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COMMENTS ON THE IMPACT OF KNOWLEDGE ON ECONOMIC GROWTH ACROSS THE REGIONS OF THE RUSSIAN FEDERATION

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Summary

Using a basic growth accounting approach it is deduced how far the regional knowledge infrastructure plays any significant role across the regions of the Russian Federation. Aside from aspects of the size of the regional innovation system, like the number of researchers and students, it is discussed in how far the inflow and outflow of knowledge plays a role in determining the economic growth. The study shows thereby that while the Russian growth dynamics are indeed driven by the exploitation of natural resources, foremost of oil and gas, a significant part of Russian growth is due to its innovation system. This shows that innovation oriented growth politics as promoted by former president Dmitry Medvedev do have a solid foundation to be built on.

Keywords: Economic Growth, Russian Federation, Knowledge, Innovations.

Introduction

Not only since the works by Machlup[1], who described the modern society as a knowledge society, has the aspect of knowledge as a production factor and an essential building block of economic growth been acknowledged.

A broad range of studies exist that have reported empirical results on the importance of knowledge in economic growth. However most of these studies focus on Western Europe, the European Union, its member states, the USA or other highly developed economies. A smaller range of studies focuses on how knowledge, and in specific the inflow of knowledge, can facilitate economic growth in developing economies, especially those in transition.

Internationally the Russian Federation is generally considered as a provider of basic resources or low quality goods. Only a few authors have considered the Russian innovation system and thereby the contribution of knowledge to Russian economic growth. In some part this shortcoming is motivated by the lack of suitable data.

In the present study this research gap is filled by providing an insight into the effects regionally domestic knowledge sources, as well as intra-regional knowledge flows, have on Russian economic growth.

In the following second section the research design is presented while in the third section the results from a dynamic spatial panel regression are presented and discussed before in the fourth section some preliminary conclusions are drawn.

Knowledge Extended Growth Accounting

Using a growth model approach, this section argues how different sources of knowledge, knowledge spillovers and the absorptive capacity, influence the economic situation in the Russian Federation, measured by the GRP. A number of studies like Guellec and and van Pottelsberghe de la Potterie (2004) exist that analyze the importance of R&D and the institutional environment on the output of an economy. For the Russian Federation, however, Ahrend (2002) argues that political and institutional features are almost unimportant and can therefore be left out of a growth-related analysis.

In addition to the knowledge inputs generated inside the region, knowledge inputs generated outside the region that enter the region in the form of interregional spillovers and through international channels of knowledge transfer like foreign trade or direct investments are considered.

From a theoretical point of view the model picks up on the Solow growth model, assuming an influence of the labor and capital inputs on the level of the GRP. However, the most interesting aspect lies in modeling the Solow residual.

Finally, the new economic geography stresses the importance of the underlying spatial structure, motivating thereby the implementation of spatial models.

The model underlying the following estimations is always considered to be in log-linear form. Therefore, all variables, as long as they do not represent a quota or percentage, are logarithmized versions.

As the state-owned sector makes up a comparatively large share of total production, but might be considered less efficient than the private sector[2], and the amount of government personnel can also be interpreted as a proxy variable for corruption, which should also have a negative effect on growth, government personnel is included as a control variable[3].

Partially hand in hand with the importance of state-owned firms goes the share of natural resources in the Russian economy, of which the oil and gas sector comprises a significant share; therefore, the amount of produced oil and gas is included into the model as well. Here the hypothesis of the *resource curse* can be recalled, as it proclaims a negative relation between the development of the GDP and the amount of non-renewable natural resources - especially natural oil and gas[4].

The knowledge input side of the economy is represented by four indicators: the number of researchers, the expenditures on R&D, the number of students and the number of patents granted. As spillover effects are to be included in the model as well, but respective indicators are only available for patents granted by the EPO, only patents granted by the EPO are considered in the analysis.

