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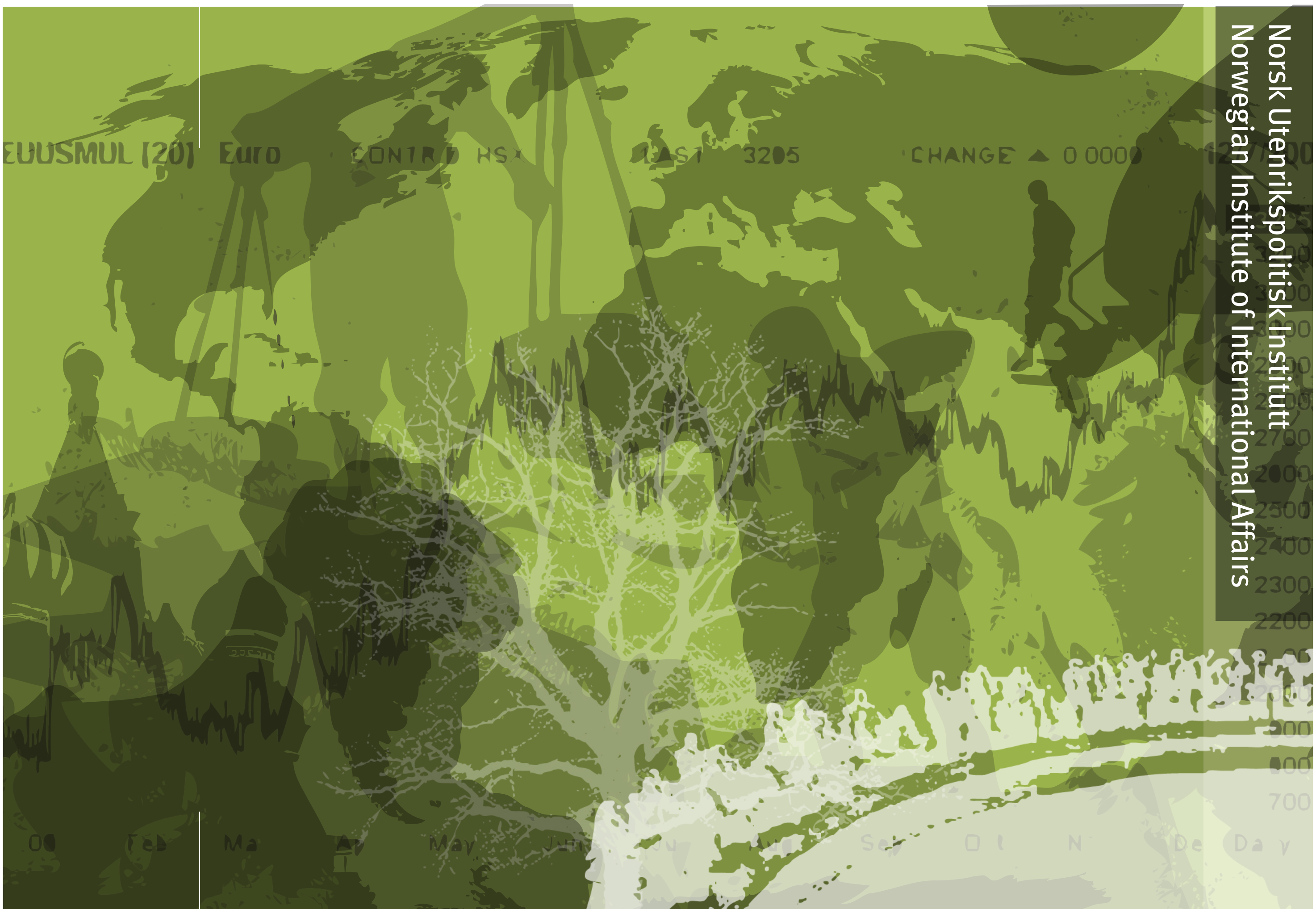
Linda Skjold Oksnes



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[Abstract] The paper analyzes the convergence process of industrial productivity across Russian regions during the period 1996-2004 by applying empirical methods. The industrial sector refers to, in accordance with Russian official statistics, oil & gas extraction, electricity production, mining & quarrying and manufacturing. Convergence in productivity levels is well analyzed in economic literature, but few have tested the hypothesis on Russian regions. Most previous convergence analysis of Russian regions has examined the development in income per capita. Russia's special history and vast geographical extent have led to huge regional variations in resource endowments, market access and industrial structure, to name a few. Since the regression results are highly sensitive for region-specific factors, these are identified and controlled for in the analysis. In addition, panel data techniques are used to check the robustness of the results to region-specific characteristics, which are not always measurable. The analysis also tests whether there is a tendency to economic agglomeration in the data. The hypothesis of absolute convergence is not supported in the analysis, but when region-specific factors are controlled for there are signs of convergence among Russian regions.Trade and investment as a share of regional industrial production appear in the analysis as the most significant explanatory variables.

Table of Contents

Preface

Linda Skjold Oksnes* was granted a Master student scholarship at NUPI during January-December 2008. This paper is a revised and shortened version of her Master thesis; presented to the Department of Economics at the University of Oslo in 2008. The paper is one of NUPI's contributions to the ENEPO (EU Eastern Neighbourhood: Economic Potential and Future Development); a European research project under the 6th EU Framework Programme where NUPI participated jointly with research institutions in 11 other European countries. For this project, a common database for European regions was developed, and the analysis of this paper is also based on these data.

Oslo, March 2009.
Fulvio Castellacci
Head of Department, Economics

* The author would like to thank her colleagues at NUPI for their inspiration, valuable comments and suggestions during the writing of her Master thesis and in particular the staff at the Department of International Economics and the Department for Russian and Eurasian Studies for their outstanding support.

List of Tables

Tables in the Thesis.

Tables in the Appendix.

List of Figures

1. Introduction

Industrial production in Russia has undergone major structural changes. The break-up of the Soviet Union brought an end to the command-and-control based economic system, and the Russian economy started to transform into a market-based system. It is reasonable to expect that the dismantling of the command lines and the introduction of market incentives have affected the industrial composition, the geographical structure and the distribution of industrial productivity, the question is how.

The first years of the transition were marred with problems; rapid inflation and a rent seeking and fraudulent economic behaviour led to falling investments and production. When the old command and supply lines were dissolved, trust and experience had to be established with the new market-based system. In the second half of the 90s inflation was brought under control and the economy started reacting to market incentives.

Using regional data from Rosstat for the period 1996 to 2004 I will analyse how the regional distribution of productivity in Russia has developed under the conditions of a market economy and how the observed pattern resonates with economic theory. Have investments and technology flowed into the least capital-intensive and less technologically advanced regions, so that the initially less-productive regions have caught up with the relatively more productive ones - or will we find a tendency for economic agglomeration and yet more diverging productivity rates? To answer my questions I have applied an empirical method, testing for absolute and conditional convergence. I have identified a set of explanatory variables considered of importance for regional productivity performance. Among these are investments, population growth, foreign trade and investments, indicators on the climate for technological development and business creation, market potential and initial industrial structure. Since the regression results could be sensitive to regional specific effects, which are not always measurable, I have applied panel data techniques, in addition to the cross-sectional analysis widely used in the literature, to control for these effects.

As a measure of productivity I will use labour productivity, defined as value added per worker employed in industry. The focus will be on what has been traditionally regarded as the main Russian industries: oil and gas extraction, electricity production, mining and quarrying, together with manufacturing. I will later refer to this sector simply as the 'industry sector'.

Russia's large and highly industrialized economy and huge geographical area makes it unique examining regional convergence process. Barro and Sala-i-Martin (Ch. 11, 2004) argue that we are more likely to find support for the hypothesis of absolute convergence across regions than across countries, because, although differences in technology, preferences and institutions exist across regions, these differences are likely to be smaller than across countries. In the case of Russia, geography and initial industrial structure, including the country's large resource industry, and substantial differences in the regions' resource endowments may obstruct the results of convergence. The majority of the Russian regions are highly industrialized in specialized manner: many regions have concentrations of just one or two sectors.

There exist few analyses of convergence applied to data for the industrial sector in Russia. Studies on regional convergence in GRP (gross regional output) tend to support the hypothesis of conditional convergence; when regional specific factors are controlled for the general findings are convergence (Solanko 2003, Merkina 2004, Maurseth 2006, and Nielsen 2005). However, the results are not unequivocal (see for example Maurseth 2003). Ledyaeva and Linden (2008) find, applying panel data techniques to the Russian GRP for the period 1996-2004, support for the hypothesis of conditional convergence. It is an interesting study whether the industrial sectors has adjusted differently than the rest of the economy and differ from regional income levels with respect to convergence.

Analysis of convergence in productivity has stressed the importance of industrial structure and regional industrial structure is commonly used as control variables in analysing convergence among regions within a country (see for example Barro and Sala-i-Martin 1991 or Ahrend 2002 and 2008 for the case of Russia). Before the financial crisis initial conditions, such as regional industrial structure, endowments of resources and human capital and geographical locations have proven to explain a significant share of inter-regional income disparities in Russia (see Ahrend (2002) and (2008)). Especially resource orientated regions seem to do better in terms of economic growth (Dolinskaya (2002) and (Popov (2001)). Empirical findings suggest that a large share of extractive industries in industrial production[1] has positive effects on regional growth, also after the financial crisis (see Ahrend (2008), Maurseth (2005), Nielsen (2005) and Solanko (2003)). Ledyaeva and Linden (2008) on the other hand find no such positive effects.

