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Do Institutions Matter for Technological Change in Transition Economies? The Case of the Russia's 89 regions and republics

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Abstract

We explore the impact of institutions on technological change in a transition economy. We use regional panel data for Russia's 89 regions and republics during the period of recovery and growth from 1998 to 2004 to show the impact of institution building in transition. The degree of institutional reform ranged from full enforcement of property rights in the Northwest to red belt Communist regimes in the southeast. We find an unambiguous relationship between strong and sustained institutional development and technological change. We provide a model proxying the quality of institutions by the investment risk rating compiled by the rating agency ExpertRA Regions.

Keywords: Institutions, technology change, Russian regions

JEL Classification: O33, O17, O18

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I. Introduction

This paper explores the impact of institutions on technological change using data for the Russian Federation's 89 regions for the years 1998 through 2004. A large empirical literature, inspired by Commons (1950), Knight (1952), Coase (1960), Davis and North (1971), North (1990, 1991 and 1994), establishes the importance of formal institutions for economic performance. Stable and effective market institutions encourage sustained investment in physical and human capital and better technologies (Acemoglu, Johnson and Robinson, 2002; Acemoglu, 2003). Effective institutions provide stimuli to technical change (North and Wallis, 2004; Nelson (2002). Economic institutions are thought to co-evolve with technologies, reinforcing over decades or centuries a technological regime. Their persistence is due to the embeddedness of informal institutions in culture. This embeddedness leaves considerable doubt that new formal institutions can be exogenously installed without fatal resistance (Shirley, 2005). In this paper we show for one transition country the power of a "critical juncture", a term used by historical institutionalists theoretically to describe decisive periods for institutional transformation (Greif, 2004; Pierson and Skocpol, 2002). We show for Russia, where transformation has been a region-by-region process, the significance of early adoption of market institutions in some regions and the general significance of market institutions and some of the consequences in those regions where federal laws and norms fail to be adopted and/or

enforced. Regions with effectively functioning institutions can be identified by the technological change that has accompanied political transformation.

Transition institution switching—that is, market institution building—has attracted little theoretical study by institutionalists or development specialists. [1] Yet market reforms succeeded on a large scale in Central and parts of Eastern Europe in reordering the institutional regime built on state ownership and administrative command. Communism in Central and Eastern Europe (CEE) lost its vitality and legitimacy in a simultaneous political and economic swivel.

The Russian experience was particularly harsh in that the struggle to beat inflation was prolonged, and society suffered severe welfare consequences. To the challenges faced by all transition countries was the additional task of creating a federative structure and determining the appropriate amount of regional autonomy. There was considerable local resistance to market reform, splashing the political map with large areas of unreformed institutions in part because of the initial attempt to decentralize authority as much as possible. The weight pulled by new market institutions in parts of Russia increased rapidly, showing institutional persistence over time (Leonard 2005). In unreformed regions, possibly showing the resilience of communist informal institutions, signs of economic weakness—low investment and dependence on federal budgets—tended to vary. The gap between regions widened (Solanko, 2003).

Our data, described below, provide a unique opportunity to measure with almost laboratory precision the degree of association between institutional development and technological change among the 89 different regions over time. Our measure of institutions, investment risk, does not allow us to distinguish between

[1] Durlauf and Quah (1999) review the large quantity of empirical papers on the effect of non-linearities and distributional dynamics on growth, arguing that the theory that incorporates institutional factors is still in its infancy, noted also by Sala-i-Martin (2002).

formal and informal rules. However, it does allow a proxy measure for adoption and enforcement of federal level legislation, reassessed annually. The early strengthening of this critical component of institutions pushed some regions permanently into the top (lowest) category of risk premium, but there were shifts throughout the lower rankings that created considerable variation over time, and these can be associated with annual data on technological change.

Our proxy for institutions accords with the familiar meaning of the term. Effective market institutions make human interactions predictable in product markets, which lowers transaction costs and makes an economy more productive (Menard and Shirley, 2005; Nelson and Sampat, 2001). Formal institutions are rules, supported by social convention, encouraging activities based on trust and cooperation and constraining or ruling out actions that, if widely practiced, would undermine property and individual rights (North, 1990). Institutions are both formal rules, as in constitutions, regulations and laws, and informal, as in mores and conventions.

Technological change, like institutional change, is generally "evolutionary".[2] The importance of technological change as a determinant of economic growth has been amply documented in the literature, going back to the Solow growth model and others, and as evidenced by Grossman and Helpman (1997).

We are unaware of any other work that has specifically tested the impact of institutions on technological change at the regional level, and assessed the extent of regional diversity beyond 2001, when the Russian economy was just entering its full recovery trend. Several papers look at the institutional and economic diversity in Russia's regions for the previous period. Among them are Berkowitz and DeJong (2003, 2005), Ahrend (2005), Mikheeva (1999) and Popov (2001, 2002). Desai,

[2] For co-evolution of "social technologies" with physical technologies, see Nelson and Sampat (2001). See also, Desierto (2005).

Freinkman and Goldberg (2003) contribute to this discussion in assessing the link between output recovery and fiscal policy.

In this paper, we examine economic factors once a steady rate of growth began to be realized. With a new set of data for the period after recovery and under growth conditions through 2004, we get strong results. If for the period before 1998, regional product estimates are unreliable, after 1998, they conform to international standards of reliability. We avoid, however, making regional product the dependent variable. We strengthen and clarify the focus of what we mean by impact by choosing a proxy that is unambiguous, technological change. To test the impact of variation in the quality of institutions, the specific test of technological change can reveal the presence or absence of that impact much better than some general measure of economic performance—we have far fewer variables to control for and they allow us a more precise focus.[3] Here, we do not aim contribute to an understanding of exactly how institutions stimulate technological change or to the debate about how technological policy or investment strategy actually works.[4] Our assessment of the way in which institutions affect technological change is based on general predictability in the environment.

The period covered, 1998-2004, saw the beginnings of strong recovery from a decade-long post-Soviet recession. The potential for technological change was a strong inheritance of the Soviet period, and while damaged by that recession, it nevertheless survived. A combination of greater stability and macroeconomic stabilization on the back of sounder monetary and (especially) fiscal policies, provided a fertile environment for an innovative economy. The federal institutional

[3] Sala-I-Martin, Doppelhofer and Miller (2004) note that growth theories are not explicit enough about what variables belong in the true regression. Another indication of the many variables found to be significantly correlated with growth, is that these authors found 67 variables.

[4] See Skinner and Staiger (2005) for a review of the literature explaining how technological innovation can be fostered.

framework was improved, mostly to western standards. National data turned strongly positive, with annual growth in real GDP between 1999 and 2004 averaging roughly 6.6 per cent (OECD 2005). The cost of capital fell rapidly, as reflected in the three leading international credit rating agencies' promotion of Russia's sovereign rating to investment grade. Foreign direct investment took off from 2005.

Against this positive national backdrop, Russia's 89 regions – with their widely diverging levels of institutional development and impacts – comprise a unique source of data. Our database allows an exacting measure of the degree to which predictability has been achieved. Our measure of technological change — expenditures on technological innovation and research—are taken from R&D statistics for all component parts of the federation and are new to the literature on Russian regional performance and institutions. For our measure of institutional development, we followed Leonard (2005) in adopting the regions' "investment risk" ranking, a variable for the investment climate developed by the Ekspert RA (Ratings Agency) as indicative of the level of local protection of property rights, and observance of federal laws and regulations. Founded by *Ekspert*, the Russian business and financial weekly[5], the agency is an authorized agent of the Central Bank of Russia and the Federal Securities Commission for the disclosure and dissemination of information on banks, financial institutions, insurance companies and issuers of securities. The ratings for investment potential and investment risk have been issued from 1996, and they are based on a series of indicators, discussed below. Other control variables are measured using equally comprehensive sources – economic statistics covering each of Russia's regions.

