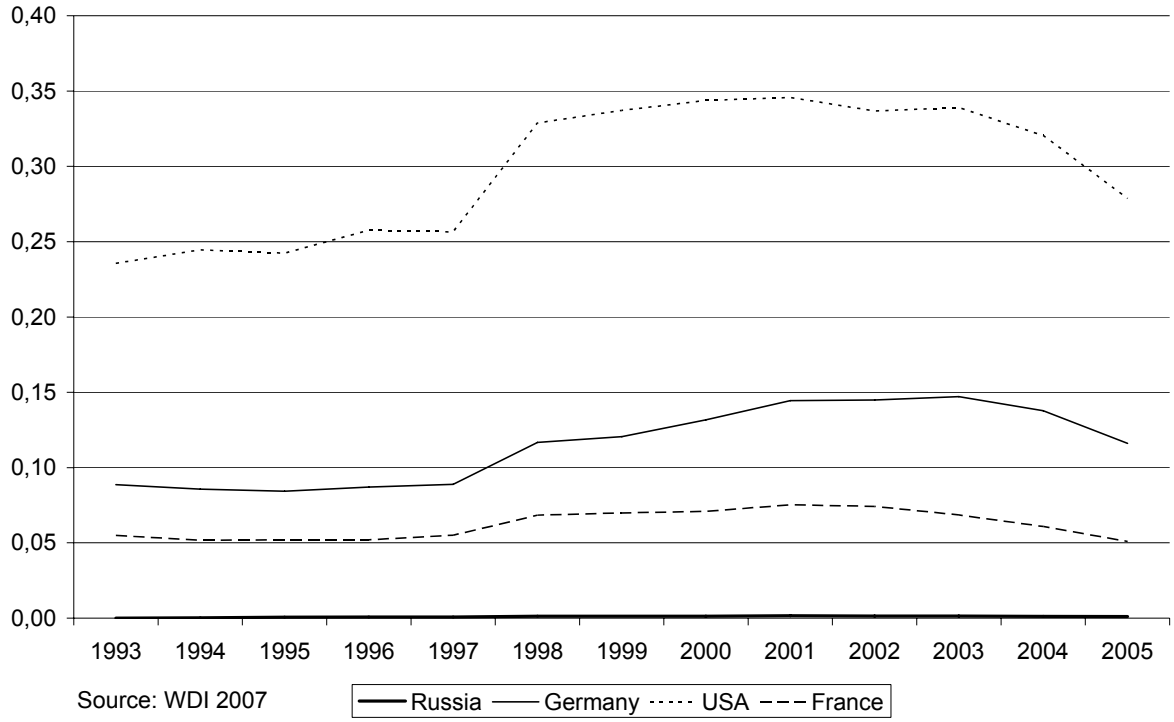


Figure 4: Real GDP Growth in the Eurozone, Russia and the US

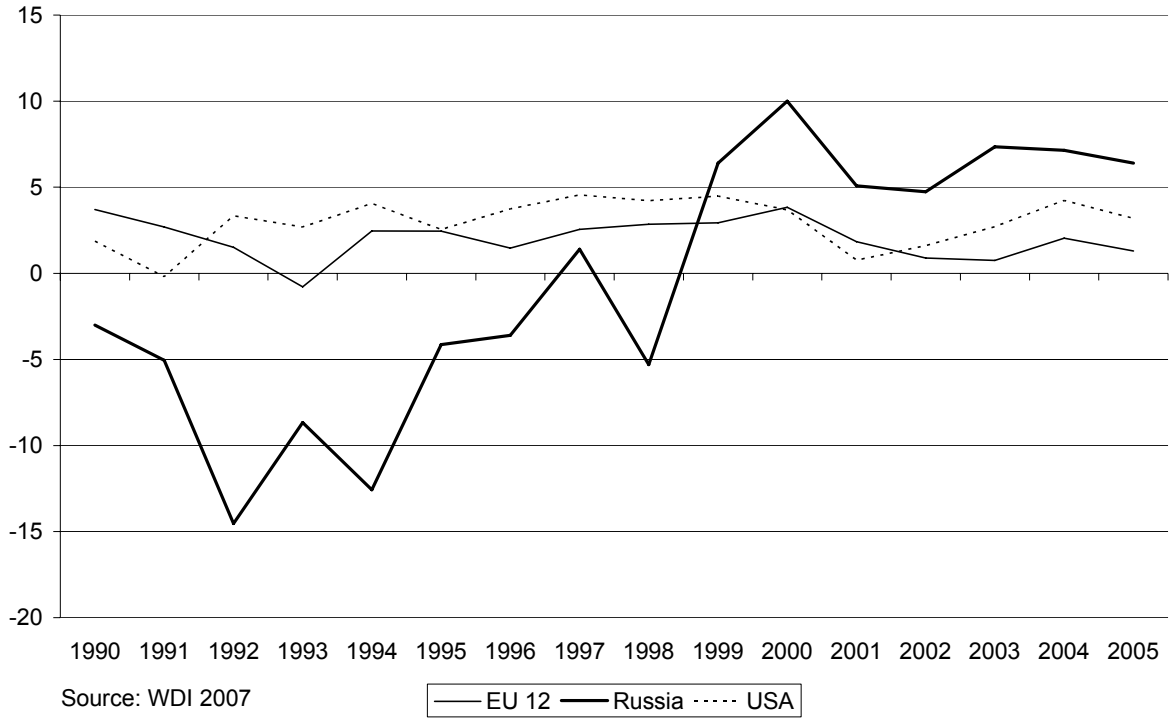
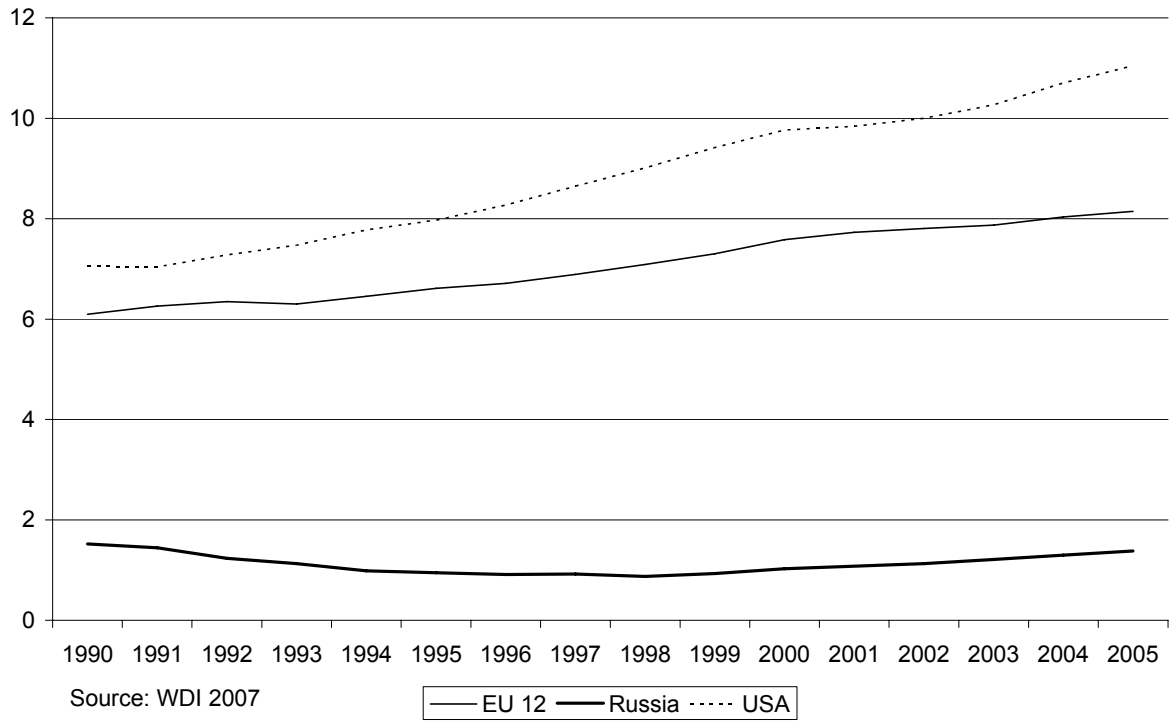


Figure 5: Real GDP in 1000 Billion $ PPP



3. Selected Theoretical and Empirical Aspects of Economic Growth

3.1 Theoretical Aspects

Understanding long term economic growth is not possible without growth theory, which basically puts the focus on the supply-side; in contrast, short-term and medium term growth analysis will often take into account a demand side perspective. In certain cases, both perspectives can be adequately combined (WELFENS, 2007). The standard analysis of supply-side oriented growth theory is summarized in AGHION/DURLAUF (2005) and additional ideas are discussed in EICHER/RÖHN (2007) and ALGAN/CAHUC (2007). In modern Economics there often is a strong emphasis on the microeconomic foundation of Macroeconomics which certainly is useful for many issues. However, one may raise some doubts as to whether typical assumptions about economic agents maximizing profits or utility over infinite horizons are always adequate. At least in the context of business cycle dynamics, one will often find that relevant time horizons are changing and that a shortening of time horizons and a sudden rise of risk premiums in capital markets can play an important role. (The subprime housing market crisis in the US in summer 2007 is indeed a good example for a major confidence crisis that started in the US, then affecting many banks and countries.) For long term growth analysis, the assumption of long term planning of households and firms is rather convincing. However, it is also adequate to call for a Macroeconomic foundation of Microeconomis (see appendix); there is a mutual need for consistency.

An important aspect of growth interdependence in the world economy is related to the relative size of countries as measured by real GDP on the basis of purchasing power parity. In the context of a simple two-country model, the world GDP Y## = Y + q*Y* (with Y* denoting GDP in country II and q*=: eP*/P the real exchange rate where e is the nominal exchange rate and P the price level); hence the growth rate – g denotes growth rates – of the world economy is calculated as $g_{Y\#\#} = \varepsilon g_Y + (1-\varepsilon)[g_Y^* + g_{q^*}]$, where ε is the share of Y in world GDP. Let ε denote the share of OECD GDP in global income – about 40% at the beginning of the 21st century. Taking into account that the world growth rate will increasingly be determined by Asia and that Asian growth rates (which might be around 5% in the medium term), at least for one or two decades, might well exceed that of OECD countries, it is clear that Asia will increasingly affect the development of global economic growth (here we ignore potential long term changes in the real exchange rate). This, however, does not imply that Asian economic dynamics will dominate the world economy around 2030 or 2040 unless the weight of Asian stock markets in global stock markets – as measured by stock market capitalization – should strongly increase; here world markets are still dominated by the US.