In conformity with the empirical convergence literature I find support for the hypothesis of conditional, but not absolute convergence in my data. Regional openness for trade and investment prove to be most important explaining the observed regional differences in productivity growth rates. Industrial structure proves insignificant, only the variable indicating resource intensive industries has some explanatory power. There are no signs of economic agglomeration in that regions showing largest growth in productivity are clustered, they are rather scattered around the country.

The paper is organized as follows: section 2 presents a brief economic and political background, section 3 explains the theoretical framework that underlies the empirical analysis, in section 4 I present a description of the Russian regions with respect to the core economic variables in the analysis, whereas section 5 offers the empirical analysis and regression results.

[1] Most energy and fuel, as well as ferrous and non-ferrous metallurgy sectors are included in extractive industries

2. Political and economic background

The political and economic background can possible shed some light on the regional economic performance during the transition. I will in this section briefly go through some of what I claim is important in understanding the regional development of productivity in Russian industry: reform politics and the special features of Russia's regional industrial structure.

2.1 Regional politics – fragmentation and integration

Soviet economy was based on the principles and mechanism of a command-and-control system: main economic decisions regarding resource allocation, what and how much to produce and where to produce these goods were taken by the central government. Under the planned economy, the regional economy was basically a constituent part of the national economy. The local governments had limited economic power, whereby the large enterprises where managed directly from Moscow (Lavigne 1995). Soviet planning was performed on a sectoral basis rather than on regional. Production, consumption, trade and investments were determined not by regional demand, but by state plan and the policies of federal departments. The centre exercised strict control over regional income flows (Granberg 2000).

Legal and economic fragmentation of the Russian Federation arose after the collapse of the Soviet Union. Dispersion of the systems for economic interaction together with a weak centre led to regional separatism. The relations between the federal centre and the regions became rather ad-hoc based. Under these conditions, the regions lobbied for greater autonomy and bargained for favourable fiscal arrangements. Many regional leaders took advantage of the weak federal centre under Yeltsin to size powers and control over regional resources. Many regions started passing and enforcing regional laws, many of them inconsistent with federal legislation. The struggle for power has also led to an inward focus, and building up new trade lines was not a high priority. Inter-regional trade as a part of GNP fell from 22% to approximately 12–13% in the period 1990 to 2000 (Granberg 2000). By the end of Yeltsin's period many regional leaders were running their federal subjects as personal fiefdoms.

On January 1992 the implementation of transition policies started with a large scale privatization and price liberalization program. Most of the prices were liberalized during the first year and by the beginning of 1997 much of the privatization process had been accomplished with private enterprises accounting for a large part of industrial output in general, but large regional differences existed. The regional leadership had different attitudes towards liberalization and privatization reform. Some regions refrained from privatizing their industries and refused to implement legislation concerning privatization of land. Large enterprises could put pressure on the local government to gain private benefit, often referred to as 'state capture'. Firms could for example push for perpetuation of the property-rights regime to restrict new entry into their markets, preserves their opportunities to arbitrage between reformed and unreformed parts of the regional economy, and protects themselves from regulatory interference by the central government (Desai et. al, 2001).

Putin's primary object has been to tighten federal control of the regions and create a unified economic and legal space. Putin's efforts to bring regional legislation in line with the 1993 Constitution and federal statues have shown results. In 2000, a comprehensive reform of inter-governmental fiscal relations was initiated, making the federal transfer allocations to the regions more transparent. Indeed, the new formula-based methodology for determining the transfer allocations has made the transfers more predictable and helped concentrate federal recourses in the poorest regions (Desai et. al. 2001). The work of simplifying the bureaucracy and the tax system has helped to strengthen the centre/ periphery relationship. Today's Russia has, to greater extent, become a unified legal space and an integrated national market.

2.2 Industrial structure

Economic policy under the Soviet followed the objective of self-sufficiency and creating the Soviet economy into one of the world industrial and military super-power. The participation in foreign trade was limited and concentrated among socialist countries. As a result the Soviet economy was producing in a range of sectors, but different sectors worked at different levels of competitiveness (Senik-Leygonie and Hughes 1992) – not all competitive at international standards. The Soviet economic system contained few incentives for economization of resources and investments in innovative activity. Economic planning was often rather subjected to other political priorities than profitability. Governmental investments were put into developing the heavy and military industry. Military oriented R&D accounted for about 75% of the federal science budget, even as late as the second half of the 80s (Saltykov 1997).

As a result of the Soviet control-and-command system economic activity was concentrated in large production units and spread out over the country. The Soviet leaders always had preferences for large projects and their belief in economies of scale has proved astonishingly long-lived (Gros and Steinherr 1995). They had a clear strategy for spreading the production to new regions and small towns. Specific regions and towns were singled out as industrial locations. Many urban areas, especially in the North, were designed to serve the needs of a single giant enterprise. Extreme cases of this kind are the 'closed' towns servicing secret enterprises, facilities and research institutes (Granberg 2000).

The rapid industrialization that commenced with the first Soviet Five-Year Plan, in the late 1920s, brought with it the need for natural resources like coal, oil and heavy metals (Blakkisrud 2006.). This meant the start of the industrial policies for the North and Far-Eastern regions, so richly endowed with natural resources. The eastward orientation was reinforced by the wartime evacuation of hundreds of factories were evacuated, to protect them from the Nazis. Many of them remained after the war. A military-industrial base was by then established in the east.

Industry under transition

During the transition industrial production was reduced by more than half, but some industries fared worse than others. In light of the mono-industrial pattern across regions, the transition had varying regional consequences. Those regions that inherited the 'wrong' industries experienced huge losses. Especially hard hit was the manufacturing industry, together with mechanical engineering, chemical and forest industries. Important factors here were falling national demand, loss of international competitive ability and cutbacks in state subsidies. Faced with increased competition, especially when the CIS-countries opened towards the West, Russian industry faced competition problems. According to OECD (1995) calculations, the disruption of the trade with CIS-countries contributed to 10% of Russia's economic decline in the early 1990s.

Granberg (2000) has identified three especially vulnerable types of regions: those with a high concentration of manufacturing industry, peripheral regions, and those dependent on federal transfers. Among the latter, regions based on military industry found themselves in a particularly difficult situation during the transition. Northern peripheral regions without large reserves of natural resources were hit especially hard. The industrialization of this area had been to some extent policy-dictated and did not reflect real economic costs. Transportation costs rose sharply during the transition, and many Northern enterprises started running at huge losses. The winners were the regions endowed with oil, gas, non-ferrous metals and diamonds, and nodal centres. (See Blakkisrud 2006.)

Since 1998 the pace of structural change has slowed down, while intra-sectoral change has become an increasingly important source of productivity growth. The devaluation of the rouble increased the international competitiveness of the Russian industry, especially manufacturing industry, which began to catch-up. Although many firms increased production by utilizing existing input, those firms that managed to actively restructure also increased their employment. Especially after 2002, the easy gains from the devaluation became exhausted and the firms that had increased productivity managed to do so through active restructuring (Ahrend 2004).

3. Theoretical conciderations

How will the regional distribution of productivity rates develop when the economy is transformed from a command-and-control and into a market economy? According to economic theory, with the opening up for market forces, investments will flow into regions with the largest growth potential, and firms will adopt technologies that serve to maximize profit. In a command-and-control economy no such self-regulating mechanism exists, while it depends on the central authorities preferences and whether their ability to enhance profitability. Opening up for market forces is expected to lead to convergence for two reasons: decreasing marginal factor productivity, and the transfer of technology from regions at the productivity (technology) frontier to relatively less productive regions, which have greater potential to improve their productivity through investing in technology. In the absence of one or both of these assumptions, economic agglomeration and divergence may emerge.

3.1 Neoclassical theory – decreasing return to capital

The hypothesis of convergence originates from neoclassical growth models in the tradition of Solow (1956), Cass (1965) and Koopmans (1965). The models aim to explain growth dynamics in a period of transition, while long-term growth rates are taken as given. Since the Solow-model assumes full employment, output per capita is equivalent to production per employed labour (or value added per worker), my indicator on labour productivity. The central mechanism is decreasing return to capital. Diverging growth rates in productivity are explained by differences in the regional possibilities to grow through investing in increased capital/labour ratio, which depends on how far the regions are from their steady-state level of productivity. Thus further away a region is from its steady-state productivity level, given by the regions initial characteristics, thus higher the growth in productivity. Ceteris paribus, because of decreasing return to capital regions with a lower capital/labour ration are expected to grow faster than other regions. In steady-state the prospects for growth through increased capital/labour ratio is exhausted and the only source of productivity growth is through technological development. Assuming that technology is a public good, all regions will have access to the same type of technology, and thereby grow at the same long-term growth rate in steady-state.

Any differences in steady-states in the original Solow-model are due to differences in the consumers' time preferences, which determine the saving rate, growth in the workforce or the rate of depreciation[2]. The Solow-model assumes a perfectly competitive world: all markets are in equilibrium, such that the saving rate equals the gross investment rate[3] in a closed economy. Assuming that regions forms separate economic units, opening up for factor mobility will repeal the restrictions the local saving rate put on the rate of investments. Capital and labour will flow into the regions, which offer highest marginal returns. Relative capital scarce regions will grow relatively faster, because of capital inflow.

The model, as I have described it, predicts higher rate of convergence than those observed empirically. Mankiw, Romer and Weil (1992) show that when human capital is included in the closed version of the model, so that diminishing return set in more slowly, the model accords better with empirical evidence on convergence. Later Barro, Mankiw and Sala-i-Martin (1995) show that also an open-economy version of this model conforms with the empirical evidence on convergence, if an economy only can borrow to finance a portion of its capital needs.