[5] *Ekspert* is a Russian language weekly that provides news, including the latest index and exchange rate figures, and feature length articles on business, finance and economic issues. It also includes a number of 'specials' or overview reports focusing on, for example, particular sectors or trade with particular countries.

The paper is arranged in six sections, including this Introduction. The immediately following Section II begins by explaining why Russia's transition constitutes a valid and useful case for the study of the importance of institutions for technological change. Section III maps regional divergence. The next Section (IV) examines the data and adjustments. In Section V, we analyse the empirical evidence. We document the effect on R&D investment of variations in regional application of federally-driven reforms (federal laws and other institutional measures). Section VI summarizes the conclusions.

II. The Environment Fostering Institutional and Technological Change

It is increasingly agreed that cultural norms and behavioural conventions play a powerful role in the reproduction of institutions.[6] Cultural receptiveness lowers the costs in switching and reduces the risk of political challenge (North, 2004; Shirley, 2005; Greif and Laitin, 2004, p. 635). In Russia, there is clear evidence of the spread of a profit-making mentality well before the fall of the Soviet regime in interviews carried out by the Harvard Interview project.[7] Also, effects of liberalization during Perestroika from 1985 to 1991 widened the set of permissible beliefs and to some extent discredited the communist approach to economic and social problems. Regions where market institutions were accepted early in the 1990s, therefore, probably "switched" culturally before some of the more communist regions in the "red belt". The growing attraction to economic decentralization and market liberalism was by no means limited to the central cities, but the regions which have sturdier institutions are those in the urbanized areas of the Northwest, Urals, and Siberia.

[6] See Nelson and Sampat (2001), p. 35.
[7] For the Harvard Project on the Soviet Social System (interviews carried out between 1951 and 1953), see http://daviscenter.fas.harvard.edu/research_portal/emigre.html.

The laboratory potential of such marked variations in institutional development between regions is well suited to a study of the correlation with technological change, given the natural tendency of technology to regional concentration.[8] Knowledge intensive industries at the high end of production are affected by global markets, by regional competition for relatively mobile factors of production and by local externalities, as pointed out in the key theoretical works (Marshall, 1920; 1927; Krugman, 1991; Nelson and Winter, 1982). At the low end of the market, such regional agglomeration effects are much weaker (Cowan and Cowan 1998, p. 205).These effects can accumulate quickly. The rate of innovative activity forms a dynamic, dramatically increasing with firm entry and firm growth.[9]

A. Technological Trajectory

Our assessment of the impact of institutions on technological change would be of limited usefulness in an environment where other preconditions for innovative activity are lacking. Some barriers to innovative activity mentioned by Watkins (2003) are weak domestic demand for domestically produced technologically advanced equipment; management and strategic planning skills in Russian firms to develop commercial connections with western firms; and emigration of graduates of higher technological institutions.[10] These and other components of the environment for technological change divide into two broad categories: (I) scientific and technological potential and (II) a growing economy, especially as regards domestic demand. We find that in our period of study, weaknesses in both areas were greatly diminished.

[8] See a review by Baptista (1998) of the literature conceptualising innovative potential as an evolutionary economic process of learning that is powerfully affected by geographic factors.
[9] However, following the emergence of a regional concentration, further growth of innovative activity depends on the industry life cycle, and innovative activity may lose its regional attractor quality when the industries do, because of cost disadvantages of congestion and intense competition (Swann 1993).
[10] Watkins (2003), p. 2-7.

Russia's scientific and technological potential was enormous as the transition began. It had the largest digitalized science database in the world, and a huge scientific establishment. However, the Communist legacy was one of state-funded R&D, largely through military-related programmes which enjoyed privileged resource allocation and were accordingly slashed after the collapse of the Soviet system. Reflecting the large share of the state in total R&D expenditure, this indicator (Gross Domestic Expenditure on R&D, GERD) fell dramatically from 2.03 per cent in 1990 (the last full year of the Soviet Union's existence) to 0.77 per cent in 1993.

Overall, post-Soviet Russia's innovative performance has been relatively weak. Innovation has been concentrated in three sectors, machine building, chemicals and food processing, with telecommunications and other services catching up.[11] Russia's export structure is dominated by raw materials, and its share of world exports of high technology products is only 0.3 per cent.[12] Trends in patent applications in Europe show Russia (583) to be roughly in the category of Spain (696) in total applications, and Russia (8) can be grouped with Portugal (6) in patent applications per million of labour force.[13]

However, these constraints on Russia's technological trajectory eased over time. With improved trends after 2000 and rising demand, Russia's past investment in science and technology infrastructure (research capability, technically educated work force, and technical higher education institutions) bore new fruit.[14] GERD recovered to 1.28 per cent in 2003, roughly the same as for the Czech Republic (1.26), but well

[11] Gokhberg and Kuznetsova (2004), p. 7, showing that up to 25% of firms in the three core innovative sectors conducted R&D and over 15% of firms in new service sectors by 2002.
[12] Watkins (2003), p. 1, who cites a background report prepared by the Ministry of Industry, Science and Technology for the Helsinki seminar on Innovation Policy and the valorization of Science and Technology in Russia (12 March 2001), paragraph 3.
[13] Gokhberg and Westholm (2002), pp. 73-75.
[14] Watkins (2003), p. 3.

below the OECD (2.24 per cent) and US (2.6 per cent).[15] The number of industrial firms performing R&D – rising from 5-6 per cent during the period 1995-1999 to 10 per cent in the period 2000-2004 – likewise remained well below the EU, whose average is 47 per cent; but the accelerating growth rate was a positive change.[16]

B. Proxy for Russia's Institutions

Suitable for comparisons with existing studies, the proxy we choose for institutions conforms in its components to the numerous variables that have been found to correlate with per capita income growth in developed countries (Aron, 2000).[17] The Expert RA investment climate survey is based on a large variety of indicators covering the key institutional variables, including the legislative base. That base comprises the main reform achievements of successive governments during the early transition period. The key areas are:

- legal protections for property rights, from the Basic Law (Constitution) of 1993 and Civil Code of 1994 to the appearance or reliable real estate cadastres and the strengthening of creditor and shareholder rights;[18]
- corporate transparency, including the use of international accounting standards and improved disclosures;
- a range of structural reforms, notably in taxation (simplification and reduction in rates), but also covering factor markets (Land and Labour Codes), state

[15] OECD Main Science and Technology Indicators, Online services, 2005.
[16] Gokhberg and Kuznetsova (2004), p. 6.
[17] They include protection of property rights and enforcement of contracts, civil liberties, political rights and democracy, political instability, institutions fostering cooperation and trust.
[18] The single most important regulatory improvement was a thorough reworking of the existing Law on Joint Stock Companies, with amendments coming into force in January 2002. The Transition Report from the EBRD (2005), pp. 24-30, compares transition countries, showing that even some of the EU entrants (Estonia) have difficulty with enforceability of minority shareholders' rights, and most need to upgrade further their commercial regulations.

controlled energy and transport utilities, pensions, exchange and currency control liberalization, and the judiciary.

Through 2004, the law remained weak in protection of intellectual property, although by 2006, after the years covered in this paper, protection had been considerably strengthened. Laws were amended to make innovators the owners of patents which they acquire as a result of R&D financed from the state budget.[19] The critical problem is the enforcement of existing IP law rather than the need for new law.[20] Because of its relatively weak enforcement, we do not use a variable specifically identified as the protection of intellectual property (IP).

In fostering technological change, IP is important in advanced economies. We note, however, that using IP protection to assess the investment in and diffusion of technology can actually be misleading, given that our measure of technology output does not use unembodied indicators, such as patents and licences. We also observe that the degree of protection that promotes investment in technological change is by no means clear from empirical research and remains controversial (Baldwin, 1996; Kanwar and Evenson, 2003; Lerner, 1994; and Schankerman, 1998; Smarzynska, 2004). For example, Chin and Grossman (1990) show that only when R&D productivity is large, will the protection of intellectual property encourage the incentive for R&D investment. For all these reasons, we use technological change as our dependent variable.