Finally, from an international perspective, the exports and imports as well as the openness indicator - to give a general insight into the integration of a region into the world economy - are considered[5]. However Lichtenberg and and van Pottelsberghe de la Potterie (1998) argue that it is not so much the intensity of the imports, and thereby the exports as well, but the distribution of the countries of origin or their destination that influence economic development. The trade related indicators are accompanied by the amount of FDI inflows - as another channel through which knowledge can enter a region[6].

Running a series of tests on a first basic model reveals that only the fixed effects model will produce reliable estimates for the model, and it also suffers from heteroskedastic error terms. The ongoing analyses therefore rely on robust standard errors.

Application of a Moran's I test and robust Lagrange multiplier tests for spatial autocorrelation effects reveal significant spatial autocorrelation effects.

Further testing shows that the model suffers from serial autocorrelation as well. Summarizing these results leads to the use of the Blundell-Bond estimator for dynamic panel models in the context of a Han Philips Spatial Dynamic estimation method[7].

To account for a structural break, which is rather likely in the event of the crisis in 1998, the total time frame has been divided into the transition years including 1998 and the later years starting with 1999. To test for a structural break in levels a dummy variable for the transition years is included in a first regression (model I). In two other regressions the transition (model II) and the later years (model III) are considered separately.

Since the correlation matrix for the independent variables suggests that some of the variables are highly correlated, variance inflation factors are calculated, revealing that severe problems with multi-collinearity exist. Testing different reduced versions of the basic model leads to the result that it can be cleaned of multi-collinearity - or rather of variables reporting variance inflation factors larger than ten - by omitting the labor and capital variables, which are highly correlated with each other as well as with the researchers, R&D expenditures and government personnel.

The expenditures on R&D have been removed as well since they are highly correlated with the researchers and the government personnel.

As a fourth variable, either the researcher or the government personnel variable needs to be removed from the equation. While removing the researchers leads to a qualitatively better model in general, their removal would also exclude an essential insight on the influence of the tacit knowledge potential on the economic development across regions. Therefore, two basic models have been estimated - one with researchers and one with government personnel. The model implementing government personnel is considered as well as a stability test for the results of the researcher model.

While it can be argued that the approach is no longer valid since labor and capital variables as base variables of the underlying production function structure had to be excluded, the approach here can be seen as measuring the effect of mostly knowledge-oriented inputs that influence economic growth aside from labor and capital, which are natural drivers of economic development and growth nonetheless. Referring to the neoclassical growth model, this reduced version is basically an approach to quantify the Solow residual.

Empirical Analysis

While the patent variable and the spillover variables are based on patent data by the European Patent Office all other variables are based on the regional statistical yearbooks by Rosstat.

Data has been used for the years 1994 to 2009 in a first model which does not include spillover effects and for the years 1994 to 2006 in a second model which includes spillover effects. Therefore, the estimation considers sixteen or thirteen years and 80 cross-sections each[8] leading to a total of 1,280 or 1,040 observations respectively.