3.2 New growth theory – technological diffusion

More recently, inspired by endogenous growth theory, convergence has been applied to the hypothesis of technological catch-up. In technology-gap theory technological diffusion and the regions' ability to adopt available technologies play a key role in whether laggard regions tend to catch up or not. The 'catch-up' argument, developed by Gerschenkron (1962), Abramovitz (1986) and others, emphasizes the distance to the technology frontier for the scope of imitation of exciting technology. Relatively less technological advanced countries behind the innovation frontier, it is argued, can grow faster by coping technologies already

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[2] The saving rate is exogenous in the Solow model. Cass (1965) and Koopman (1965) have endogenized the saving behaviour, but the main results remain.

[3] By gross investment I mean all fresh investment provided, including those, which covers capital depreciation.

developed in technologically more advanced countries (Fagerberg 1995). At the other hand if the technology gap becomes to large the lagging regions may not have the prerequisite to take advantage of the excising pool of technologies and find them self trapped in equilibrium with low economic development.

Barro and Sala-i-Martin (1997) formalize this argument in a model where the relative cost advantage to be gained from imitating desirable technology serves as a mechanism for convergence. Based on the framework for technological progress of Romer (1990), they describe the transitory dynamics. In this model, productivity growth is a result of an increase in the variety of new intermediate products[4] available for the final goods sector.

Access to new products can come through own innovation effort or through trade with other regions, which have invented new products (imitation). Imitation, as used here, is a way to achieve technological development, not by innovating self, but rather adopt new technologies developed in other regions. The cost advantage in 'imitating' makes it possible for the laggard regions to adopt new technologies at a faster rate and thereby grow faster than the frontier regions, required that they are able to raise sufficient funds for investments. For regions at the technological frontier 'imitations' is no feasible strategy, when there are simply no products to imitate. The prospects for faster growth through 'imitation' are only temporary, while the cost of 'imitating' is assumed to increase when the regions are approaching the technological level at the frontier.

In steady-state the regions are growing at the same rate, equal the rate innovation in the technological frontier region. The regions steady-states level of productivity is given by the regional market size and political and institutional factors. Barro and Sala-i-Martin (1997) give governmental policies securing infrastructure services, an efficient tax system, the degree of maintenance of property rights and rule of law as examples of such. The lagging regions tend to be technological inferior and have lower steady-states, but the model opens for a shift in frontier regions. If initial technological inferior regions, turns out to be intrinsically

[4] Growth through increased variety of new products is based on the product variety theory of Dixit and Stiglitz (1977).

technological superior in term of underlying parameters, then the lagging region eventually will eventually catch-up and pass the productivity leader.

The model is similar to the neoclassical Solow model in that the driving force is decreasing returns (here to adopting technology), and that the countries are expected to converge to the same long-term growth rate. The main difference is that the process of catch-up is by no means automatic. If the initial productivity (technology) gap is too large, given by too low technological capacity or small market size, the regions are not able to generate sufficient investments to catch-up through imitation. Despite the relatively lower price on imitation, the lagging regions imitate at a lower rate than new products are invented and remain in the productivity backyard.

3.3 Economic agglomeration

The Barro and Sala-i-Martin model do not geographically restrict the externalities. If the technological spillovers/externalities are geographically restricted or tied to certain sectors, the result could be economic agglomeration instead. Geographical distance may act as a barrier – if, for example, transport costs are significantly high. Even though transport costs in Russia have been kept low relative to transport prices generally observed in other market economies, they have been rising sharply during the transition.

Krugman (1991) presents a core-periphery model describing a source of agglomeration working through the size of the market, were trade or transport cost plays a crucial role[5]. The central point in this model is that agglomeration is driven by the combination of pecuniary externalities, economies of scale in production and the presence of trade cost. Given the existence of economies of scale, firms will face a trade-off between being able to make use off gains from being located in one market and the loss from trade costs connected with serving the markets, which the firm are not located. If the trade cost (eq. transport cost) is large relative to the economies of scale the firms will find it more profitable to be located in

[5] See also Krugman and Venables (1990)

‘both’ markets. At the other hand if the trade costs are sufficient low location does not matter. For an intermediate level of trade costs, being located in the largest market is for a firm most profitable. Given one location, being in proximity to the largest market minimize trade costs.

Demand and thus the size of the market are assumed to be proportional to the number of firms located in the market. ’Manufactures want to locate were the market is largest; the market is largest where the manufactures locate’ (Krugman 1991). The linkage between number of firms and market size could be explained by several mechanisms. In Krugman’s core-periphery the number of firms in a market attracts additional people to that location leading to increased demand facing each firms in that market. In presence of trade cost people living in regions with relatively many firms have access to a larger variety of goods to relatively lower prices than the people living in the regions possessing smaller markets, which gives an incentive to migrate. Increased demand gives additional firms incentives to relocate to that location. Having a large market initially will then attract more firms to the region, which attract migrants and in turn additional firms. There is a circular effect in that the number of firms that want to locate in a certain area increases with the number of firms located there.

4. DESCRIPTIVE ANALYSIS

In 1996, output per worker was 25 times higher in the most productive region (Tyumen incl. Khanty-Mansijsk & Yamalo-Nenets) compared to the region with the second lowest output per worker (Dagestan republic)[6]. Ingush republic was recorded as being by far the least productive, but the observations seem unreliable: both productivity level and growth vary extremely from year to year. I have therefore excluded that region in the summary statistics.

The highest level of labour productivity is to be found in the Urals and eastern Urals – which are substantially endowed with natural resources: oil, gas, metals and forests[7]. This area is shaded dark shaded on the map in Fig. 4.1 and Fig. 4.2, which shows the geographical distribution of productivity levels in 1996 and 2004 respectively. The maps are divided into four equally large productivity intervals, with darker shading for higher productivity. The darkest area contains the ¼ most productive regions; the second darkest area contains the ¼ second most productive regions and so on.

[6] Tables with summary statistics are given in appendix A4.

[7] Following Bradshaw (2006), I define resource intensive production as production in fuel, metal and timber, woodworking and pulp/paper industries.

Figure 4.1. *Labour productivity 1996. Source: Rosstat, Regional Statistics.*

Figure 4.2. *Labour Productivity 2004. Source: Rosstat, Regional Statistics.*

Regional output per worker has increased by almost 60 percentage points on average from 1996 to 2004, but regional growth performance has differed substantially. While some regions can note significant productivity growth over the whole period, others have experienced negative growth rates: in four regions, labour productivity actually fell from 1996 to 2004. These were regions, which never recovered after the financial crisis.

Figure 4.3) shows the regional distribution of average productivity growth rates for the period 1996 to 2004. While the map with productivity levels showed a clustering pattern in the resource belt, regions with the highest growth rates are scattered around the country. The resource-rich regions do not stand out here. Despite sharply rising oil prices from 1998, only some of the regions with substantial oil and gas production, like Sakhalin oblast and Arkhangelsk incl. Nenets, have had relatively high average growth. Tyumen incl. Khanty-Mansijsk & Yamalo-Nenets shows only moderate growth performance. The two main financial centres, St. Petersburg and Moscow, were among the regions with relatively high growth rates.

Figure 4.3: *Average regional productivity growth 1997–2004. Source Rosstat Regional Statistics.*

5. Empirical analysis

In this chapter I investigate how relative productivity levels across the regions of Russia have developed during the period 1996–2004. I will apply the hypothesis of absolute and conditional convergence in productivity and addition investigate the effect of Russian industrial structure[8] on regional industrial productivity growth. By using indicators on 'market potential'[9] and 'technological spillover' I will test for the tendency of geographical agglomeration, in the sense that highly productive regions are clustering together. With productivity I have labour productivity in mind, defined as value-added industrial production per employee. My focus is on what has been traditionally regarded as Russian industry – oil and gas extraction, electricity production, mining and quarrying, and manufacturing. I refer to these sectors simply as 'industry' or the industrial sector.

5.1 The concepts of convergence

There are two main concepts of convergence: β- and σ-convergence. If the initially less-productive regions tend to grow faster than the more productive regions, given regional specific factors, we have β-convergence. If we observe decreasing disparities in productivity levels over time, we have σ-convergence. It can be shown that β-convergence is a necessary, but not sufficient, condition for σ-convergence[10]. β-convergence is commonly used analyzing whether poorer or less productive regions are catching up with the richer and more productive ones.

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[8] The industry sector used in the analysis are described in the appendix (Table A.5: Cross-regional analysis)

[9] Market potential is emphasised in Krugman's core-periphery model and reflects the firms' potential market (Krugman 1991).

[10] For a derivation of the equation interested readers are advised to consult Barro and Sala-i-Martin (2004).

However if we get support for β-convergence, in the sense that less productive regions tend to grow faster than the more productive ones, this does not necessarily reflect convergence as predicted by the Solow-model or the technology-gap model of Barro and Sala-i-Martin (1997). It could be that less-productive regions grow faster, overtaking the productive leaders, such that over time large differences will remain, only with a shift in the leaders. This phenomenon, also known as ‘leapfrogging’, has been analysed by Brezis Krugman and Tsiddon (1993) among others. I will analyse σ-convergence to see whether the dispersion in the labour productivity levels is increasing or decreasing over time, but this measure is quite sensitive to business cycles, when it is based on yearly deviation in productivity rates. The main focus will be on β-convergence: I will test for β-convergence, in order to determine whether there is a tendency for less productive regions to catch up with initially more productive regions.