[19] See Shapalov and Voronov (2004), p. 15.
[20] "Parlamentskaia gazeta", No 1324(195), published 21.10.03. See the amendments to the Patent Law of the Russian Federation, 23 September, 1992, #3517-I, changes and amendments, 7 February 2003, Federal Law #22-FZ, in force as of 11 March 2003.

III. Regional Divergence

The mapping of regional divergence follows the asymmetric, or peripheralized, federalism adopted by the federal government under Boris Yeltsin regime which, to prevent regions leaving the federation, granted large concessions in the Federation Treaty of 1991 when the Soviet Union fell apart (Lapidus, 1999; Shleifer and Treisman, 2000).

While the quality of Russia's overall institutional framework is determined by federal policies, the potential of institutional reforms initiated by the federal government to deliver economic benefits depends to a considerable extent on how far those institutional reforms are implemented and enforced at the regional level. There are some important exceptions to this. For the key natural resource sectors, the institutional and regulatory framework created and run by the federal centre became decisive during the Putin presidency, regardless of action or inaction by regional authorities. Outside the natural resource and some other major sectors, however, the economic impact of institutional reforms will depend more on their implementation in the regions.

There has been considerable variation in economic performance across Russia's regions. These variations exist against a positive backdrop: most regions experienced some growth since 2000, and conditions for investment and innovation clearly improved across the country (on average, 79 to 80 regions experienced steady improvement in investment rankings over the period 2000 to 2003).[21] But the notable variations in the degree of these improvements from one region to the other create the

[21] EkspertRA (2005).

basis for our study of the extent to which enforcement of federal institutional reforms, including property rights, can account for such variations.

A Divergence in Institutions

The Yeltsin government allowed diversity to the point of sovereignty, and concluded separate treaties[22] with special fiscal arrangements to appease potentially troublesome regional governments (Treisman, 1999). Some regions and republics failed to permit land sales or decontrol prices; some refused to privatize large state enterprises. Some regional governments failed to pay wages at state owned firms and met production expenses by transfers negotiated from the federal budget. Rent-seeking authorities in some regions captured state assets. Although, the Constitution of 1993 fell short of endorsing the full autonomy granted by the Federation Treaty, it still provided for "joint federal and regional competence" in various areas, two of which – trade and property rights – are particularly relevant to this study. This joint competence gave regional governments discretion in the adoption of market institutions. Their decisions governed licences and product registration, and the preferences of regional leaders affected the behaviour of regional departments of federal agencies. Regional differences began to diminish somewhat after a vigorous effort by Putin to recentralize government and harmonize laws. However, regional authorities retained considerable power over policy implementation by their control over the branches of federal agencies in the regions (OECD, 2005).

[22] Almost half of the 89 regions and republics (21 republics, 6 territories, 49 oblasts, 2 cities of federal importance, one autonomous oblast', 10 autonomous areas [okrugi]) concluded treaties.

The overall picture of regional variation in institutional development is one of few leaders and many laggards.[23] The divergence among Russia's regions is well known: "islands of core in an ocean of periphery" (Treyvish, 2005). The enforcement of property rights is weak in most regions. 79 per cent of all foreign investment in 2004 went to 10 regions of the Russian Federation.[24] Through 2004, many regions continued to violate federal laws, presumably reflecting lack of demand for these laws.[25] Elites in many regions have not yet behaved as they historically do, demanding formal property rights for the benefit that clarity, transparency and enforceability provides in exchange.[26] Regional government weakness and dependence on federal transfers have also reduced demand among firms and the general populace. There is continued demand for welfare benefits and for redistribution via soft budget constraints, which benefit elite managers of state enterprises.[27] Problems of enforcement of property rights are not limited to the regions, and there has been concern over the level of state intervention during Putin's second term.[28] However, we end our study before his second term begins (2004), and we concentrate on variation among regions rather than national aggregates.

Persistent regional diversity is illustrated in Table 2 (the "Institutional Potential" rankings for the period 2004 to 2005). *Expert* has two investment assessment categories: risk and potential. As can be seen, Moscow and St Petersburg, Moscow oblast and Smolensk, have achieved the highest rank. We illustrate the overlap in this survey with rankings for innovation in Figure 1, a plot of regions by

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[23] The leaders are the two central cities, Moscow and St Petersburg—both of which are subjects of the Federation; Belgorod, Novgorod, Iaroslav, Nizhegorod, Kaliningrad, Moscow and Krasnodar oblasts; and the Republic of Tatarstan.

[24] "Struktura innostrannykh investitsii po vidam ekonomicheskoi deiatel'nosti v 2004 goda," 31 July 2005, *Statisticheskii Biuleten*', no 5, Table 2.

[25] Berkowitz, Pistor and Richard (2000); Pistor et al (2003).

[26] Demsets (2002); Libecap (1989); Alston et al (1999).

[27] Polishchuk and Savvataev (2004), p. 104.

[28] For a review of the state of property rights in Putin's Russia, see issue 6 of *Eurasian Geography and Economics*, 2004, which contains articles by Anders Aslund, Marshall Goldman and Philip Hanson.

institutions and innovative potential, with leaders shown in the lower left corner, including Yaroslav, Novgorod, the cities of Moscow and St Petersburg, Kaliningrad, Belgorod, Leningrad Oblast' and the Republic of Tatarstan. The ones with weak market institutions, which are also the ones receiving large transfers from the federal budget, are in the majority (Leonard, 2005).

B. Divergence in Regional Conditions

Regional variations in growth are similarly wide and the gap between the better-off regions and the poorest regions is large and not converging (Solanko, 2003). By quintile, 53 out of 89 regions (60 percent) were in the lowest brackets of per capita income in 2003. These 53 received on average 23 percent of their budget in transfers from the federal government.

Two regions form the top per capita income quintile—Moscow city and Yamalo Nenets in the Urals—and they receive less than 2 percent of their budget in federal transfers.[29] In deciles, the top 10 percent exceeded the bottom 10 percent by 15 times.[30] Moscow city nominal per capita income in 2004 is almost twenty times that of the income of the poorest sub-national unit and almost five times that of the average for the regions.[31] Moscow city has double the average number of university graduates in the working age population of Russia. Two of Russia's seven federal districts (the broad groupings of regions introduced by Putin as part of his centralisation campaign in 2000) – the central and Urals okrugs – gradually increased their share of regional product in a steady development.[32] The concentration of regional product is shown in Table 3.

[29] The data are from Goskomstat, *Statisticheskii Ezhegodnik*, provided by EastView publications.
[30] Russia Economic and Development Trade Ministry (2004).
[31] Goskomstat (2004).
[32] Ahrend (2003).

Regional differences in economic performance can of course be explained by several factors in addition to variations in institutional development. The most important additional factors are natural resource endowments[33] and Soviet production legacies.[34] The prior predominance of agriculture or military production has tended to diminish relative regional product.[35] The combination of non-competitive sectors and weak restructuring requirements led to sustained low rates of growth among the laggards.[36] Also important is the legacy of research infrastructure and migration, both of which with strong geographical aspects. By tradition and Soviet-era central planning, basic and applied research was located in the central areas of the country, and most specialized research institutions and innovatively active firms remain in these locations. Weak infrastructure and harsh climactic and general living conditions has halted the population movements eastward and northward seen in the Soviet period, and there has been a flood of out-migration from northern European Russia and Siberia. [37] Finally, economic policy such as import restrictions and local price controls, impaired local firms' adjustment to suddenly real costs of production and trade, including transportation.