	Lag-Model			Durbin-Model		
	I	II	III	I	II	II
LAGT-1	0.5416***	0.7647***	0.7093***	0.7127***	0.9567***	0.9567***
	(8.02)	(9.04)	(8.62)	(10.11)	(8.43)	(8.43)
EX	0.0012	0.0367***	0.0248***	-0.0069*	0.0336***	0.0336***
	(0.37)	(4.42)	(5.73)	(-1.79)	(4.39)	(4.39)
IM	0.0062	0.0243**	0.0320***	0.0046	0.0206*	0.0206*
	(1.41)	(2.06)	(6.43)	(0.82)	(1.83)	(1.83)
FDI	0.0016	0.0133***	0.0133***	0.0017	0.0149***	0.0149***
	(1.51)	(7.22)	(7.35)	(1.30)	(7.96)	(7.96)
RES	0.0027	0.3286***	0.3216***	-0.0115	0.3623***	0.3623***
	(0.18)	(20.72)	(25.02)	(-0.64)	(23.32)	(23.32)
OILGAS	0.0414***	0.0668***	0.0690***	0.0760***	0.0781***	0.0781***
	(3.03)	(8.50)	(11.53)	(4.13)	(9.09)	(9.09)
OPEN	-0.1481***	-0.0696**	-13.1829***	-0.1316***	-0.0257	-0.0257
	(-3.73)	(-2.01)	(-5.13)	(-3.40)	(-0.58)	(-0.58)
STUD	0.0054	0.0026	0.0516***	0.0063	-0.0021	-0.0021
	(1.55)	(0.50)	(6.60)	(1.49)	(-0.40)	(-0.40)
TRDUM	-0.0062			-0.2264***		
	(-0.68)			(-8.30)		
CONST	0.0235	0.0066**	0.0130***	3.5984***	0.0039	0.0039
	(0.60)	(2.22)	(3.58)	(10.21)	(1.32)	(1.32)
λ	0.9867***	0.7557***	0.7609***			
	(69.99)	(68.85)	(93.82)			
λEX				-0.4297***	-0.2939***	-0.2939***
				(-14.53)	(-3.74)	(4.05)
λIM				0.1987***	-0.2472***	-0.2472***
				(8.17)	(-5.18)	(4.10)
λFDI				0.0222**	-0.0246	-0.0246
				(2.33)	(-0.71)	(5.93)
λRES				-2.6035***	1.2334***	1.2334***
				(-8.53)	(16.95)	(11.28)
λOILGAS				2.7668***	0.4634**	0.4634**
				(16.83)	(2.28)	(11.27)
λOPEN				-1.2464***	-1.3894***	-1.3894***
				(-7.47)	(-3.60)	(-11.80)
λSTUD				0.1605*	-0.3029***	-0.3029***
				(1.76)	(-3.27)	(-6.83)
R^2	0.882	0.991	0.995	0.746	0.993	0.993
F-Test	458.87	2k	3k	349.16	954.66	954.66

Table 1: Regression Results using Researchers

	Lag-Model			Durbin-Model		
	I	II	III	I	II	II
LAGT-1	0.5419***	0.9600***	0.8458***	0.7029***	0.9418***	0.9418***
	(7.89)	(13.99)	(6.80)	(10.05)	(10.18)	(10.18)
EX	0.0013	0.0355***	0.0235***	-0.0019	0.0068	0.0068
	(0.41)	(3.95)	(5.32)	(-0.48)	(1.18)	(1.18)
IM	0.0050	0.0210	0.0435***	0.0037	0.0101	0.0101
	(1.13)	(1.60)	(8.60)	(0.67)	(1.25)	(1.25)
FDI	0.0015	0.0116***	0.0152***	0.0013	0.0061***	0.0061***
	(1.37)	(5.95)	(8.19)	(1.04)	(3.94)	(3.94)
GOVPERS	0.1926**	0.4968***	0.8713***	0.0965	1.4609***	1.4609***
	(2.33)	(14.38)	(30.40)	(0.75)	(42.82)	(42.82)
OILGAS	0.0395***	0.0591***	0.0519***	0.0645***	0.0543***	0.0543***
	(2.89)	(6.69)	(9.62)	(3.35)	(8.73)	(8.73)
OPEN	-0.1579***	-0.1598***	-20.0553***	-0.1189***	-0.2114***	-0.2114***
	(-3.96)	(-5.52)	(-7.51)	(-3.54)	(-4.63)	(-4.63)
STUD	0.0049	0.0107**	0.0277***	0.0078*	0.0010	0.0010
	(1.41)	(2.02)	(3.89)	(1.89)	(0.25)	(0.25)
TRDUM	-0.0106			-0.0703***		
	(-1.14)			(-3.20)		
CONST	-0.2514**	0.0251***	-0.0188***	-1.4790***	0.0013	0.0013
	(-2.03)	(6.83)	(-4.16)	(-7.03)	(0.54)	(0.54)
λ	0.9486***	0.5291***	0.2167***			
	(44.16)	(17.21)	(8.96)			
λEX				-0.1493***	-0.2827***	-0.2827***
				(-4.68)	(-4.10)	(-4.10)
λIM				0.0168	-0.0894***	-0.0894***
				(0.61)	(-2.84)	(-2.84)
λFDI				0.0205**	-0.0555*	-0.0555*
				(2.28)	(-1.79)	(-1.79)
λGOVPERS				1.8023***	-0.5768***	-0.5768***
				(7.94)	(-10.86)	(-10.86)
λOILGAS				1.5518***	0.7163***	0.7163***
				(7.49)	(4.77)	(4.77)
λOPEN				-1.4631***	-0.5637	-0.5637
				(-9.94)	(-1.39)	(-1.39)
λSTUD				0.2865***	0.4686***	0.4686***
				(3.23)	(6.86)	(6.86)
R^2	0.882	0.989	0.996	0.673	0.996	0.996
F-Test	607.60	2k	3k	327.02	967.59	967.59