5.2 The model

The empirical literature on convergence analysis has tended to use cross regional data, whereas a panel-data approach has become more and more common with increased data availability, where Islam (1995) and Caselli et al. (1996) among others have contributed to the work. The cross-regional approach has been criticized for inconsistency due to omitted variable bias and that at least some of the explanatory variables are endogenous (Caselli et al. 1996). Omitted variables could typically be inter-regional differences in technology, politics, culture and climate, which are not always observable. Since I have panel data it may be possible to remove the region-specific effects, including non-observable events, with model utilizing the variation over time as well as regions. The weakness is that the time intervals for which the growth rates are calculated over become shorter. This leads to estimates that are more sensitive for cycles around the trend. Only eight years are covered in my time series, which yields at most two four-year periods. As that the fluctuation has been substantial over the years in Russia, I will base my analysis on the cross-regional approach and use the results from the panel analysis as robustness check.

Cross-regional regression

To test for convergence I employ a linear model with regional average growth (ag_i) as a function of log initial productivity level ($\ln(cind_{i,1996})$) and a set of control variables, given by $X_{i,j}$, were i is denoting regional observations and j the specific control variables. Equation (5.1) defines the model to be used in the cross-regional analysis, while equation (5.2) describes how I have calculated the average growth rate.

(5.1) $$ag_i = \alpha + \beta \ln(cind_{i,1996}) + \sum_j \lambda_j X_{ij} + \varepsilon_i$$

(5.2) $$ag_i = \frac{1}{8} \sum_{t=1997}^{2004} g_{i,t}$$

β in equation (5.1) is the convergence coefficient, α is the intercept, assumed common to all regions, ε_i is the regional-specific error term, and λ_j represents the coefficient on the j control variables (X_{ij}). A negative β implies that regions with relatively initial lower productivity level in general have higher average growth rates over the period analyzed, so a negative β supports the hypothesis of convergence. The Solow model and the technology-gap model of Barro and Sala-i-Martin (1997) predict a negative sign on β, while Krugman's (1991) core/periphery model predicts a positive sign on β.

The average growth rate (eq.5.1) is calculated from the yearly growth rates ($g_{i,t}$) from 1997 to 2004. This approach is somewhat different from that of the Barro and Sala-i-Martin (1991, 1992) regression. Barro and Sala-i-Martin use the log of the end observations, the observations measured in the first and last years of the period analysed. This renders the average growth rate sensitive to possible cycles in these two years. To make the measure of the productivity growth trend more robust for cycles in the end observations, I take the average of the yearly regional growth rate over the period analyzed. This is in general a more robust measure on the growth trend. On the other hand, my measure is more sensitive to the large regional fluctuations in growth rates in the years after the financial crisis of 1998. So by comparing my result with the outcome, when using 'Barro and Sala-i-Martin's method' for calculating the growth rate, I can get an indicator of whether the results of the analysis are sensitive to the fluctuations in the years after the financial crisis.

There is no single answer as to which control variables (X_j) to include in the analysis. It all depends on the theory approach and characteristics of the area of interest, as well as data availability. Based on these considerations I have, in my analysis, chosen to include: the share of value added invested in the industry (investments), the share of employees with a bachelor degree or higher as an indicator on investment in human capital (human capital), population growth as an indicator on the growth in the labour stock (population), regional net migration (migration), total trade and foreign direct investments as a share of GRP (trade and FDI), reflecting regional openness for trade and foreign direct investments respectively, share of total employment in research and development (R&D), reflecting the regional rate of innovation in the industry, a technological spillover variable (spillover), an indicator on market potential (market potential), formation of small and medium-sized enterprises[11] (SME) and initial industrial structure, including the share of resource intensive production in the regions (recourses).

Variables of regional industrial structure are commonly used as control variables in analysing, convergence among regions within a country (see for example Barro and Sala-i-Martin (1991) or Ahrend (2002) for the case of Russia), while political and institutional differences, such as type of regime (often degree of democracy), rule of law and investment and business climate, are often assumed away when analysing convergence among national regions. Referring to earlier discussions, there is no doubt about that Russian regions differ in terms of geographical location, resource endowments and industrial structure. Especially the extractive industries (the resource sector) have drawn attention in empirical literature on Russian regional growth performance (see Popov (2001), Dolinskaya (2002), Bradshaw (2006) and Ahrend (2002 and 2008)). With respect to political, institutional and cultural features it could be argued that interregional differences among Russian regions are smaller than among regions across countries. On the other hand, regional policies during the 1990s were fragmented and largely diversified in their reform performance, although in larger extent subordinated federal politics after Vladimir Putin came to power in 2000. In my analysis the SME variable, but also trade and FDI, could work as indicators on market-friendly policies.

[11] SME is defined as an enterprise employing fewer than 250 people.

Industrial structure, resource endowment, human capital, market access and political and institutional factors have emerged as important for regional growth in GRP per capita, but the evidence differs. Maurseth (2005) and Östreich-Nielsen (2005) find evidence that being close to large national markets or having large resource endowment is favourable for regional growth. Ahrend (2002, 2008) finds that initial industrial structure, endowment of natural resources and human capital had large impacts on economic growth performance during the 1990s, but the importance decline significantly after the 1998-crisis. Also Dolinskaja (2002) derives a similar conclusion, with findings that confirm the importance of industrial structure and natural resources in explaining regional differences in growth rates.

Empirical findings on the effect of reform-friendly policies, including the degree of price liberalization and privatization, on economic performance, are not unequivocal. Berkowitz and DeJong (2001) find that reform friendly politics exhibit positive correspondence with economic growth, Popov (2001) also find a positive association between reform politics and economic growth, but this effect is not significant when initial conditions as resource advantage and institutional strength are controlled for. Ahrend (2002, 2008) finds that political variables and economic reforms do not explain the variation in economic performance among Russian regions before 1998. However in contrast to what expected, especially with a view on the centralization of Russia under Putin's presidency, in post-crisis Russia reform-oriented policies and better regional leadership are found more important in explaining regional differences in economic performance (see Ahrend 2008).

A list of the included variables and a description of how they are constructed are attached in appendix 5.2. Some variables require extra attention as to their construction and quality as indicators. I will go through them below. Issues more directly related to the quality of the data will be discussed in a separate section (5.3).

The variables under closer consideration

The market potential for a firm is not restricted by the size of the economy of the region in question, but depends also on the size of the markets in surrounding regions. A firm in one region are serving markets in other regions, but the market potential for each firm is assumed declining with distance, due to the presumed increase in trade costs. To measure region i's market potential I take the sum of the gross regional product (GRP) of all the regions, including regions i's GRP, and weight by the distance to region i. The distances between the regions are calculated by taking the great circle distances between the capitals.[12] There is one important weakness in my calculations; foreign markets are not included. This probably gives the variable an eastward and inward (domestic) bias. The variable does not include the possible positive effects of being close to large foreign markets. The result is an underestimation of the effect of being located in central federal district or as well at the border to other Asian markets in the east.

To capture the possible effect of inter-regional spillovers within Russia I have constructed an indicator (spillover) of technological transfer, similar to the market access variable, using the other regions' productivity level instead of GRP. This indicator is based on the assumption of increased geographical proximity for the channels for technological spillovers in general, as inter-regional trade and investments.

Included in the recourse variable is the regional share of fuel, timber, woodworking and the pulp- and paper and metal industry in production. Depending on the quality of the national and regional institution, the resource variable is expected to have positive or negative impact on growth. Empirical findings show that economies with an abundance of natural resources tend to grow more slowly than those without (Sachs and Warner 1995, 1997 a,b, Auty 2001). One argument is that the large resource rents spur a kind of rent-seeking behaviour among entrepreneurs and politicians, and that the resource sector over time could suppress other productive sectors. Mehlum, Moene and Torvik (2002) argue whether this is the outcome depends on the quality of the institutions that govern the economy. Such concerns have been voiced about the oil and gas sector, but I maintain that the argument applies to all sectors that

[12] For a formal description of the *mp* variable see appendix (A.5: Market potential).

are based on highly valuable natural resources with opportunities for easy gains. Even though the oil and gas industry is responsible for much of the revenues generated in the Russian economy, for some regions other sectors and resources, such as metals, diamonds and forest products, are a substantial source of revenue. The large fortunes from these commodities are a determining factor for a number of resource regions (Bradshaw 2006).

My list of control variables is far from comprehensive. Political, cultural and institutional differences are especially hard to capture. In addition I have not been able to create a variable that captures the effect of being close to foreign markets. It could be argued that all these features change slowly over time, or at least the relative pattern between the regions remains approximately the same in time. Fixed-effect panel regression could therefore possibly control for these effects. I will therefore carry out a panel analysis to check the robustness of the convergence analysis.

Panel regression

A fixed-effect panel regression is intended to control for all factors that vary across regions but remain fixed over time. By applying this method I test for a sort of conditional convergence. A negative sign on the convergence coefficient (b) implies convergence, conditional on all factors determining the different regional steady-states.

I will do a 'before and after' analysis, which is a type of fixed-effect regression with two time observations (Stock and Watson 2003). By dividing the dataset into two equal time periods (1996–2000 and 2000–2004), I get two equal equations for convergence (5.3), one for each sub-period τ ($\tau = 1,2$). Initial productivity for the first and second periods is measured in 1996 and 2000 respectively, and the growth rates are the four-year average for each period. By subtracting the equation for period 1 from period 2, I get a difference equation (5.4) that expresses the change in average growth as a function of the change in productivity level.

5.3. $$ag_{i,\tau} = \alpha + b\ln\left(cind_{i,\tau}\right) + \sum_j \lambda_j X_{ij} + \varepsilon_{i,\tau} \qquad \tau = 1,2$$

5.4. $$ag_2 - ag_1 = b\left(\ln cind_{99} - \ln cind_{96}\right) + \left(\bar{\varepsilon}_{i,2} - \bar{\varepsilon}_{i,1}\right)$$

By focusing on changes over time I have removed the factors that differ over regions, but are fixed over time. Theoretically this implies that I control for all regional characteristics determining steady-states, since these factors are assumed to remain fixed over time.