IV. Data

We examine indicators of technological change, institutional and socio-economic development in the regions with controls for the asymmetries as between the

[33] Berkowitz and DeJong (2003); Freinkman and Yossifov (1999); Desai et al (2003); Ahrend (2003); Popov (2001); Solanko (2003);
[34] Mikheeva (1999); Popov (2001); Ahrend (2003); Berkowitz, DeJong and Husted (1998).
[35] Berkowitz, DeJong and Husted (1998); de Melo, Ofer and Yossifov (1999); Popov (2001).
[36] Alekseev and Kurlyandskaya (2003); Ahrend (2003).
[37] See numerous important articles on patterns of regional economic growth, including Bradshaw and Prendergrast (2005).

component parts of the Russian Federation. There are some differences in the status of those component parts of the federation (republics, oblasts, autonomous districts and single cities), but for the sake of convenience they are all referred to in this study as 'regions'. Equally, there are large variations in population density, resource endowments, and income. These controls and the main indicators are taken from official data, the Federal Service for State Statistics ('Rosstat' formerly known as Goskomstat), which embrace R&D expenditure, regional per capita income, industrial performance and social indicators. Table 4 contains definitions of the variables of the dataset and descriptive statistics.

A. Measures of Technological Change

We follow the literature in taking as the measure of technological change, expenditures on technological innovation at the regional level (EXPEK) as a percentage of the regional product (VRP).[38] This is our dependent variable which we call RDI. EXPEK is defined as total expenditures on technological innovation by firms and other organizations that produce items/ideas/processes/goods used for technological innovation. These "external" expenditures at the national level are financed by firms' retained earnings, federal/regional/local budget resources, extra-budgetary funds, foreign and other investments. R&D expenditure is recorded by official records published by Rosstat. The most important resource is the national R&D survey (which, since 1989, has applied Frascati manual definitions of activities). The current government survey was introduced in 1994 and improved in 1995. It embraces expenditures under Section 6 of the Federal Budget, "Science and Technology" (i.e. budgetary financed civilian R&D and related activities) by (1)

[38] See the literature on sources of technological change which include Bound et al (1984), Hausman, Hall and Griliches (1984), and Hall, Griliches, and Hausman (1986).

ministries, governmental agencies, and public foundations intended to promote S&T; (2) government S&T programmes; (3) state research centres; (4) federal programs containing R&D components. Other spending is calculated from the national innovation survey introduced in 1996-1997, covering expenditures on R&D by industrial enterprises including, after 1999, services. Value added tax is not included in R&D expenditure. [39] In 2003, this survey listed 3,797 institutions performing R&D, of which 32 per cent were government institutions, 52 per cent industrial firms, 14 per cent were higher educational institutions, and 0.13 per cent were non-profit non-governmental institutions.[40] Of all these various types of institutions carrying out R&D, 70 per cent are publicly owned.[41] Most spending (70 per cent) goes to R&D institutions based on headcount, facilities and equipment, leaving 22 per cent for priority objectives and 8 per cent allocated by competitive selection procedures[42].

B. Measures of Institutional Reform: regional investment climate

To measure institutional development, we use the average weighted investment risk (INVRISK) (Russia=1), as assessed by the rating agency ExpertRA and consisting of private/public sector investment surveys. The ratings used here start in 1998. ExpertRA draws primarily on data provided by Rosstat, state agencies – including the Ministry of Finance, Ministry of Economic Development and Trade and Central Bank, a data base of laws ("Konsul'tant Plius-Regiony"), and the rating agency, Expert RA. Weights, established by surveys carried out for Expert RA by foreign and domestic investment and consulting companies, are used to rank investment "risk"

[39] Gokhberg (1999), pp. 15-30; OECD, National Methodological Changes (2005).
[40] The current system replaced the obsolete Soviet era sectoral classification by R&D institutes, higher education and university research. See Gokhberg and Kuznetsova (2004); *Rossiiskii Statisticheskii Ezhegodnik* (2004), 21.1.
[41] CSRS (2002), p. 12.
[42] Watkins (2003), p. 12

and "potential" by region. The risks assessed included political, economic, social, criminal, ecological, financial and legislative (see Appendix 1).[43] The surveys were carried out by major firms and the investment departments of regional governments, and also by Russian and foreign investment and consulting companies including BKG Management Consulting, the Boston Consulting Group, the Russian Development Bank, Alfa Bank, the German Institute of Industrial Development (BFA). Longitudinal data with annual investment environment rankings provides a formally exogenous variable for the investment environment in the 89 regions. The annually repeated surveys are compiled into indices, rating Russia's regions by institutional measures.

C. Measures of R&D Investment

Investment is known to be a robust determinant of growth (Levine and Renelt, 1992), it has also its part in technological change. To measure R&D investment in a way which reflects the lack of lending by financial institutions to R&D activities, [44] we use regions' own funds available for innovation – (INEXTK) internal expenditures on technological innovation – lagged one period (INEXTK(-1)) as a proportion of regional product and we call our variable INEXVRP. Internal expenditures are current and capital expenditures by organizations carrying out R &D, including state bodies, private firms, higher education institutions, and private non-profit entities. Internal expenditures are those assigned to R&D by all such organizations and firms from their own sources of financing, including current and capital expenditures.

[43] Expert.ru (1997-2005). See Issledovanie investitsionnogo klimata regionov Rossii: problemy I rezul'taty, at http://www.raexpert.ru/researches/regions/investclimate/
[44] See Kanvar and Evenson (2003), pp.243-44.

Since a large part of the literature has shown the profit motive to be among the sources of technological change, we introduce a demand pull variable.[45] We mentioned above that Watkins (2003) considers weak domestic demand for domestically produced technologically advanced equipment as a barrier for innovation. To capture the demand pull factors, we use the ratio of current (value added per capita) regional product to lagged per capita VRP (Gross Regional Product) to remedy partially for the pro-cyclical characteristic of R&D investment and mitigate a potential problem of endogeneity, given that our time series are quite short. We call it VRPPC.

In contrast with Kanwar and Evanson (2003), we do not compute the ratio of non public R&D expenditure to regional product while "it may be argued that the public sector is not necessarily responsive to monetary incentives"[46]. Instead we introduce variable capturing expenditures on innovation by innovative firms. This is the share of R&D spending[47] by enterprises which conduct R&D (i.e. which have an R&D component to their operations) – EXPINAO, in short the share of R&D spending in innovative company costs. We also control for capital investment per capita – CAPINVPC. And we add a time fixed variable capturing the share of the regional budget comprised of transfers from the federal budget, BTRAN, developed by Desai, Freinkman and Goldberg (2003) to show the extent of regions' dependency on the federal centre.

[45] See Acemoglu (2002), p.9 for details of the literature.
[46] Kanwar and Evanson (2003), p.257.
[47] Spending recorded in companies' statutory accounts as part of the 'cost of goods sold' line of the income statement

D. Background economic and social variables

As economic variables, we sought a measure of human capital, to which innovation has been shown in the literature to be strongly linked. For Russia, where the average rate of literacy and education is high, we first chose enrolment in secondary education to represent the human capital variable but the time series ran only from 2000 to 2002 therefore limiting the length of the estimation of the relationship. We therefore proxied human capital by workers who graduated from Elementary Professional Educational Institutes in a time series run from 1990 to 2004 and we call this variable PROFEDU. We also added another human capital variable, the enrolment of students at middle special education schools, MIEDTH.

Then, to control for other factors that cause regions to differ widely in levels of economic development and innovation, we use openness to trade estimated by taking the share of regional exports as a percentage of total Russian exports (OPENN) calculated for the whole sample 1998 to 2004. We also use small and medium enterprises (SME) per 1000 persons as well as the percentage of natural resources in VRP, RESPROD, another fixed variable used by Desai, Freinkman and Goldberg (2003). We use the ratio of current SMEPOP over SMEPOP lagged one period to strengthen the proxy.

We also add unemployment as a proportion of the labour force (UNEMP). This variable is used to control for sectors particularly affected by the transformation recession. As shown by Ickes and Ofer (2006), the impact of transition on employment patterns extended from particular sectors to whole regions. This was the result of shifts in demand (to private consumption from state-funded investment in defence industries and related production complexes with heavy regional concentration), and in production functions as enterprise restructuring proceeded –

often in the face of extended competition as the economy was opened to global competition. These post-Soviet transformations produced large divergences in regional unemployment figures.