What determines economic growth in the long run? The standard neoclassical growth model is a useful starting point for our analysis and can be extended in various ways, e.g. by considering more input variables than just capital, labor and knowledge. Economic growth must be carefully considered in various ways. One important aspect concerns the

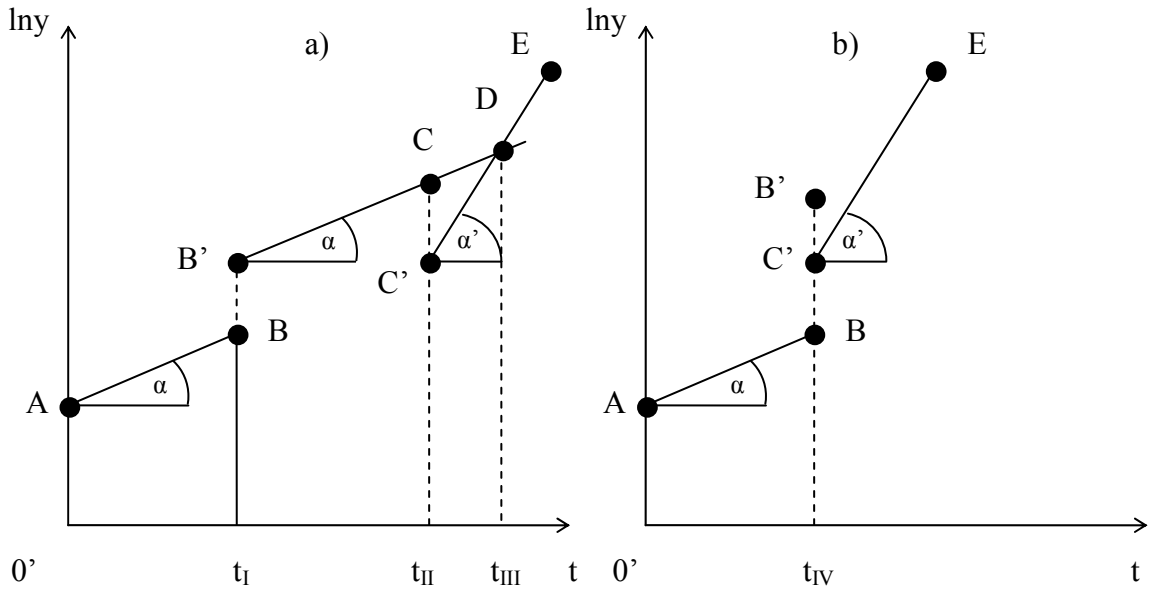
distinction between the level of the growth path and the trend growth rate (the growth path itself). The distinction becomes clear if we briefly recall the neoclassical standard growth model based on the following assumptions (with e' denoting the Euler number):

- production function is linear-homogeneous; we will use $Y=K^{ß}(AL)^{1-ß}$; $0<ß<1$
- savings $S=s(1-\tau)Y$ where τ is the income tax rate and the savings rate s is in [0,1]
- equilibrium condition for the goods market which is S= investment I where I is the sum of net investment dK/dt and capital depreciations δK (δ is depreciation rate)
- growth rate of labor (L) is exogenous, namely dlnL/dt=n;
- growth rate of knowledge (A) is exogenous: dlnA/dt= a: hence $A(t)=A_0e'^{at}$
- the steady state ratio $Y/(AL)=:y' = [s(1-\tau)/(a+\delta+n)]^{ß/1-ß}$
- per capita income in the steady state is $y\# =:Y/L= \{[s(1-\tau)/(a+\delta+n)]^{ß/1-ß} A_0\}e'^{at}$.

Hence the growth rate of the per capita income y in the steady state is equal to "a". At the bottom line, the level of the growth path is given by the bracket term {…} and the long term trend growth rate is given by a. Hence a rise in the savings rate s, a fall in the tax rate τ, a fall in the depreciation rate δ and in the population growth rate n will raise the level of the growth path of per capita income. The growth rate of real GDP is given by the sum of a and n. The above per capita equilibrium will also hold for an open economy as long as there is no foreign direct investment and as long as we assume a balanced trade account and a balanced government budget as long run constraints for economic policy (see on this and a potential trade-related impact of trade WELFENS (2007)).

In a lny-t diagram (see a) in the following diagram) we may consider a country which experiences an upward shift in the level of the growth path in a certain point of time (t_I) – see the switch from point B to B' – while the growth rate (the slope of the line: see tg α) remains the same. At a later point of time t_{II} there could be a rise in the progress rate a so that there is a downward shift in the level of the growth path combined with a steeper slope (tg α'). It will take some time until – in t_{III} – per capita income on the new path is higher than it would have been under the old regime. In panel b) we have shown the case that there is a simultaneous increase in the level of the growth path and the trend growth rate, so that the overall path of y is given by ABC'E.

Figure 6: Change in the Level of the Growth Path (a) and the Trend Growth Rate (b)



Policy measures such as a cut of the tax rate or incentives designed to increase the savings rate s raise the level of the growth path. One should not, however, overlook the fact that specific tax incentives – tax rebates for firms investing in R&D – can also affect the trend growth rate a.

An exogenous increase in the trend growth rate "a" will obviously reduce the level of the growth path and raise the trend growth rate at the same time. In a politico-economic system, which is extremely short-sighted, a policy option to increase "a" will not seriously be considered, as the short-term effect of a fall of the growth rate will dominate. However, politicians who take a long term perspective will clearly favour options that raise the trend growth rate since over time a rise in the trend growth rate dominates the short-term fall of the level of the growth rate.