5.3 Econometric issues

The analysis is based on regional data from Rosstat, which issues the official statistics in Russia, for the period 1996–2004. This gives me a balanced panel with 8 yearly and 79 regional observations for growth and productivity level.

Some weaknesses of the data

Although technically correct, the Russian data suffer from reporting problems. Price statistics are often regarded as unsure, and views have differed as to whether it is preferable to use the official price statistics on deflation or not. I have regional price statistics for the whole period, which enables me to adjust for regional price differences over time. Despite their weaknesses, the regional price statistics for the industry are the best price indicator available and I will use them in deflation of the data.

Another potentially significant source of bias is the under-reporting of value added in the industry sector. Much of the value added generated in industry is reflected not in the accounts on the relevant industrial sector, but in the accounts of affiliated trading companies. The problem is that this practice applies to certain sectors more than others – resource and the export sector in particular, which could have consequences for the observed regional distribution of productivity levels. According to World Bank estimates, value added from oil and gas production in GDP was under-represented by 11.4% in the official statistics in 2000 (World Bank 2004). Since I do not have an indicator on this bias except for 2000, I am not able to control for this bias.

The observations on FDI are rather doubtful. A substantial part of the FDIs are actually Russian investments that have been on a ‘round trip’, and are not real foreign investments. The result is that the FDI variable also partly reflects Russian investments.

Missing values

In general there are not many missing values, but some regions and variables stand out. For the regions Chechnya, Chukotka autonomous okrug and Ingush republic, some observations are missing. Several observations are missing for the industrial employment and structure variables. With Chechnya, observations are lacking on almost all variables, so I have chosen to remove Chechnya from the sample. Moreover, the region has been destabilized for a long time, and in that sense represents an outlier. For the other republics and variables I have enough information to extrapolate the missing observations. A description of which observations have been extrapolated and how is found in appendix (A.5. Correlation table).

Distribution of the data

Figure 5.1. gives a picture of the distribution of average growth rates, conditional on initial productivity (1996). Most observations appear clustered around a slightly downward sloping line, but three observations stand out. The observation in the upper left corner represents the Ingush republic; the point furthest to the right is the oil- and gas-rich region of Tyumen incl. Khanty-Mansijsk & Yamalo-Nenets, while the observation second to the right is Sakha (Yakutia) republic, a region with considerable metal and mineral resources. Especially the Ingush republic can be regarded as a potential outlier – an assumption supported by the large annual fluctuation in the observations for that region. Tyumen incl. Khanty-Mansijsk & Yamalo-Nenets and Sakha (Yakutia) republic have by far the most resource-intensive production.

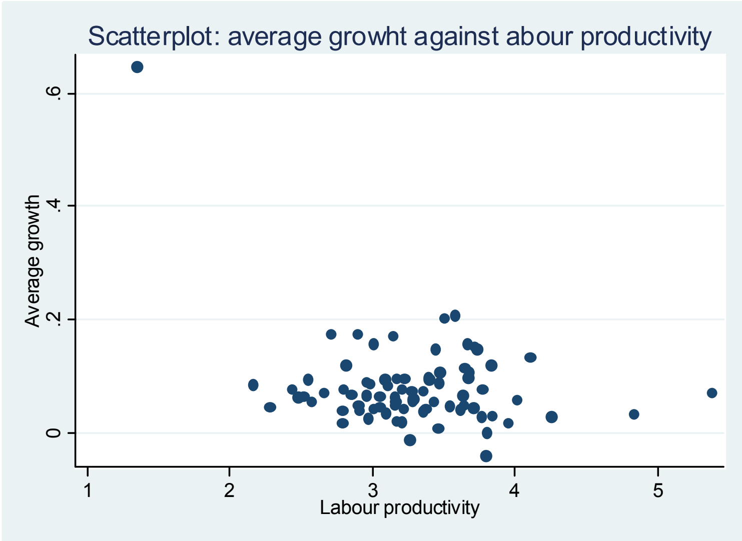

Figure 5.1: *Average growth 1997–2004 versus productivity level in 1996.*
Source: Rosstat, Regional Statistics.

Since the OLS estimators are sensitive to outliers I will control for the three outlier regions in the analysis by using regional dummies. In the multiple regression analysis, testing for conditional convergence, I will drop the observation on the Ingush republic and assume that the resource variable accounts for much of the effect from Tyumen incl. Khanty-Mansijsk & Yamalo-Nenets and Sakha (Yakutia) republic.

Correlation between the variables

In general, correlation between the explanatory or control variables is not a problem and the results in the analysis are still valid, but when the correlation is high it results in less precise estimates and the test statistics become less reliable. Population growth and migration as a share of the regional population are highly correlated (0.9296), not surprisingly since migration constitute an important part of the population growth in some regions. Market potential, spillover and migration are substantially correlated (corr≥2/3) and R&D is substantial correlated with market potential, education, as well as migration. The resource variable is highly correlated with initial productivity. A correlation table is presented in appendix 4.4.

The financial crisis

Several studies stress that the years following the crisis, including the regime shift in 2000 represents a shift in the Russian economy, changing the importance of the underlying forces in the economy (see for example Maurseth 2005, Nielsen 2005 and Ahrend 2008). Because of the short time period, and the large fluctuation in the growth rates also in the years after the financial crisis, I have not put any focus on dividing my regression into several periods.

5.4 Empirical results

From my descriptive analysis I found that the largest resource-rich regions were by no means the most productive, whether in 1996 or in 2004. I also found that the productivity ranking was quite stable, especially at the bottom. The five least productive regions in 1996 were the same in 2004. Even though the ranking has remained quite stable, the productivity differences between regions could have decreased. Whether the regional productivity rates have converged or diverged from 1996 to 2004, and dependent on which factors, is what I will try to answer next.

Absolute convergence

The test for absolute convergence supports neither convergence nor divergence among Russian regions. The convergence coefficient, b, has in general a slightly negative sign, but is definitely insignificant. When controlling for potential outliers, the effects of initial productivity on growth disappear.

The results are presented in Tab.5.1. The first row shows the basic regression, reg1, on a full sample without any regional dummies. In regression 2, reg2, I have included a dummy for the Ingush republic (d_Ingush), a potential outlier. I have also tested the effect of including dummies for additional two potential outliers, the resource regions Tyumen incl. Khanty-Mansijsk & Yamalo-Nenets (d_Tyumen) and Sakha (Yakutia) republic (d_Sakha), in the regression. These results are found in appendix (A.5.Empirical results). In regression 3, reg3, I have removed the Ingush republic from the sample. In the final regression (reg4) I have tested the hypothesis of convergence on the 2/3 initially richest regions.

The convergence coefficient, b, is slightly negative, but not significant in either of the regressions. Controlling for potential outliers further reduces the significance of the b. Only the dummy for the Ingush republic (d_Ingush) is significant, while the two other regional dummies do not show any significant effects on the result. Including a dummy for Ingush republic (d_Ingush) increases the explanatory power considerable. This large increase, because of controlling for one observation, is disturbing, and provides a strong argument for removing Ingush republic from the sample. When the observations for Ingush republic are removed from the sample R-square drops.

	Absolute convergence							
	reg1		reg2		reg3		reg4	
Obs	79		79		78		78	
R-squared	0.1087		0.6433		0.0014		0.0013	
	Coefficient	**P>|t|**	**Coefficient**	**P>|t|**	**Coefficient**	**P>|t|**	**Coefficient**	**P>|t|**
lncind	–0.0467	0.2300	–0.0034	0.6860	–0.0034	0.684	–0.0043	0.7040
constant	0.2340	0.0800	0.0853	0.0020	0.0853	0.002	0.0883	0.0320
d_Ingush			0.5670	0.0000				

Table 5.1: *Testing for absolute convergence. Source: Rosstat Regional Statistics*

Regression (regr4) shows results of testing the hypothesis on convergence on the 2/3 initially richest regions. The rationale for this is that the least productive regions could stand out when it comes to convergence. In the Barro and Sala-i-Martin (1997) technology-gap model there could exist a threshold for where the gap between the least productive regions and the technology developed and advanced regions is too large. A possible outcome is then that the laggard regions are simply left behind. Regression 4 does not support the hypothesis of higher convergence among regions that were more similar in terms of initial productivity. I have also looked if there is any sign of convergence among the 1/3 least productive. The convergence coefficient is significantly negative, but the sign of convergence disappears totally when the Ingush republic is controlled for. Results from this regression are presented in appendix A.5: Empirical results.

There are in general no signs of either absolute convergence or divergence in my data.[13] The OLS-estimator appears quite sensitive to the observation for the Ingush republic and the explanatory power increases disturbingly when a dummy for Ingush republic is included. I will continue to test for conditional convergence, as argued, without the Ingush republic in the sample.

Conditional convergence

My findings support in general the hypothesis of conditional convergence, although there is no sign of any strong convergence. There is no single factor alone which, when controlled for, leads to convergence in the results. When I include investments, including FDI, population growth or migration, in combination with resources and/or trade, the convergence result become significant. (See Table 5.2 and Table 5.3.)

Only the regressions most important for explaining the fit of the theory and/or the pattern in data are included. Some other regressions are presented in appendix A.5.Empirical results. I have divided the regressions into two categories, according to which theory they are basically explaining. In Table 5.2 I have reported the regressions including the factors important in neoclassical convergence, while Table 5.3 includes variables important for the technological catch-up argument. Both tables include a variable controlling for regional resource production.