Then, we introduce alternate measures of the rule of law such as criminality, corruption and bad governance such as "murders per capita", since reliable crime statistics for property crimes do not exist. MURDER, was introduced as a variable reflecting security of property which in turn stimulates investment in innovation. In his work on the US, Robert Putnam (2000) shows murder per capita to be strongly correlated with the level of social capital.[48]

E. Outliers

Five outliers in innovative activity are identified. LEADERS is included to reflect the large discrepancy between the leading regions. These include the city of Moscow, Yamalo Nenets, Chukotka and Kalmykia. We add a separate dummy for SVERDLOVSK. Sverdlovsk ranks 6 in Table 2 describing the institutional potential for 2004-2005 and is classified by ExpertRA as 1B in terms of investment climate (2003-04) meaning high potential and moderate risk.[49] We also took account of regions experiencing civil conflict, including Chechnya, via a dummy (CONFLICT), with the value 1 for regions exhibiting conflict and 0 otherwise. Dummying civil conflicts is important in part because the statistics in conflict regions are rather sparse. Oil and metal being so important to the VRPs of some of the regions, we introduce two more dummies, one for oil – DUMOIL and one for metal – DUMMETAL.

[48] Putnam (2000), p. 12.
[49] See http://www.raexpert.ru/ratings/regions/

F. Instrumental Variables

We also use a set of three proxies as instrumental variables: PAVEDROADS, the km roads per thousand km territory, is our proxy for infrastructure improvements (roads), which has been shown in the literature to be an institutional variable of some importance. FDIPCT is the regional foreign direct investment as a percentage of total foreign direct investment. FDI is included as higher than average FDI inflows outside the natural resources sector which, after controlling for market size, could be a measure of higher institutional development.[50] Our decision to include INFLATION, the regional inflation rate is inspired by the literature on growth and political risk. Mumpower, Livingston and Lee (1987) find, for a survey of 49 countries, evidence of a positive linear relationship, significant at the 5 per cent level, between a political risk score and inflation. Moreover, examining an earlier stage of US history, from the 1880s through the 20th century convergence process, Mitchener and McLean (2003) find that institutional and geographical influences are important in explaining observed and persistent spatial differences in cost of living. Variation among regional CPI estimates is in part linked with the differences in speed and degree of price liberalization across Russian cities (Gluschenko 2003), which created a picture of remarkable divergence in nominal personal incomes across regions. Table 5 shows that the standard deviation of the regional CPI between 1992 and 2003 is significant. It is roughly in the range of the variation among states in highly developed countries, although lower than the variation among transition states and states in the region of emerging markets in Latin America. The regional inflation rate also reflects geographical differences such as transport costs and also state transfers. Gibson, J., S.

[50] This was kindly suggested to us by Lucio Vinhas de Souza.

Stillman and T. Le (2004) note how informative regional price data are by the way they are collected and the consumer price index is calculated. [51]

V. Empirical results

We use data for 1998 to 2004, for which period indicators by Rosstat are compatible with international standards. This is based on a maximum sample size of 89 regions (listed in Table 2). Annual indicators of technological change are used with caution. Since legal institutions generally evolve quite slowly, correlations with annual indicators of technological or economic change are noisy statistically (Sussman and Yafeh, 2004). We would not expect yearly changes in external expenditures in technological innovation to reflect the response of innovation to changes in institutions (Kanwar and Evenson, 2003). Innovation decisions are generally long term decisions. However, the transition dynamic is unique. Investment and innovation have taken place at a high speed; the result of the combination of rapid and sweeping privatization. In some regions, property rights would have been implemented for almost ten years helping us in the estimation of a causal model, despite the difficulty of using annual data.

A. *Pooled OLS*

We use regional-level data for 1998-2004 to estimate the following specification.

(1) $\text{Log(technological change)} = \alpha + \beta \log(\text{institutional development}) + X'\gamma + \varepsilon$

[51] Previous studies include Granville, B. and J. Shapiro (1994)

We use RDI to measure technological change at the regional level. Institutional development is measured by the average weighted investment risk (INVRISK) (Russia=1). The coefficient β measures how technological innovation changes when institutional development changes. Since we use a logarithmic form, β is the institutional development elasticity. Typically, since our proxy for institutional development is the investment risk rating, we expect β to be negative.

The vector X includes other potential predictors of technological change such as measures of R&D investment, other socio economic variables and outliers.

Table 6, columns 1-4, reports Ordinary Least Squares (OLS) estimates of the coefficients (elasticity) in equation (1). We use White period as the coef covariance method to compute standard errors that are robust to serial correlation. Column 1 shows a statistically significant correlation between investment risk and technological change. The estimate of β is -2.492 with a standard error of 0.605, which is significant at the 1 percent level. If causal this estimate would imply that a 1 percent increase in investment risk, log(INVRISK(-1)), is associated with a 2.5 percent reduction in technological change, as measured by RDI. Column 2 shows that the negative association decreases but remains significant when the R&D investment variables are introduced in the regression. Interestingly, our budget transfer fixed variable has a negative coefficient and is negative, this could have been a very interesting story showing that budget transfers have a negative effect on innovation but the coefficient is too small for us to reach such conclusion. In column 3, we include our other socio-economic variables. These are our measures of human capital (MIEDTH), unemployment (UNEMP), openness (OPENN), the number of small and medium enterprises (SMEPOP) as a proportion of the regional population per year and per region, as well as MURDER. With regards to human capital, we first run the

regression with both the number of students graduating from primary professional education (PROFEDU) and the number of students enrolled in middle special education schools (MIEDTH); but only the coefficient of MIEDTH turned out to be statistically significant and positive. In column 4, to control further for possible omitted variables and so to limit the risk of endogeneity, we include our controls for individual regional characteristics: LEADERS, CONFLICT, SVERDLOVSK, DUMOIL and DUMMETAL.

The regression results in columns 1-4 indicate that investment risk is significantly negatively associated with technological change. Column 4 reports that a 1 percent increase in investment risk is associated with a 1.1 percent reduction in technological change.

B. *Fixed versus Random Effects*

In estimating our OLS regression, we first assumed that pooling across regions is valid so long as we used lagged explanatory observed variables and added proxy variables for the unobserved explanatory variables. We attempted to mitigate the problem of endogenous variables by adding dummies for LEADERS, CONFLICT, SVERDLOVSK, DUMOIL and DUMMETAL to control for any neglected heterogeneity. However, we still have to determine whether regional specific effects are best modeled as random or fixed. The random effect approach is attractive in maximizing the number of degrees of freedom and in taking into account all information available by comparing all individual regions. If we used fixed effects, we would not be able to include our OUTLIERS nor any other time fixed variables such as BTRAN since these variables do not change.

To determine whether regional specific effects are best modeled as random or fixed, we use the Hausman (1978) approach to test if the random effects are uncorrelated with the explanatory variables. Performing the Hausman test on our model as specified in column 3, leads to a statistic of 7.305, with a p-value of 0.504 while performing the test in our model as specified in column 4, leads to a statistic of 6.104, with a p-value of 0.296 supporting the adoption of a random-effects (RE) specification. The difference between the estimates is quite small. For instance, using the model in column 4, the coefficient for log(INVRISK(-1)) under a fixed effect specification is quite similar to the one reported under the random effects: -0.958 compared to -1.056 (the differential being around 0.08). Therefore, we adopted the random effects approach, especially as the number of regions (89) exceeds considerably the number of time periods (6).