Cross-country empirical analyses as well as panel analyses of economic growth typically suffer from a specific problem, namely that they do not apply a double test on structural breaks. There could be a structural break with respect to:

- the level of the growth path;
- the trend growth rate;
- both the level of the growth path and the growth rate itself.

We can learn from empirical analysis only if the sample of countries considered is rather homogeneous and if adequate dummy variables for trend breaks have been used.

One should emphasize that in an open economy context with foreign direct investment one will have to carefully make a distinction between gross domestic product and gross national product where GNP per capita will normally exceed GDP per capita if the country considered is a net investor in the world economy (e.g. the case of US or the Netherlands or Germany as opposed to the UK, Ireland, Italy or China – the latter four countries all

being important host countries for foreign direct investment). Disregarding international labor mobility one may state for the case of a pure source country of foreign direct investment: the gross national product Z is the sum of Y (GDP) and profits accruing from abroad which under certain conditions are proportionate to foreign gross domestic product Y*. If there is two-way foreign direct investment it is naturally net international profit accruing which has to be taken into account.

Efficient versus Optimal International Specialization

In the traditional optimum growth theory (following the golden rule established by PHELPS and VON WEIZSÄCKER) it is emphasized that the steady state ratio of capital to labor in efficiency units is not necessarily identical to that ratio k'#opt which maximizes long term per capita consumption and the level of the growth rate of per capita consumption. As per capita consumption is maximized if k'# is such that at this ratio the slope of the tangent at the production function is equal to $n+a+\delta$ we face an interesting problem – not treated in the literature thus far – with respect to international specialization once we implicitly consider a two-sector economy: The initial "non-golden intersection points" of the curve $sk'^{ß}$ and the $(n+a+\delta)$-line in country I and of $s^*k'^{*ß^*}$ and the $(n^*+a^*+\delta^*)$-line in country II could be such that $k'\#_0$ exceeds $k'^*\#_0$ so that – according to the Heckscher-Ohlin-Samuelson approach – the home country should specialize in capital-intensive goods and country II in labor-intensive goods; while a corresponding adjustment might bring specialization gains for both countries and thus effectively raise the progress rate in both countries.

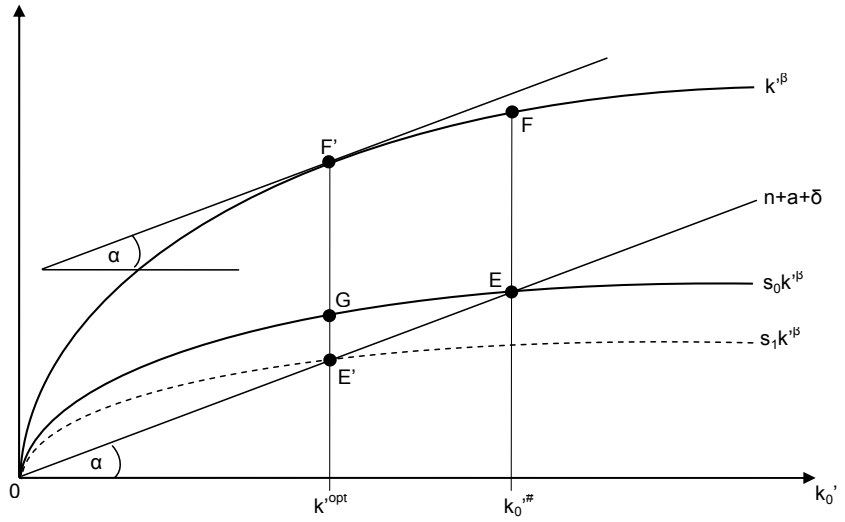
In an open economy there is, however, the topic of optimum international specialization which is not trivial at all since – as is argued here – it is not easy to determine which country has a relatively higher capital intensity: the term relative capital intensity indeed might refer to the actual capital intensities abroad or at home; alternatively, one may want to focus on the capital intensities occurring in a (hypothetical) global state of the golden age which maximizes per capita consumption in both countries. Global golden state is defined here in that way that both countries are in the golden age; that is the golden rule has been realized in all countries (the respective capital intensity of this optimum state is denoted as k^{opt}). If the respective golden rule capital intensities k'^{opt} and $k'^{*\,opt}$, respectively, are such that the relative ordering changes, namely $k'^{opt} < k'^{*\,opt}$ (alternatively, initially $k'\#_0 < k'^*\#_0$ while in simultaneous golden rule states: $k'^{opt} > k'^{*\,opt}$), we have an interesting ambiguity about efficient international specialization (here we are not dealing with the relatively trivial case that there is no qualitative difference between initial ratios in a steady state and the ratio of steady states in the golden global age). While initial non-golden steady states in both countries have implied that country I should specialize on capital intensive goods while country II should specialize on labor intensive goods, the global golden rule suggests just the opposite: Country I should specialize in labor-intensive goods production while country II should specialize in capital intensive production (see the subsequent graph). A global golden state may be dubbed Golden Optimal Specialization.