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[13] I have also tested for absolute convergence for the sub-periods, 1996 –1998 and 1999–2004, but the results were not significantly different when the Ingush republic was removed from the sample. The results are attached in appendix (A.5: Empirical results).

When only the classical factors from the Solow-model and investment in human capital (education) are included, the sign on b is negative, but insignificant. Investments prove to be an important determinant for productivity growth. This is an expected result, especially since the Russian economy had been stagnating for many years prior to 1996 and, even though the economy was capital-intensive, the capital equipment used by the firms was not necessarily the most productive. It is reasonable to expect great potential in Russian firms for productivity growth through investments and adoption of already existing technology.

Education is not significant in explaining the regional differences in productivity, even when potential omitted variables are controlled for. Population growth and migration have a negative coefficient as predicted by the Solow-model. Although the variables have high coefficients, the effects of the variables are quite uncertain, and their significance depend on that both variables are included.

FDI is included in the 'neoclassical-model' table (5.2), because it constitutes a part of the total investment share in industry. The variable proves to be significant in most of the specifications. FDI is correlated with other 'catch-up' variables, such as R&D, SME, trade and 'market potential'. According to the 'catch-up' literature FDI is a potential channel for technological transfer, but give such an interpretation of the effect from FDI is rather of ambiguous.

Neoclassical model				
	reg5		**reg6**	
Obs	78		78	
R-squared	0.1184		0.2251	
R-squared adj	0.0701		0.1713	
	Coefficient	**P>|t|**	**Coefficient**	**P>|t|**
lncind	-0.0064	0.4920	-0.0265	0.0210
constant	0.0265	0.5840	0.0827	0.0160
Investments	0.1109	0.0170	0.0601	0.1430
Population growth	-0.9423	0.2250	-0.3957	0.4540
Human capital	0.0019	0.3020		
FDI			0.0021	0.0020
Resources (res)			**0.0007**	**0.0450**

Table 5.2. *The Neoclassical Model. Source: Rosstat, Regional Statistics.*

When FDI is included together with resources, the convergence coefficient becomes significant at the 5% significance level, supporting convergence. Also when we include the combination FDI and trade, the convergence result becomes significant.

Comparing regression reg6 (Tab. 5.2) and regression reg7 (Tab. 5.3) we see that including trade in the regression greatly increases the explanatory power of the model. Together with the regional investments, trade is the most robust variable, explaining a significant share of the variation in regional growth rates. No other factor stands out alone as so important for explaining the variation in the data.

In regression reg8 I have included a set of variables, which could be important for catching-up through technological transfer. Trade and FDI are still significant. Migration is the only of the new variables with significant effect, but the coefficient is quite low. Neither spillover, R&D or SME has significant effect. When replacing spillover with the variable on 'market potential' in the regression, SME becomes significant (reg9), but the coefficient on SME is also quite low. Neither SME nor migration can be considered as very robust, since their significance is sensitive for the combination of variables included in the regression. The low significance of the R&D variable is not surprising, given that the Russian R&D-sector is considered to be highly unproductive and that few innovations have commercial potential (Gianella and Tompson 2007).

The technology gap model						
	R7		**R8**		**R9**	
Obs	78		78		78	
R-squared	0.3335		0.4231		0.3345	
R-squared adj	0.2772		0.3467		0.2680	
	Coefficient	**P>|t|**	**Coefficient**	**P>|t|**	**Coefficient**	**P>|t|**
lncind	-0.0298	0.015	-0.0249	0.049	-0.0249	0.0660
constant	0.0829	0.0000	0.091	0.013	0.1090	0.0030
investment	0.0776	0.039	0.0868	0.0030	0.0822	0.0530
population growth	-0.9031	0.1370				
FDI	0.0015	0.0180	0.0016	0.0210	0.0017	0.0060
trade	0.0829	0.0000	0.0729	0.0000	0.0858	0.0000
Migration			-0.0009	0.0010	-0.0007	0.0000
SME			0.0002	0.1640	0.0004	0.0000
R&D			0.2990	0.1220		
spillover			0.0010	0.1340		
market potential					0.0000	0.0380
resourses	0.0015	0.018	0.0004	0.2800	0.0002	0.5950

***Table 5.3**. The technology-gap model. Source: Rosstat, Regional Statistics.*

The analysis does not support Krugman's hypothesis of divergence and economic agglomeration. The convergence coefficient has in general a negative sign, although it is not significant in all regressions. The variable reflecting market potential proves to be significant in some occasions, but is sensitive for the model specification and is not robust. Migration, which should in the presence of economies of scale have a positive impact on growth rates, generally has a negative sign in the results. The hypothesis of higher growth in regions with large market potential has not been supported.

I also tested whether initial industrial structure could explain some of the differences in growth rates over the period, but no single sector had any explanatory power, and the coefficient were all insignificant. The results from this regression are found in appendix A.5: Empirical results. Ahrend (2002, 2008) found that initial industrial structure, together with natural and human resource endowments are important in explaining regional growth performance[14] before the 1998-crisis, but that initial factors, except resource endowments, are significant less important after. Neither of the industrial sectors, except resource intensive industries, is found significant in explaining regional differences in productivity growth in my analysis[15], which accords with Ahrend's results for the post-crisis period.

The only structural variable that appears to have some explanatory power is the variable reflecting the regional share of resource intensive industry in production. Each of the defined resource sectors (fuel, metals and timber, woodworking and pulp-and-paper industry) shows no significant effect separately, but pooled together they get significant in explaining regional differences in productivity. The results do not support the 'resource curse' argument - the variable shows a positive coefficient. However, this result is not very robust and the significance of the resource variable depends on the variables included in the analysis.

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[14] Ahrend (2002, 2008) used growth in GRP as an indicator on regional growth performance.

[15] We both use the sector divisions supplied by Rosstat; the only difference is that I have merged a few of the sectors.

My results seem to support the hypothesis of conditional convergence predicted by the Solow-model and technology-gap model by Barro and Sala-i-Martin (1997). In addition to initial productivity, of the control variables, investment and trade seem to be most important in explaining the observed differences in regional productivity growth rates. The result do not change substantially, when calculating the average growth rate following Barro and Sala-i-Martin (1991,1992), which implies that the main conclusions of the analysis are not very sensitive for how the average growth rates are calculated.

Comparing the cross-regional analysis with the panel regression

The panel regression supports the result of conditional convergence. Caselli et al. (1996) among others have showed that using a panel analysis instead of a cross-regional tends to increase the estimate of the convergence coefficient. An omitted variable bias tends to underestimate the estimate on the convergence coefficient, but the fact that the analysis are more sensitive to business cycles could also cause an upward bias on the estimates. Since the time period is short, I will not focus on the magnitude of the coefficient, but rather use this regression as a check. The results from the panel regression support my general findings in the conditional convergence analysis. The result from the panel regression is shown in table 5.4.

Panel regression		
Obs	**Regions**	**Year**
	78	8
R-squared	0.8173	
	Coefficient	P>|t|
lncind96	-0.3697	0.0000
constant	0.0593	0.0000

Table 5. 4. *Panel Regression*

5.5 Testing for σ-convergence

Up to now I have focused on what is referred to as β-convergence, or convergence towards the mean. In general there is evidence that initially less productive regions have experienced greater growth from 1996 to 2004, conditional on factors like share of investments in production (national and foreign), openness for trade and large resource industry. However, at the same time, some regions have fallen behind, while other regions have had substantial growth. Analysing σ-convergence I find that the dispersion in labour productivity is largely varying over time. From figure.5.2. we see that the variance on log (labour productivity) does a large jump around 1997, possibly related to financial crisis. The large differences remain in the years after, until dropping around 2001.

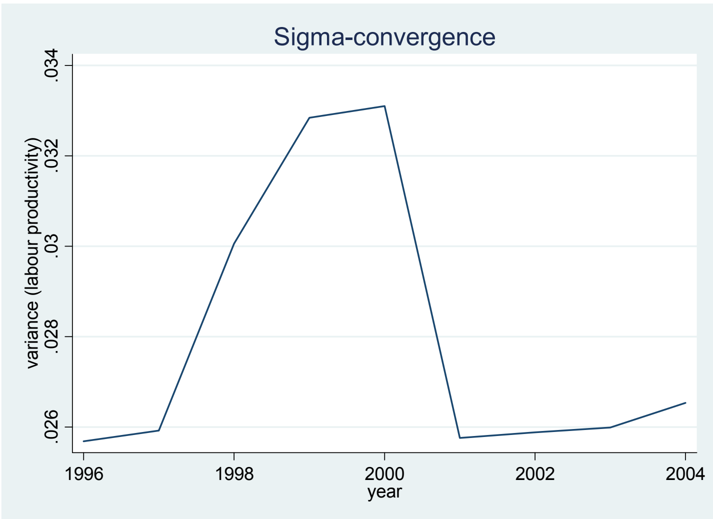

Fig. 5.2. *Sigma-convergence Source: Rosstat, regional statistics.*

The years around the financial crisis were characterized by economic instability and a sharp decline in industrial production. In the years following the crisis industries recovered, and especially regions owing industries, which managed to utilize the opportunities after the finical crises, experienced large improvement in labour productivity. I can not rule out the risk that the conditional convergence pattern is influenced by a shift in the productivity ranking; that some initial less productive regions have by passed initial more productive regions. However, I will contend that my conclusions from analysing β-convergence remain.

Conclusion

In this paper I have analysed the regional development of labour productivity in the Russian industry, defined as oil and gas extraction, electricity production, mining and quarrying and manufacturing, in the years 1996-2004. I have applied the hypothesis of absolute and conditional convergence and I have identified some regional specific variables important for productivity performance.