Columns 1-4 in table 7 report estimates of the effect of institutional development on technological change using the cross section random effects generalized least squares (GLS) (with Swamy and Arora estimators for the component variances) and White period standard errors and covariance. The coefficients of INVRISK in columns 1 and 2 are lower than in table 6 but remains negative and statistically significant at conventional levels. The results of columns 3 and 4 in table 7 are similar to the results of the equivalent columns in table 6. Column 4 reports that a 1 percent increase in investment risk is associated with a 1.1 percent reduction in technological change compared to 1.1 percent in table 6. Therefore, the random effect method results seem to confirm a strong negative association between investment risk and technological change. Internal expenditures on technological innovation as a proportion of regional product, log (INEXVRP(-1)) are also confirmed as having a strong positive influence on RDI supporting the literature that internal funds are

important for R&D.[52] A 1 percent increase in internal expenditures is associated with a 0.2 percent increase in technological change compared to 0.3 percent in table 6. This is also true of our variable EXPINAO measuring the share of R&D expenditures in the innovative company costs.

C. IV Regressions

Our previous results revealed little about causation. Grossman and Helpman's (1997) finding is that innovation drives investment not that investment drives innovation[53]. Therefore, we are concerned that our R&D investment variable, INEXVRP, is endogeneous. If endogeneity is present, then our estimates will be biased and inconsistent. To test this hypothesis, we need to find a set of instrumental variables that are correlated with our investment variable INEXVRP but not with the error term of our proxy for technological change. Here we take the share of regional FDI in total FDI, the regional inflation rate and the ratio of kilometres of paved roads to the region's total territory, respectively named FDIPCT, INFLATION AND PAVEDROADS. To test for endogeneity, we carry out the Hausman test. We run two OLS regressions, regressing first INEXVRP on all exogeneous variables and instruments and retrieving the residuals. Column 1of table 9 shows that none of the variables are significant with the exception of LEADERS and SVERDLVOVSK and the 2 instruments FDIPCT and INFLATION. FDIPCT is significant at the 0.05 significance level and INFLATION at the 0.01 significance level. Then in the second regression, we re-estimate RDI including the residuals from the first regression as an additional regressor. The results presented in column 2 of table 9 show that

[52] See Kanwar and Evanson (2003), p.249.
[53] Grossman and Helpman, 1997, p.113.

RESIDHAUSMAN is not significant at any conventional levels, which make us conclude that INEXVRP is not endogeneous.

In the growth literature, however, investment is known to be endogeneous, therefore for the sake of robustness, we perform the IV method using our 3 instruments.

Columns 1-4 of table 8 show that results remain virtually unchanged relative to Tables 6 and 7. Column 4 of table 8 reports that a 1 percent increase in investment risk is associated with a 1.2 percent reduction in technological change compared to 1.1 percent in tables 6 and 7.

V. Conclusion

Using a new cross regional data set on technological change for the period 1998 to 2004, we started with the basic pooled OLS, we then examined fixed versus random effects to check for neglected omitted variables. We performed the Hausman test which seemed to indicate that RE were present. We succeeded in finding a significant association between technological change (proxied by expenditures on technological innovation as a proportion of the regional product) and institutional development (proxied by the investment risk rating). The results show that greater security in the contractual environment is a powerful predictor of technological innovation.

In other words, regions where there was a low risk environment—undergirded by the adoption and enforcement of federal law—were also effective in fostering technological change. This is so even without including specific variables for intellectual property protection. The results obtained using ordinary regression become stronger when instrumental variable methods are used to correct for reverse

causation. We have privileged technological change as a response to profit incentives which in turn are dependent on the institutional environment.

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Tables and Figures

Table 1
Gross expenditure on R&D in G8 countries by source of funding, 2002, percentage by source of funds

	UK	Germany	France	Italy	Japan	Canada	USA	Russian Federation
Government	26.9	31.5	36.9	50.8	20.9	33.3	30.2	58.4
Business enterprises	46.7	65.6	54.2	43	72.3	45.3	64.4	33.1
Abroad	20.5	2.5	7.2	6.2	0.1	12	-	8
Other	5.9	0.4	1.7	-	6.7	9.4	5.4	-
	100	100	100	100	100	100	100	100

Source: OECD databank (June 2004; updated 7 December 2004) via ONS; "Struktura vnutrennikh zatrat na issledovaniia i razrabotki po istochnikam finansirovaniia v 2002 g. (v protsentakh k itogu)" (31 December 2004, *Nauka i teknologii* (Goskomstat: Moscow).

Table 2
Regional Rankings, 2004-2005
Institutional Potential

Region	Rank	Region	Rank	Region	Rank	Region	Rank	Region	Rank	Region	Rank
Moscow city	1	Stavropol krai	16	Yaroslav oblast'	31	Ulyanovsk oblast'	46	Kostroma oblast'	61	Kalmykia Republic	76
Smolensk oblast'	2	Volgograd oblast'	17	Vologda oblast'	32	Arkhangelsk oblast'	47	Orel oblast'	62	Evreiskii ao	77
Moskow oblast'	3	Kaliningrad oblast'	18	Khabarovsk Territory	33	Riazan oblast'	48	Amur oblast'	63	Altay Republic	78
Krasnodar krai	4	Krasnoiarsk krai	19	Tula oblast'	34	Komi-Perm ao	49	Kurgan oblast'	64	Tyva Republic	79
Rostov oblast'	5	Leningrad oblast'	20	Udmurtia Republic	35	Lipetsk obast'	50	Chita oblast'	65	Ingushetia Republic	80
Sverdlovsk oblast'	6	Altay krai	21	Tver' oblast'	36	Dagestan Republic	51	Marii El Republic	66	Chukotski ao	81
Tatarstan Republic	7	Omsk oblast'	22	Vladimir oblast'	37	Pskov oblast'	52	Yamalo-Nenetsky ao	67	Komi Republic	82
Nizhny Novgorod oblast'	8	Kemerovo oblast'	23	Chuvashia Republic	38	Kursk oblast'	53	Mordovia Republic	68	Nenets ao	83
Samara oblast'	9	Sankt-Peterburg city	24	Tomsk oblast'	39	Novgorod oblast'	54	Kabardino-Balkaria Republic	69	Taymyr (Dolgano-Nenetsky) ao	84
Bashkortostan Republic	10	Voronezh oblast'	25	Murmansk oblast'	40	Sakhalin oblast'	55	Northern Osetia-Alania Republic	70	Aginsky Buryatsky ao	85
Primorski krai	11	Orenburg oblast'	26	Kaluga oblast'	41	Ivanovo oblast'	56	Khakassia Republic	71	Ust-Ordynsky ao	86
Novosibirsk oblast'	12	Khanty-Mansiysky ao	27	Penza oblast'	42	Sakha Republic	57	Kamchatka oblast'	72	Koryaksky ao	87
Perm oblast'	13	Irkutsk oblast'	28	Astrakhan oblast'	43	Karelia Republic	58	Adygea Republic	73	Chechnya Republic	88
Cheliabinsk oblast'	14	Briansk oblast'	29	Saratov oblast'	44	Tambovsk oblast'	59	Magadan oblast'	74	Evenkia ao	89
Tiumen' oblast'	15	Belgorod oblast'	30	Kirov oblast'	45	Buryatia Republic	60	Karachaevo-Cherkessia Republic	75		

Source: ExpertRA.ru

Table 3
Regional Product as Percent of GDP

Region (Okrug)	1995	1996	1997	1998	1999	2000	2001
Central Federal Okrug	25.1	26	27.6	29.3	32	32.9	32.9
Northwest Federal Okrug	10.6	9.7	9.4	10.4	10.3	9.7	9.7
South Federal Okrug	8.2	7.9	7.6	8.1	7.9	7.6	7.8
Volga Federal Okrug	20.7	20.2	20.4	19.2	18.6	18.1	17.9
Fareast Federal Orkug	5.8	5.9	6.2	6	5.8	5.1	5
Siberia Federal Okrug	15	14.5	13.7	13.1	11.8	11.5	11.4
Urals Federal Okrug	14.6	15.8	15.1	13.9	13.6	15.1	15.3

Source: Goskomstat (December 2003).