Table 2: Regression Results using Government Personnel

For reasons of multicollinearity researchers and government personnel are not implemented together, therefore Table 1 summarizes the results for the model without spillover effects including the researcher variable while Table 2 summarizes the results for the model without spillover effects including the government personnel variable[9].

Comparing the tables there is no big difference in the signs of the coefficients whether researchers or government personnel are used as a variable. Quality indicators like the R^2 and the F-test yield similar results for the lag-model; with the Durbin model the F-statistics are significantly larger in the case of using the government personnel variable. However, they are a first indicator that the results are stable.

Additionally, when comparing the results for the spatial lag and the Durbin model the variables retain their signs even though a few lose their significance the quality statistics indicate largely comparable results.

Considering the signs of the variables themselves most of them represent results expected

from economic theory. The only exceptions are the positive impact of imports, the negative impact of openness and the positive impact of the government personnel.

However, the positive impact of imports can be explained by assuming that the positive relation is not a direct effect but rather represents the effects of an antecedent variable. Having a better economic situation in a regions leads on the one hand to higher GRP values and on the other it leads to a larger number of wealthy inhabitants who in turn are more interested in acquiring foreign products.

On the other hand it can be assumed that a region that is producing efficiently also requires quality equipment which in turn is imported from abroad - a similar argument holds for foreign direct investments as well which on the one hand raise the economic output of a region but on the other hand might lead to higher imports of intermediate goods.

Nevertheless, a peculiar result is the consistently positive impact of the government personnel which, from the perspective that state ownership generates less efficiency as well as from the perspective that the number of government personnel can be used as a proxy for the level of corruption, can be seen as counter intuitive. Especially, since the comparatively large coefficient implies that a doubling of the amount of government personnel will lead to unrealistically high growth rates. This effect might be generated via the large share of government activity in the sector of natural resources which biases the analysis from the start.

Considering that the spatial lag variable is highly significant in the spatial lag model and that most of the spatially lagged variables in the Durbin model are highly significant this shows that there are important links between the regions. This goes along with the consistently positive and highly significant lagged variable which shows that economic growth across the regions of the Russian Federation is highly path-dependent.

Regarding the size of the coefficients the most important result of this study stems from comparing the researchers and the oil and gas production coefficients. While a doubling of the amount of produced oil and gas only results in raising the GRP by roughly 5% to 7%, a doubling of the amount of researchers results in raising the GRP by roughly 25% to 32%[10]. Even considering that the results might be biased by measurement errors it shows the remarkable importance of the research sector for the economic development of the Russian regions. Furthermore, it strengthens the hypothesis that investments in Russian high technology, research intensive sectors is not only more sustainable in the long term, but has consistently - even in the transition years - been driving the Russian regional development process.

Additionally, the importance of FDI inflows is even less significant for Russian growth as a rise of FDI inflows by one percent only leads an additional 0.01% of economic growth. However it needs to be considered that on average it is much easier to double the inflow of FDI than doubling the output of the oil and gas sector.