My results do not support the hypothesis of absolute convergence, but the hypothesis of conditional convergence predicted by both the Solow-model and the technology-gap model by Barro and Sala-i-Martin (1997) is supported. Investment and trade, but also to large extent FDI stand out as the most important factors explaining differences in productivity growth. Assuming that trade and FDI are important channels for international technological spillovers, these findings could be explained, among others, by the technology-gap model.

There is neither tendency for agglomeration among the Russian regions, nor any spatial association regarding productivity levels. Krugman’s hypothesis of economic agglomeration and diverging productivity levels is not supported by the analysis. While the most productive regions shows a clustering pattern around the resource-belt, the regions proving highest productivity growth during the period are scattered around the country.

Differentiated industrial structure across regions has been emphasized as important when analysing regional convergence and is described as a potential barrier for technological transfer. Only the variable indicating the share of resource industry in industrial production prove significant in explaining regional differences in productivity growth. However, having a large resource industry seems not to be neither boosting nor hampering growth in the Russian regions. There is evidence that an extensive resource sector has a positive effect on regional productivity growth, but the results depend on other regional specific factors.

By analysing for σ-convergence I find that the dispersion in productivity level increased sharply right before the financial crisis in 1998 and remained high in the years after until it dropped around 2001. Even though my results seem not to be sensitive to including these years in my average growth estimates, I can not rule out that there has been a shift in the underlying forces working in the economy. Further research is needed to look into these issues in a longer time perspective, especially comparing the period before and after the 1998 financial crisis and the subsequent economic instability.

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A.4

Labour productivity: Top5			
Regions	**Productivity 1996**	**Regions**	**Productivity 2004**
Tyumen	216.080	Tyumen	337.339
Sakha (Yakutia) republic	125.463	Sakha (Yakutia) republic	153.299
Chukotka auton. okrug (10)	70.029	Komi republic (13)	113.205
Krasnoyarsk	60.391	Lipetsk oblast (14)	112.04
Vologda oblast (12)	55.122	Krasnoyarsk	111.536

Table A 4.1. Labour productivity: Top5

Labour productivity: Bottom 5			
Regions	**Productivity 1996**	**Regions**	**Productivity 2004**
Ingush republic	3.838	North Ossetia - Alania	11.417
Dagestan republic	8.639	Altai republic	12.626
North Ossetia - Alania	9.770	Ingush republic	14.917
Adygeya republic	11.386	Dagestan republic	15.364
Altai republic	11.910	Adygeya republic	17.758

Table A 4.2 Labour productivity: Bottom 5

Variable	Mean	Std. Dev.	mean adjusted Std. Dev.[16]	Min	Max	Difference	Median	Lower quartile	Upper quartile
cind1996	31.838	26.758	34,419	8.639	216.080	207.441	19.249	25.601	38.143
cind1997	33.568	27.067	33,022	9.749	225.544	215.795	19.241	28.094	40.962
cind1998	33.255	30.995	38,170	9.219	258.688	249.469	18.609	25.959	38.393
cind1999	35.189	33.459	38,940	7.015	274.901	267.886	20.098	28.747	40.983
cind2000	44.940	43.658	39,785	7.759	354.716	346.957	24.092	36.506	49.855
cind2001	46.652	38.145	33,486	11.039	284.316	273.277	25.063	39.231	53.706
cind2002	44.540	34.814	32,011	11.323	275.350	264.027	24.257	39.052	51.270
cind2003	47.792	42.727	36,613	11.668	361.165	349.496	25.043	41.035	54.081
cind2004	50.807	43.115	34,753	11.417	337.339	325.922	26.006	40.503	56.960

Table A 4.3. **Annual average labour productivity. Source: Rosstat, Regional Statistics.**

[16] Weighted by productivity average over the period as a fraction of the annual average.

Regional average productivity growth	Mean	Std. Dev.	Min	Max	Differanse	Median	Lower quartile	Upper quartile
Average 1996-2004	0.0747	0.05	-0.028	0.231	0.259	0.065	0.044	0.105
ag_ing[17]	0.083	0.091	-0.028	0.752	0.78	0.065	0.044	0.106
g1997	0.068	0.171	-0.577	0.482	1.059	0.048	-0.019	0.168
g1998	0.017	0.377	-0.561	2.819	3.380	-0.060	-0.124	0.076
g1999	0.059	0.225	-0.601	0.841	1.442	0.047	-0.082	0.170
g2000	0.288	0.305	-0.094	2.015	2.109	0.224	0.093	0.369
g2001	0.097	0.205	-0.344	1.089	1.433	0.084	-0.032	0.208
g2002	-0.028	0.174	-0.580	0.494	1.074	-0.036	-0.099	0.086
g2003	0.089	0.252	-0.173	2.009	2.181	0.055	-0.022	0.139
g2004	0.062	0.170	-0.365	0.536	0.901	0.031	-0.058	0.175

Table A. 4.4. Annual average growth

Top10		Bottom10	
Region	**Avg. growth**	**Region**	**Avg. growth**
Ingush republic	0.1508	Omsk oblast	-0.0891
Sakhalin oblast	0.1288	Evrei autonomous oblast	-0.0357
Arkhangelsk incl. Nenets	0.1223	Ulyanovsk oblast	-0.0153
Astrakhan oblast	0.1210	Orenburg oblast	-0.0082
Saint-Petersburg	0.1166	Kamchatka incl. Koryak	0.0017
Moscow oblast	0.1130	Volgograd oblast	0.0048
Lipetsk oblast	0.1115	Altai republic	0.0065
Komi republic	0.1108	Bashkortostan republic	0.0100
Magadan oblast	0.1060	Altai krai	0.0105
Kursk oblast	0.0797	Tuva republic	0.0109

Table A. 4.5. Top and Bottom 10

[17] ag_ing is the estimate on average productivity including Ingush republic.

A.5:

Cross-regional analysis

Table of control variables

Code	Variable name	Description	Comment	Year
ag	Average growth	$ag_i = \frac{1}{8}\sum_{t=1997}^{2004} g_{i,t}$ i=regions, t=time	$g_{i,t}$ is the regional yearly growth rates	1997-2004
lncind	Labour productivity	Log value-added industrial production/number employed in industry		1996
sinv	Investments	Industrial investment/ value-added industrial production		1996
n	Population growth			1997
prof	Human capital	Number employed with bachelor degree or higher		2000
sfdi	FDI	FDI as a share of GRP: $sfdi_i=fdi_i/GRP_i$	US$	1996
strade	Trade	Total trade as a share of GRP: $strade_i=(import_i+export_i)_i/GRP_i$	US$	1997
totmig	Migration	Net number of migrants	Measured in 1000	1996
smig	Migration share	Net number of migrants as a share of the regional population		1996
wsme	SME	Formation of SME weighted by the relative size of the regional economy: $wsme_i = \frac{\bar{y}}{y_i} \cdot sme_i$	$\bar{y}$: regional average GRP	1996
mp	Market potential	$mp_{1996,i} = \sum_{j \neq i} \frac{GRP_{1996,j}}{d_{1996,j}} + GRP_{1996,i}$ [18]		1996

[18] For a closer description see below.

res	Resources	resources=(fuel + metals [19] + timber, woodworking and pulp-and-paper industry)/ value-added industrial production		1997
srd	R&D	number employed in R&D related activities/total number of employees		1996
spillover	Spillover	$spillover_{1996,i} = \sum_{j \neq i} \frac{cind_{1996,j}}{d_{1996,j}}$	$cind_j$ is productivity in region j	1996

Table A.5.1: *Variables used in the analysis. Source: Rosstat, Regional Statistics.*

Industry sectors

I use the classification given by Rosstat. The sectors marked with *are merged from the original classification. The variables are measures as share of value added in the industry sector in total.

Code	**Industry sectors**	**year**
el	Electricity production	1997
fuel	Fuel industry	1997
metal	Metal extraction and production: ferrous + non-ferrous metals*	1997
petchem	Chemical and petrochemical industry	1997
machmet	Machine-building and metal cutting industry	1997
timbcell	Timber, woodworking and pulp-and-paper industry	1997
light	Light industry	1997
constcer	Constructions materials + ceramic and porcelain production*	1997
foodgrain	Food processing + grain and animal food industry*	1997

Table A.5.2: *Industry sectors used in the analysis. Source: Rosstat*

Market potential

I will use a weighted sum of all Russian regions` GRP, including region i`s GRP, as an indicator on region i`s ‘market potential’ (mp). The weight are based on the other regions

[19] Metals incl. ferrous and non-ferrous metal production.

distance to region i, such that GRP in regions far away will have little influence. The formula for mp_i can be expressed as follows (A.5.1.):

A.5.1. $$mp_{1996,i} = \sum_{j \neq i} \frac{GRP_{1996,j}}{d_{1996,j}} + GRP_{1996,i} \quad \forall i$$

The distance is calculated utilizing the regions latitude and longitude degrees (latd and latm) and minutes (latm and lonm). These can be converted into decimal degrees (lat and lon) by the following formulas:

$$lat = latd + \frac{latm}{60}$$
$$lon = lond + \frac{lonm}{60}$$

“lat” and “lon” are further converted into radians:

$$\left.\begin{aligned} X_i &= (90 - lat) \times \frac{\pi}{180} \\ Y_i &= lon \times \frac{\pi}{180} \end{aligned}\right. \quad \forall i$$

The variables X_i and Y_i are used as inputs in an arc distance computation, which generates the distance between the regional centres:

$$dist = 3959.0 \times \arccos\left\{\cos\left|Y_i - Y_j\right| \times \sin X_i \times \sin X_j + \cos X_i \times \cos X_j\right\} \quad i \neq j$$

Missing values

The price index for Chukotka

The 1997 observation on the industrial price index for Chukotka autonomous okrug ($P_{ind,chukotka}$) is missing.. Since I will keep Chukotka autonomous okrug in my sample I will extrapolate a value for $P_{Ind,chukotka}$ in 1997 ($P_{Ind,chukotka,1997}$). There are several ways to do this. Because of the large fluctuations in prices over time, observations on price indexes for later years do not necessarily reflect the price level in 1997. The industrial price index for Chukotka seem to follow the consume price index for Chucokta ($CPI_{chukotka}$). By regression I found that the first lag of $CPI_{chukotka}$ best explains the variation in $P_{ind,chukotka}$ over the period 1998-2004. Based on the coefficient from this regression (tab. A.5.3.) and the observations on $CPI_{chucotka}$ in 1996 I can calculate $P_{Ind,chukotka,1997}$.