Table 4
Descriptive Statistics

Definitions of variables	Variables	Obs	Mean	S.D
TECHNOLOGICAL CHANGE				
Expenditures on technological innovation as a percentage of regional product	RDI	587	1.04	4.79
INSTITUTIONAL DEVELOPMENT				
Average weighted investment risk, Russia=1,	INVRISK	623	3.39	54.80
R&D INVESTMENT				
Internal expenditures on technological innovation as a % of regional product	INEXVRP	645	0.84	1.34
Per capita regional product, in Rbs	VRPPC	912	44637	91798
Share of R&D spending in innovative company costs.	EXPINAO	525	6.10	10.95
Capital investment per capita, in Rbs	CAPINVPC	887	11096	32682.00
% of the Budget comprised of transfers from the Federal Budget (fixed: 1998-2004)	BTRAN	595	20.80	14.57
OTHER SOCIO ECONOMIC VARIABLES				
Grad primary professional education, number of students	PROFEDU	1144	9271	7654
Enrollment at middle special education schools, number of students	MIEDTH	708	24362	23516
Unemployment (officially registered), % of labor force	UNEMP	778	2.98	2.33
SMEs per 1000 persons,	SMEPOP	616	0.51	0.52
Regional exports as % of total Russian exports	OPENN	570	1.17	3.23
Murder as % of the regional population	MURDER	622	0.02	0.12
% of natural resources in VRP (fixed: 1998-2004)	RESPROD	760	27.71	16.51
OUTLIERS				
City of Moscow, Yamalo Nemets, Chukhotka, Kalmykia	LEADERS			
Dummy=1 for regions exhibiting conflicts and 0 otherwise	CONFLICT			
Sverdlovsk ranks 6 in Table 2 describing the institutional potential 2004-2005.	SVERDLOVSK			
Dummy=1 for regions with oil and 0 otherwise	DUMOIL			
Dummy=1 for regions with metal and 0 otherwise	DUMMETAL			
INSTRUMENTS				
Regional FDI, % of total FDI	FDIPCT	530	1.39	4.93
Regional inflation rate	INFLATION	784	25.23	19.21
Paved Roads, km roads per thousand km territory, 1995 then 2000-2004	PAVEDROADS	850	98.01	79.46

Table 5
Comparison of Variation in CPI (Standard Deviation):
Russia and Selected Regions and States, 1992-2003

	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003
States in Transition Region[1]	12.9	21.8	24	24.1	26.1	25.6	24.6	15.3	0	14.9	31.2	47.7
Latin American States[2]	30.7	31.9	29	27.9	25	22.1	18.8	13.6	0	10.5	15.9	24.9
Advanced Market Economies[3]	10.9	9.5	7.7	6.1	4.3	3.1	2.2	1.4	0	1.6	3	3.7
Regions of Russia (88)	6.2	3	2	2	3.9	3.5	10.7	6.2	0	4.1	5.2	2.9

[1]Albania,Armendia, Azerbaijan, Belarus, Croatia, Czech Republic, Estonia, Georgia, Hungary, Kazakhstan, Latvia, Lithuania, Poland, Romania, Russia, Slovakia, Slovenia, Ukraine.
[2]Argentina, Brazil, Chile, Columbia, Guatemala, Mexico, Panama, Paraguay, Venezuela, Ecuador.
[3]Austria, Canada, Denmark, Finland, France, Germany, Greece, Iceland, Ireland, Israel, Japan, Netherlands, Norway, Spain, Sweden, United Kingdom, United States.
Sources: World Bank Development Indicators (2006); Rostat (2006).

Table 6
Technological Change and Regional characteristics
(OLS with heteroskedasticity and serial correlation robust standard errors).

Dependent Variable: log of RDI Technological Change				
	(1)	(2)	(3)	(4)
INSTITUTIONAL DEVELOPMENT				
Log(Invrisk (-1))	-2.492***	-1.0257**	-1.196**	-1.051**
	(0.605)	(0.055)	(0.464)	(0.430)
R&D INVESTMENT				
Log(Inexvrp(-1))		0.209***	0.233***	0.251***
		(0.055)	(0.072)	(0.075)
d(Log(vrppc))		-0.370		
		(0.233)		
d(Log(expinao))		0.227***	0.224***	0.218***
		(0.054)	(0.063)	(0.062)
Btran		-0.026***		
		(0.006)		
d(Log(capinvpc))		-0.114		
		(0.189)		
OTHER SOCIO ECONOMIC VARIABLES				
Log(Miedth(-1))			0.154**	-0.082*
			(0.071)	(0.043)
Log(Unemp (-1))			-0.065	
			(0.148)	
d(Log(SMEPOP))			0.145	
			(0.241)	
Log(Openn)			0.133**	0.210***
			(0.061)	(0.066)
Log(Murder (-1))			0.413**	
			(0.182)	
Resprod			-0.154**	-0.028***
			(0.071)	(0.006)
OUTLIERS				
Leaders				0.002
				(0.243)
Conflict				0.959**
				(0.425)
Sverdlovsk				1.164***
				(0.294)
Dumoil				0.361
				(0.329)
Dummetal				-0.258
				(0.274)
Number of observations	376	418	340	340

Notes: Heteroskedascity-robust standard errors are shown in parentheses.
*Statistically significant at the 10 percent level.
** Statistically significance at the 5 percent level.
*** Statistically significance at the 1 percent level.

Table 7
Technological Change and Regional characteristics
(Pooled EGLS, Cross Section Random Effect with heteroskedasticity and serial correlation robust standard errors).

Dependent Variable: log of RDI Technological Change				
	(1)	(2)	(3)	(4)
INSTITUTIONAL DEVELOPMENT				
Log(Invrisk (-1))	-1.291***	-0.782**	-1.092***	-1.056***
	(0.324)	(0.304)	(0.306)	(0.333)
R&D INVESTMENT				
Log(Inexvrp(-1))		0.287***	0.222***	0.225**
		(0.059)	(0.080)	(0.087)
d(Log(vrppc))		-0.696***		
		(0.178)		
d(Log(expinao))		0.210***	0.222***	0.224***
		(0.051)	(0.055)	(0.054)
Btran		-0.036***		
		(0.007)		
d(Log(capinvpc))		-0.023		
		(0.161)		
OTHER SOCIO ECONOMIC VARIABLES				
Log(Miedth(-1))			0.194	0.169
			(0.151)	(0.135)
Log(Unemp (-1))			-0.090	
			(0.148)	
d(Log(SMEPOP))			-0.011	
			(0.220)	
Log(Openn)			0.098	0.100
			(0.065)	(0.076)
Log(Murder (-1))			0.367*	
			(0.202)	
Resprod			-0.014*	-0.018**
			(0.007)	(0.007)
OUTLIERS				
Leaders				0.015
				(0.263)
Conflict				0.975***
				(0.352)
Sverdlovsk				1.045***
				(0.314)
Dumoil				0.416
				(0.335)
Dummetal				-0.166
				(0.295)
Intercept	-0.822***	0.281	-0.607	-2.732**
	(-6.575)	(0.178)	(1.706)	(1.366)
Number of observations	376	347	340	340

Notes: Heteroskedascity-robust standard errors are shown in parentheses.
*Statistically significant at the 10 percent level.
** Statistically significance at the 5 percent level.
*** Statistically significance at the 1 percent level.

Table 8
Technological Change and Regional characteristics
(IV with heteroskedasticity and serial correlation robust standard errors).