If adjustment costs from switching from capital-intensive specialization to labor-intensive specialization would be rather high it might be even advisable – assuming a rather short political capitalization horizon in both countries – to stick to the initial non-golden specialization. As a policy implication one may conclude that government planning

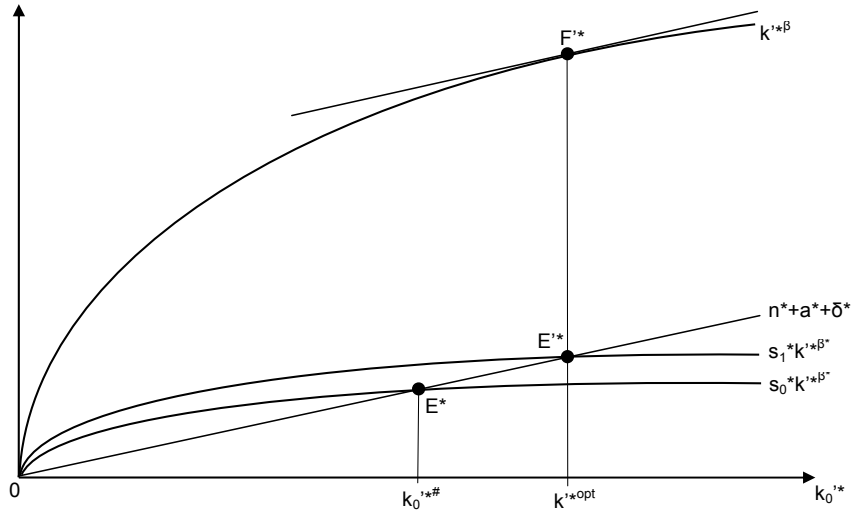
intervention in catching-up countries are wise to consider options to realize the golden rule from the outset; and this all the more the poorer the respective country is. If more developing countries were to follow the golden rule there obviously would be less starvation and malnutrition (and migration) in the world economy since per capita consumption levels in poor countries would be higher than otherwise. For development policy the topic discussed here also could be quite interesting since it does not make much sense to give high development aid to poor countries whose governments are unwilling to move the economy into the gold age as defined by growth theory. It would be a useful task of the World Bank to calculate the conditions for fulfilling the golden rule in various countries. Countries willing to indeed implement the golden rule should get a bonus in development aid. In a broader perspective it would be useful if all OECD countries and indeed many other countries would calculate the golden rule capital intensity.

Figure 7: Issue of Efficient Specialization versus Golden Optimal International Specialization

a) country I



b) country II



If both firms and countries undertake specialization according to the golden age rule abroad and at home we have "golden efficient specialization" and such a state of the world economy indeed is desirable from a normative point of view – assuming that governments (and indeed voters) want to maximize sustainable per capita consumption.

3.2 Endogenous Growth Models and Empirical Issues

In endogenous growth models, the term "a" is no longer exogenous but explained – e.g. by the ratio of R&D expenditures to GDP or the share of researchers in the overall labor force. There is a broad range of endogenous growth models (BRETSCHGER, 2004) which basically emphasize several potentially important drivers of the trend growth rate:

- the non-rivalry of technology and hence of technology spillovers across both sectors and countries;
- the possibility that individual firms' capital formation creates positive spillover effects so that the aggregate marginal productivity of growth does not decline (ROMER, 1986);
- the role of product differentiation in intermediate products on the basic of an R&D sector (ROMER 1990) which allows for the production of more variants of heterogeneous goods, which in turn stimulates demand and hence output growth;
- the role of static and dynamic scale economies – the latter refers to learning-by-doing effects as emphasized by ARROW (1962), which are particularly important for certain sectors, including automotive, air and space sector as well as ICT;
- the role of human capital formation as emphasized, for example, by LUCAS (1988) and ROMER (1990a). In the approaches of ROMER (1990b) and AGHION/HOWITT (1992) the idea of NELSON/PHELPS (1966) is picked up, namely that human capital is necessary for both R&D and innovations. As a result, the growth rate of output depends on the level of human capital. It is a priori unclear whether human capital formation affects the level of the growth path or – through increasing the rate of technological progress – the trend growth rate. If human capital is an input like other standard variables, the growth rate of output depends on the growth rate of human capital (as in LUCAS, 1988; for a discussion of both approaches see CANNON, 2000). The empirical evidence on the US suggests that the growth rate of human capital has an impact on the growth rate of output (JONES, 1995).

This reasoning implies that government has a role with respect to the growth rate, as government is typically much involved in the education system and also subsidizes R&D in most OECD countries; and this is justified from an economic perspective to the extent that there are positive external effects of private R&D.

3.3 Sustainability Issues

Considering the topic of long term growth and sustainability – in a broader sense – one will have to take into account several aspects:

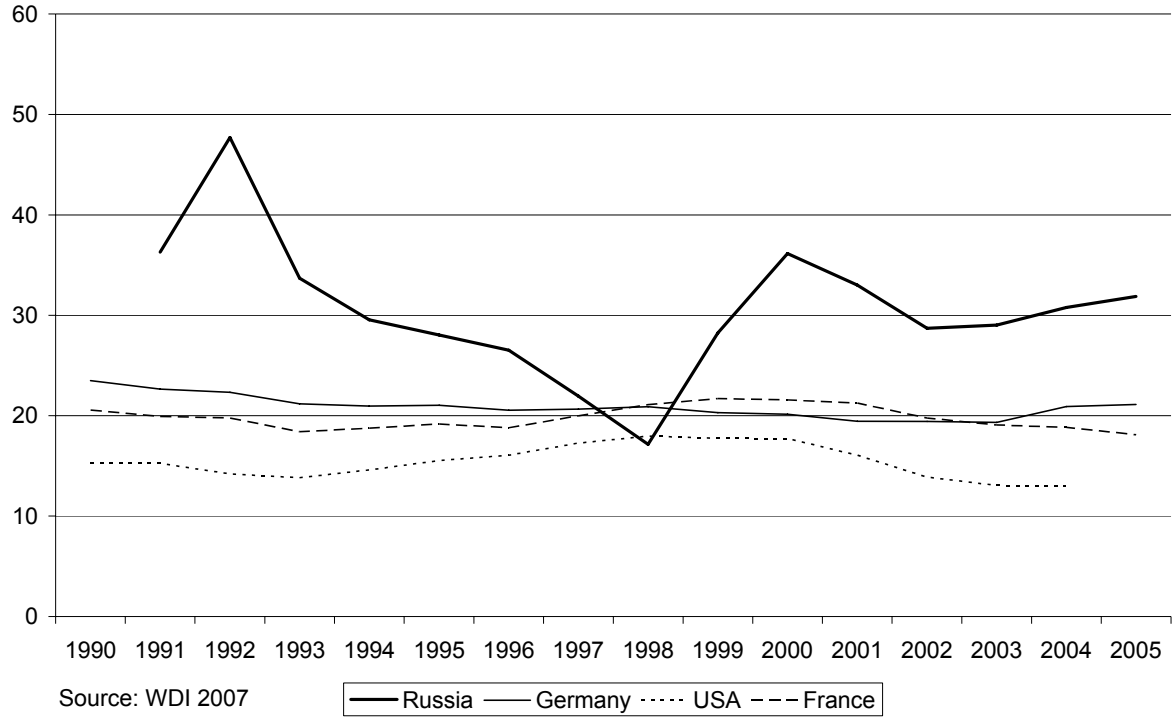
- Even if relatively high long term growth can be achieved there is the potential problem of inequality dynamics; growth might lead to a higher inequality which normally is not a problem unless it exceeds a critical dimension and unless government is not engaged in adequate redistribution policies. In a normative perspective one may state that such policies should try to avoid negative incentives for investors and innovators. From a more philosophical perspective – picking up the Theory of Justice of RAWLS (1971) who argued in his "difference principle" that inequalities should be accepted provided that they also contribute to improving the economic position of the poorest strata – one might emphasize that growth should go along not only with a rise in average per capita income but also in per capita income of the poorest strata in society.
- High growth over some decades will not be sustainable if there are high and growing emissions of particulates or CO_2 and other greenhouse gases. From this perspective the concept of sustainable growth leads to the issue of emissions but also to some other questions, including those related to energy issues. There is hardly any doubt that the ratio of global reserves to global consumption is likely to be rather stable for many years to come - according to statistics of BP (2007) that ratio is about 40 for oil and about 60 for gas. However, there are opportunity costs to the depletion of natural resources and those often are not considered, and we will see that one may argue that depletion of natural resources affects the true net savings ratio.

As regards the level of the growth path the savings ratio is decisive. The higher the savings rate the higher the level of the growth path in the steady state/the long run equilibrium. While it is true that other variables also influence the level of the growth path one should emphasize that the savings rate clearly is a variable which government can influence in various ways. Moreover, economic integration can affect the savings ratio: With a more integrated system of banks and financial markets – e.g. as in the euro area and the EU, respectively – one should anticipate a fall of the savings ratio, namely for two reasons:

- In a more integrated market, competition is more intensive and this will lead to reduced intermediation costs and hence a rise of the effective savings rate (in a growth model one may argue that savings $S=s(1-\rho)Y$ where ρ – in the interval 0,1 – is a measure of inefficiency);
- In a more competitive integrated market it will be easier for both firms and households to obtain loans so that savings of private households are likely to fall.;
- If financial market integration amounts to a positive impulse for economic expansion so that real asset prices increase, one should expect that savings – indeed the savings ratio S/Y – will fall, namely if one assumes that real wealth negatively affects savings (current savings typically are used to bridge the gap between current real wealth and an exogenous wealth target). We can see that after the start of the

Euro, the national savings rate decreased slightly in both Germany and the euro area. But after 2005, we have seen a rise in the savings rate over several years which, however, mainly reflects government budget consolidation efforts (in the subsequent graph the sum of private savings and government savings relative to GDP are shown).

Figure 8: Official Savings Rate



Source: Ameco Database (2007; annual figures)

The neoclassical model will lead for the case of a production function $Y= K^{ß}(AL)^{1-ß}$ and a gross savings rate s and population growth rate n to the following term for the level of the per capita income growth path (under the equilibrium conditions savings equals investment which is the sum of dK/dt and δK, where δ is the depreciation rate): $A_0[s/(a+n+\delta)]^{ß/1-ß}$; this can approximately be rewritten for the simple illustrative case n+a=1 as $A_0\, s(1-\delta)$. Clearly, the higher the depreciation rate of capital, the lower the level of the growth path. Since net GDP Y"=: Y-δK, we have (with y'=: Y/(AL), k'=:K/(AL)) for the steady state

$$y"\#=:Y"/(AL) = y'- \delta k' = k'^{ß} - \delta k' = [s/(a+n+\delta)]^{ß/1-ß} - \delta[s/(a+n+\delta)]^{1/1-ß}$$