1.lag Consum Price Chukotka				
	Coefficients	*Standard Error*	*t Stat*	*P-value*
Intercept	67,0101416	17,09074599	3,920844	0,011173
123,6	0,40066902	0,12984738	3,085692	0,027293

Table A.5.3.: Estimates Price Index Chukotka, source: Rosstat, Regional Statistics.

Using the numbers from the regression in tab.A.5.3. the calculation of $P_{Ind,chukotka,1997}$ can be expressed by equation A.5.2.:

A.5.2. $$P^{1997}_{ind,chukotka} = 67{,}01 + 0{,}401 * P^{1996}_{cons,chukotka}$$

Employment data

Total employment in the industrial sector is calculated from the reported share of employment in the industry (oil and gas extraction, electricity production, mining and quarrying, and manufacturing industry) times the total regional employment. Observations for the industrial employment share are missing for 1996. They are not included in the statistics I have become from Rosstat. The time series includes the years 1995 to 2004 except 1996. To construct a measure of industrial productivity I need a full time series of the employment in the industry. Since I have observations on the employment share in 1995 and 1997 I can replace the missing observation on 1996 by the average of 1995 and 1997 employment share. For Chukotka is also the observation on total employment in 1996 missing. I replace the missing 1996 observation with data on total employment in Chukotka in 1997, adjusted for the regional average fall in employment from 1996 to 1997[20].

Data on industrial structure

Several observations are missing on the share of different industry sectors in. How many observations, which are missing varies from sector to sector. The electric power industry, machine-building and metal cutting industry, timber, woodworking and the pulp-and-paper industry, building materials industry, the light industry and the food industry have none or almost non missing values, while the ceramic and porcelain industry has almost half of its values missing.

The main reason that observations are missing for a sector is either that the sector do not excist or only constitute a marginal share of the region's industrial production. The ceramic and porcelain sector are very small also on national level. Also the resource sectors, especially the fuel and metallurgy industry, have a significant amount of missing values. This is mainly because resource intensive production is largely concentrated in a few regions having large natural resource endowments. Since I am interested in the effect of regional specialization, missing values for sectors, which in general only constitute a small share of the total regional production, are not critical, even though the amount of missing values is significant for certain sectors. To control for initial industrial structure I use observations for 1997 when analysing growth in the second period. Since the industrial structure does not change significantly from 1997 to 1998 I have replaced the missing values for 1997 observations from 1998, when they exist and zero for the rest.

[20] The average regional employment is approximately 20% higher in 1996 than in 1997.

Correlation table

	ag	lncind	sinv	n	education	smig	migration	sfdi	strade	wsme	mp	spillover	srd	res
ag	1													
lncind	-0.0371	1												
sinv	0.2604	0.006	1											
n	-0.0861	-0.2559	0.2496	1										
prof	0.1269	-0.1936	0.1742	0.3816	1									
smig	-0.0706	-0.3311	0.0312	0.9296	0.3081	1								
totmig	-0.1001	-0.0133	0.0308	0.4544	0.5568	0.4414	1							
sfdi	0.3367	0.0732	0.1417	-0.1095	0.2274	-0.1384	0.2697	1						
strade	0.3663	0.2457	0.0845	0.1868	0.2837	0.1305	0.275	0.1907	1					
wsme	0.2417	-0.1184	-0.0617	0.0782	0.5092	0.1072	0.1243	0.0828	0.1604	1				
mp	0.066	0.3058	0.0453	0.3023	0.402	0.2779	0.7202	0.4093	0.3032	0.1296	1			
spillover	0.2081	-0.077	-0.1099	0.1984	0.4266	0.2652	0.5119	0.4461	0.2313	0.386	0.7665	1		
srd	0.0346	0.0774	-0.1417	0.2881	0.6546	0.2921	0.8197	0.3232	0.3001	0.3865	0.6754	0.5447	1	
res	0.1618	0.6535	0.2594	-0.2072	-0.3072	-0.3121	-0.2208	-0.0534	0.2811	-0.1957	0.0713	-0.169	-0.2403	1

***A.5.4.**: Correlation table. Source Rosstat, Regional Statistics.*

Empirical results

Empirical results

Testing for absolute convergence

Including dummies for outliers

Absolute convergence		
Obs	79	
R-squared	0.6433	
	Coefficient	P>|t|
Incind	0.0000	1.0000
constant	0.0747	0.0560
d_Ingush	0.5731	0.0000
d_Sakha	-0.0410	0.0710
d_Tyumen	-0.0048	0.8680

Table 5.5. *Absolute Convergence. Source: Rosstat*

Testing for convergence among the 1/3 least productive

	Absolute convergence bottom 1/3			
	with Ingush		**Ingush dropped**	
Obs	79		78	
R-squared	0.4911		0.0033	
	Coefficient	P>|t|	Coefficient	P>|t|
Incind96	-0.22882	0.0440	0.0098	0.6990
constant	0.716862	0.0260	0.0496	0.4540

Table 5.6. Absolute Convergence bottom 1/3. Source Rosstat

Testing for absolute convergence in the two periods up to 1998 and after

Absolute convergence 1996-1998				
Obs	with Ingush 79		Ingush dropped 78	
R-squared	0.0996		0	
	Coefficient	P>|t|	Coefficient	P>|t|
Incind96	-0.1024	0.27	0.0001	0.994
constant	0.3773	0.235	0.0251	0.703
Absolute convergence 1999-2004				
R-squared	0.0104		0.0003	
	Coefficient	P>|t|	Coefficient	P>|t|
Incind96	-0.0118	0.4580	0.0017	0.8670
constant	0.1336	0.0190	0.0847	0.0130

Table A..5 7. Absolute Convergence in 1996-1998 and 1998 – 2004.
Source Rosstat, Regional Statistics

Robustness test of my results

Regression: data deflated by the regional consum price index (CPI)				
Obs	with Ingush 79		Ingush removed 78	
R-squared	0.0100		0.0407	
	Coefficient	P>|t|	Coefficient	P>|t|
Incind	-0.0130	0.6900	0.0220	0.0750
constant	0.1181	0.2850	-0.0018	0.9630

Table A. 5 8. *CPI Regression. Source: Rosstat, Regional Statistics.*

Testing for conditional convergence

Testing the importance of differentiated industrial structure

Industrial structure		
Obs: 78	A3	
R-squared	0.1857	
R-squared adj	0.0500	
	Coefficient	P>|t|
Lncind	-0.0139	0.3700
Constant	-0.0517	0.8790
sinv96	0.1123	0.0780
El	0.0015	0.6530
Fuel	0.0016	0.6330
Petchem	0.0014	0.6640
Machmet	0.0015	0.6370
Timbcell	0.0035	0.3270
Light	0.0016	0.6450
Metal	0.0017	0.5990
Constcer	-0.0004	0.9090
Foodgrain	0.0015	0.6730

Table A.5.9. *Industrial Structure. Source: Rosstat, Regional Statistics.*

Additional regressions on conditional convergence

Conditional convergence				
Obs: 78	A1		A2	
R-squared	0.2182		0.3696	
R-squared adj	0.1639		0.3066	
	Coefficient	P>|t|		
Lncind	-0.0163	0.2330	-0.0273	0.0240
Constant	-0.0107	0.8120	0.1127	0.0020
investment share	0.1414	0.0120	0.0610	0.0310
population growth	-4.2616	0.0050		
education (prof)	0.0032	0.0850		
migration share	3.0674	0.0160		
FDI			0.0018	0.0020
Trade			0.0869	0.0000
Migration			-0.0007	0.0000
market potential			0.0000	0.0350
Resourses	0.0007	0.0830	0.0003	0.5060

***Table A.5 10**. Conditional Convergence. Source: Rosstat, Regional Statistics.*

Robustness test: Using Barro's and Sala-i-Martin's growth rate

I have here calculated the growth rate following the method used by Barro and Sala-i-Martin (1991,1992).

	BSM1		BSM2		BSM3	
Obs	78		78		78	
R-squared	0.0024		0.1069		0.2941	
R-squared adj			0.0580		0.2007	
	Coefficient	P>|t|	Coefficient	P>|t|	Coefficient	P>|t|
lncind	-0.0038	0.5980	-0.0063	0.4320	-0.0224	0.0480
constant	0.0663	0.0050	0.0272	0.5120	0.0819	0.0120
investment share			0.0953	0.0100	0.0710	0.0060
population growth			-0.6685	0.2660		
education (prof)			0.0011	0.4760		
FDI/GRP					0.0013	0.0070
trade/GRP					0.0302	0.0990
Migration					-0.0007	0.0060
SME					0.0002	0.1080
share employed in R&D					0.2011	0.3070
market potential					0.0000	0.0430
resourses					0.0003	0.3800

Table A. 5 11. *Regression using Barro and Sala-i-Martin growth rate. Source: Rosstat, Regional Statistics.*