Dependent Variable: log of RDI Technological Change				
	(1)	(2)	(3)	(4)
INSTITUTIONAL DEVELOPMENT				
Log(Invrisk (-1))	-2.574***	-1.506*	-1.539**	-1.170**
	(0.582)	(0.872)	(0.780)	(0.583)
R&D INVESTMENT				
Log(Inexvrp(-1))		-0.265	-0.182	-0.060
		(0.303)	(0.257)	(0.377)
d(Log(vrppc))		-1.766		
		(1.463)		
d(Log(expinao))		0.252***	0.211***	0.256***
		(0.093)	(0.060)	(0.093)
Btran		-0.010		
		(0.014)		
d(Log(capinvpc))		-0.194		
		(0.361)		
OTHER SOCIO ECONOMIC VARIABLES				
Log(Miedth(-1))			0.256**	-0.119**
			(0.124)	(0.050)
Log(Unemp (-1))			-0.097	
			(0.445)	
d(Log(SMEPOP))			0.300	
			(0.385)	
Log(Openn)			-0.018	0.044
			(0.085)	(0.093)
Log(Murder (-1))			0.716**	
			(0.331)	
Resprod			-0.015*	-0.009
			(0.009)	(0.007)
OUTLIERS				
Leaders				0.765
				(0.682)
Conflict				0.778
				(0.550)
Sverdlovsk				1.857***
				(0.548)
Dumoil				0.291
				(0.365)
Dummetal				0.036
				(0.261)
Number of observations	452	245	237	237

Notes: Heteroskedascity-robust standard errors are shown in parentheses.
*Statistically significant at the 10 percent level.
** Statistically significance at the 5 percent level.
*** Statistically significance at the 1 percent level.

Table 9
Technological Change and Regional characteristics
(Hausman Test with heteroskedasticity and serial correlation robust standard errors).

STEP 1	**STEP 2**	
	Dependent Variable: log of INEXVRP (1)	**Dependent Variable: log of RDI (2)**
INSTITUTIONAL DEVELOPMENT		
Log(Invrisk (-1))	-0.234	-1.209**
	(0.528)	(0.516)
R&D INVESTMENT		
Log inexvrp(-1))		0.031
		(0.382)
d(Log(expinao))	-0.013	0.244
	(0.036)	(0.063)
OTHER SOCIO ECONOMIC VARIABLES		
Log(Miedth(-1))	0.032	-0.125***
	(0.060)	(0.042)
Log(Openn)	-0.159	0.095
	(0.098)	(0.102)
Resprod	-0.005	-0.014**
	(0.009)	(0.007)
OUTLIERS		
Leaders	1.472***	0.599
	(0.215)	(0.671)
Conflict	-0.145	1.020*
	(0.605)	(0.525)
Sverdlovsk	1.072***	1.596***
	(0.235)	(0.567)
Dumoil	0.113	0.307
	(0.283)	(0.354)
Dummetal	-0.012	-0.090
	(0.313)	(0.294)
INSTRUMENTS		
Log(FDIPCT(-1))	0.125*	
	(0.066)	
PAVEDROADS	-0.000	
	(0.001)	
Log(Inflation(-1))	-0.277***	
	(0.061)	
Residhausman		0.158
		(0.410)
Number of observations	280	280

Notes: Heteroskedascity-robust standard errors are shown in parentheses.
*Statistically significant at the 10 percent level.
** Statistically significance at the 5 percent level.
*** Statistically significance at the 1 percent level.

Appendix 1
Variable for Investment Climate: Combination of 100 indicators for
"Investment Risk", "Investment Potential", and "Legal Conditions"
Rankings by Expert RA (1997-2005)

Investment potential includes:

- Resources — Estimated from regional reserves of natural resources
- Production — Economic output of region
- Demand — Purchasing power of population
- Infrastructure — Infrastructural adequacy
- Innovation — Science and technology
- Labor — Economically active population; education
- Institutions — Level of institutional development
- Finance — Taxes and other pecuniary contributions to the budget system

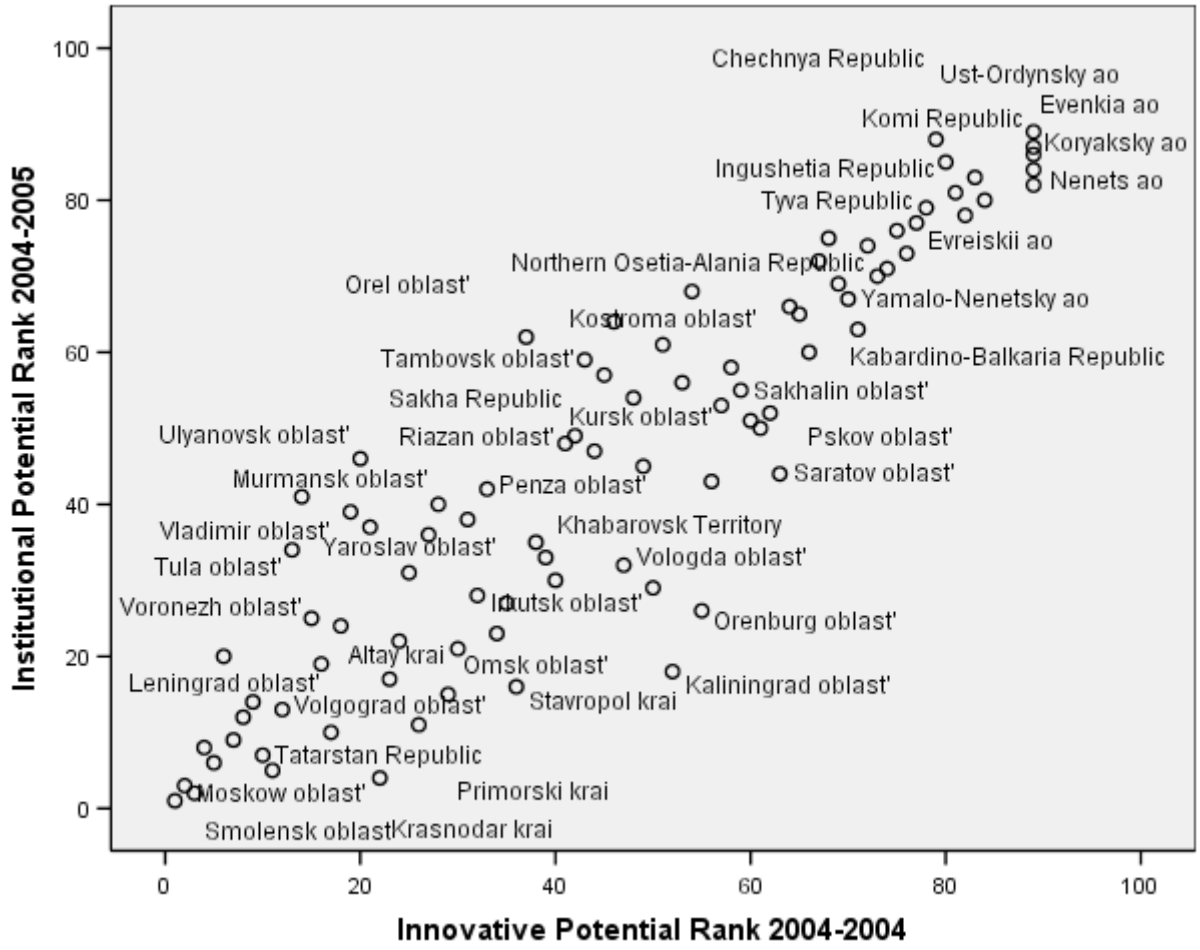
Investment risk includes:

- Political — Stability of regional authority; political views of population
- Economic — Macroeconomic indicators
- Social — Level of well being
- Criminal — Level of criminality
- Ecological — Pollution level
- Financial — Balance of the regional budget
- Legislative — Legal norms, regulations, local taxes, exemptions, limitations

Legislative Risk (divided between direct and indirect effects of laws) includes:

- Regulation of investment projects
- Tax regulations applying to investment activity
- Financial assistance and credit available to investors and potential investors
- Amortization policies
- Regulations regarding privatization and investor participation
- Access to shares by external buyers
- Security of property rights (including mortgage rights)

Figure 1 –Plot of Investment Potential Rankings (Ekspert RA) for Institutional and Innovation Measures



Source: ExpertRA.ru