For the special case of ß=0.5 we get

$$y" = [s/(a+n+\delta)] - \delta[s/(a+n+\delta)]^2$$

$$y"/[s/(a+n+\delta)] = 1 - \delta[s/(a+n+\delta)]^2$$

If $\delta[s/(a+n+\delta)]^2$ is close to zero – that is if the depreciation rate is rather small – we can use the approximation:

$\ln y'' - \ln[s/(a+n+\delta)] \approx -\delta[s/(a+n+\delta)]^2$

$\ln y'' \approx \ln[s/(a+n+\delta)] - \delta[s/(a+n+\delta)]^2$

$\ln Y''/L \approx e'^{at}\{\ln[s/(a+n+\delta)] - \delta[s/(a+n+\delta)]^2\}A_0$

We can thus clearly see that the depreciation rate strongly affects the level of net GDP per capita. Net GDP per capita (y") is a crucial economic variable since it is only y" whose production can be sustained, namely if there is adequate reinvestment which must be equal to capital depreciations (in the former GDR this condition was neglected in many years and in some years the government decided to manipulate the capital stocks statistics by effectively imposing a negative depreciation rate so that mysteriously the capital stock had increased). The traditional economic analysis looks only at capital depreciations, but this is an incomplete picture of reality; particularly if the country considered is exploiting non-renewable natural resources. At the same time the traditional concept of savings – as applied in the System of National Account – is incomplete since private expenditures on education are not considered.

Hence it holds: If there are other input factors which are depleted – such as non-renewable energy or mineral resources – the concept of sustainable growth will have to not only consider depreciation of capital but also the depletion of energy resources and of mineral resources. To put it differently, the true net savings rate – referring to our illustrative case – differs from $s(1-\delta)$: The true net savings rate will be lower, and hence the level of sustainable growth is lower, than simply looking at capital depreciation suggests. At the same time a true net savings rate will have to include private expenditure on education as an item which raises true savings above the traditional savings ratio (as shown in the systems of national accounts).

Indeed, there can be sustained growth of both output and consumption only if there is adequate reinvestment. Reinvestment in standard growth models refers strictly to capital, that is equipment and machinery plus buildings/real estate. If one wishes to assess the long term consumption opportunities of a closed economy – with a given population –, he or she must substract reinvestment per capita from per capita production. True net savings of many countries are much lower if one not only considers allowances for capital depreciation but also the depletion of non-renewable energy resources plus mineral resources and allowances for emissions of particulates and CO_2; at the same time it is important to add expenditures of human capital formation if one is to derive true net savings as calculated by the WORLD BANK (2006). True savings relative to real income is 12.7% in Canada instead of 11.5%, the official number published for 2004. For the US true savings is 8.2%, which is somewhat higher than the official figure of 5.7%. In France the true savings ratio is 14.3% which is much above the official figure of 9.4%. In Kuwait the official figure was 33.5%, while the true net savings rate was -12.9% which indicates that economic expansion in Kuwait is not sustainable in the long run. Taking a look at EU figures we generally see rather favorable growth prospects in many EU15 countries in terms of sustainability as proxied by the true savings ratio of the World Bank. China,

which has a very high true savings rate, could face some problems in the future as the burden of emissions of particulates and CO_2 will rise; at the same time one may expect China to spend more on education in the future.

Table 3: Official Savings and True Savings Relative (World Bank Concept) to Gross National Income in Selected Countries, 2000

	Gross Savings (1)	Exp. on Education (2)	Use of Capital (3a)			Energy Depletion (3d)	Emissions (4)		Net (5) Savings 1-3a	True (6) Net Savings 1+2-3-4
			Fixed Capital (a)	Mineral Resources (b)	Forests (c)		Parti-culates	CO_2		
Canada	24,6	4,9	13,1	0,2	0,0	4,9	0,2	0,4	11,5	12,7
USA	17,4	4,2	17,4	0,0	0,0	1,2	0,3	0,3	5,7	8,2
Mexico	21,0	5,0	10,6	0,1	0,0	5,9	0,5	0,4	10,4	8,4
Russia	37,1	3,5	10,0	0,4	0,0	39,6	0,6	3,4	27,1	-13,4
France	22,0	5,1	12,6	0,0	0,0	0,0	0,0	0,2	9,4	14,3
Germany	20,3	4,3	14,9	0,0	0,0	0,1	0,1	0,2	5,4	9,3
UK	15,0	5,3	11,5	0,0	0,0	1,1	0,1	0,2	3,5	7,3
Italy	20,1	4,4	13,7	0,0	0,0	0,1	0,2	0,2	6,5	10,3
Kuwait	40,0	5,0	6,5	0,0	0,0	48,7	2,0	0,6	33,5	-12,9
Indonesia	21,0	1,4	5,6	1,4	0,0	12,5	0,5	1,1	15,4	1,3
China	38,8	2,0	8,9	0,3	0,1	3,6	1,0	1,6	29,8	25,5

Source: WORLD BANK (2006)

While the growth rate of many OECD countries does not seem to be very high compared to newly industrializing countries, one should not overlook that EU growth is rather sustainable. This suggests that Europe faces favorable prospects for long term growth. The only caveat concerns the long term decline in population and the problem of ageing societies. As the "leading ageing" OECD country, Japan, has shown at the beginning of the 21st century, however, even with an ageing and declining population a country can achieve sustained per capita income growth.

Russia's economic expansion is not sustainable in the long run – say after 2050 – since it seems not realistic to expect that exploitation of natural resources can be maintained over many decades. The true net savings ratio calculated above is negative and reaches about -13% at the beginning of the 21st century. Comparing China and Russia one should not rule out that the growth of China is more sustainable than that of Russia. In any case the Russian government would be wise to increasingly emphasize innovation policy and higher R&D expenditures both in the public sector and the private sector. However, one should not confuse effects on the level of the growth path and the relevance of the trend growth rate itself. The true net savings ratio affects the level of the growth path. Only the education expenditures are somewhat ambiguous since one cannot rule out that with

respect to the growth rate of technological progress there is a positive interaction between R&D expenditures – relative to GDP – and the share of skilled labor and tertiary education, respectively.

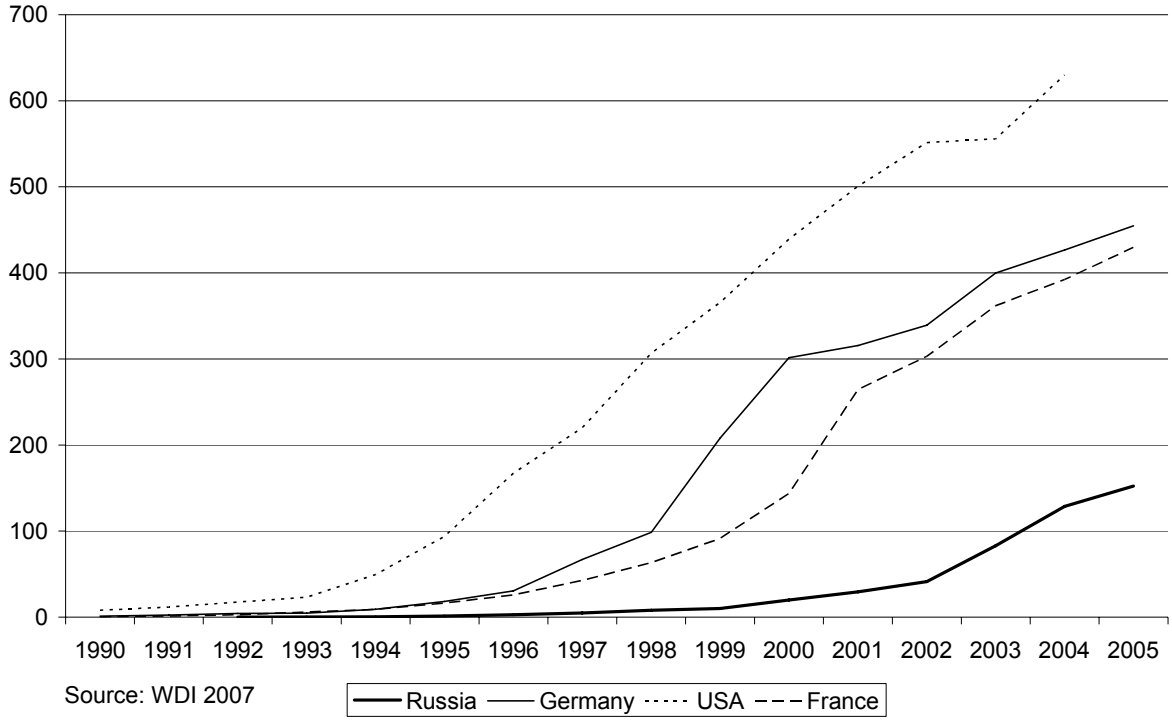
Russia's economic development will hardly be weakened much if the energy sector's output share in GDP would gradually decline. If one assumes that the growth rate of knowledge is largely determined by expenditures on education and research & development as well as international trade – read the import of technology-intensive products – Russia could sustain high growth rates. This holds for the case that government sets adequate budget priorities and stimulates expenditures on research and development through subsidies aimed at internalizing positive external effects of innovation. Classical Russian strength in the education system (and emphasis on mathematics and natural sciences) should be a fruitful basis not least for expansion of the information and communication technology (ICT) sector which has become the most dynamic sector in terms of innovation performance in the EU at the beginning of the 21st century – and the same holds for the US. The new Russia has favourable long term opportunities for long term growth, but a rise of internet user density and of host density are high should be high on the agenda of policymakers (see appendix). As regards the options for raising productivity the diffusion of knowledge through the use of ICT is important as could be the production of ICT goods; the latter field will be, however, difficult to enter since there is strong competition in world markets. While hardware is a particularly difficult field software could be more interesting, at the same time it is clear that here one is facing strong global competition in the long run. High Schumpeterian rents could be earned.

A decline of the natural resources sector and demographic problems will undermine economic expansion only transitorily. This implies a rather favourable long term economic outlook for Russia. There is, however, a certain caveat, namely whether or not Russia's financial system will be able to come up with adequate financing for innovative small firms. The rule of law is another critical area, in particular for the creation and expansion of young firms in the ICT sector. More integration with the EU also could be useful for full exploitation of digital networking in the 21st century.

Stimulating joint international research in energy R&D through government subsidies – aiming at internalizing positive external effects of innovation – could be useful for many reasons: Besides internalizing positive external effects in a strictly economic sense it could contribute to more long term cooperation among countries; such cooperation in R&D might in turn contribute to more long term stability in the world economy.

Appendix

Figure 9: Internet Users per 1000 Inhabitants



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