	Lag-Model			Durbin-Model		
	I	II	III	I	II	III
LAGT-1	0.5337***	0.7676***	0.6603***	1.7321***	0.5639***	0.7584***
	(7.28)	(8.82)	(7.08)	(10.30)	(6.87)	(9.09)
PATEPO	0.1723	0.0048**	-0.4821	0.1238	2.9759	-0.9755
	(0.19)	(2.15)	(-0.30)	(0.14)	(1.26)	(-0.62)
PATZIT	-1.8045*	4.5306***	18.1540***	-0.3742	3.0140*	14.4048***
	(-1.84)	(2.81)	(4.45)	(-0.37)	(1.79)	(3.58)
PATGEN	0.3196	-1.3661	4.1923***	0.0094	0.4196	4.0536**
	(0.43)	(-1.07)	(2.58)	(0.01)	(0.31)	(2.49)
MOBIN	0.1766	0.9549	-0.3093	-0.3438	1.2636	-0.4260
	(0.34)	(0.72)	(-0.36)	(-0.67)	(0.90)	(-0.49)
MOBOUT	-0.3831	-4.1656**	0.8150	0.1989	-3.3247	1.2014
	(-0.64)	(-2.01)	(1.01)	(0.33)	(-1.52)	(1.49)
EX	-0.0020	0.0388***	0.0299***	-0.0059	0.0341***	0.0209***
	(-0.56)	(4.41)	(5.78)	(-1.42)	(4.27)	(3.94)
IM	0.0048	0.0253*	0.0292***	0.0050	0.0115	0.0202***
	(0.95)	(1.91)	(5.22)	(0.91)	(0.96)	(3.51)
FDI	0.0008	0.0134***	0.0163***	0.0000	0.0144***	0.0103***
	(0.60)	(6.49)	(7.16)	(0.02)	(6.55)	(4.29)
RES	-0.0046	0.3224***	0.3554***	-0.0034	0.3705***	0.4209***
	(-0.26)	(17.89)	(24.09)	(-0.19)	(21.36)	(25.22)
OILGAS	0.0498***	0.0682***	0.0739***	0.0554***	0.0726***	0.1026***
	(3.15)	(7.69)	(11.65)	(2.62)	(7.93)	(12.66)
OPEN	-0.1720***	-0.0660*	-14.0198***	-0.0923***	-0.0718	-6.4719**
	(-3.96)	(1.69)	(-4.84)	(-3.72)	(-1.17)	(-2.05)
STUD	0.0010	0.0029	-0.0003	-0.0005	0.0032	-0.0019
	(0.83)	(1.11)	(-0.17)	(-0.45)	(1.12)	(-0.96)
TRDUM	-0.0053			-0.2106***		
	(-0.51)			(-8.45)		
CONST	0.0246	0.0084**	0.0117***	0.7670***	0.0001	0.0053
	(0.48)	(2.27)	(2.95)	(3.19)	(-0.04)	(1.22)
λ	0.9920***	0.7573***	0.7509***			
	(49.28)	(60.70)	(76.51)			
λPATEPO				87.4550	-288.7600***	17.2842
				(0.70)	(-3.94)	(0.77)
λPATZIT				89.7519***	-31.8619	-409.8724***
				(5.28)	(-0.79)	(-4.47)
λPATGEN				-49.1100***	132.5739***	-21.0194
				(-4.29)	(3.66)	(-0.57)
λMOBIN				-34.6833***	-10.8976	-31.0710**
				(-5.96)	(-0.35)	(-2.52)
λMOBOUT				21.8302***	215.7066***	6.0879
				(3.93)	(4.35)	(0.75)
λEX				-0.4180***	-0.5521***	-0.0994
				(-10.27)	(-3.41)	(-1.42)
λIM				0.2579***	-0.7076***	0.3127***
				(8.64)	(-5.44)	(2.91)
λFDI				-0.1185***	-0.0902	-0.0185
				(-7.11)	(-1.46)	(-0.77)
λRES				-0.4519	1.5370***	0.9082***
				(-0.92)	(13.20)	(8.75)
λOILGAS				2.0935***	0.1225	0.9992***
				(12.46)	(0.55)	(6.08)
λOPEN				0.1928	-1.4693	-107.1882***
				(1.04)	(-1.59)	(-4.29)
λSTUD				-0.1947***	-0.0430	-0.1789***
				(-8.36)	(-0.46)	(-4.19)
R^2	0.835	0.991	0.996	0.492	0.994	0.995
F-Test	189.74	914.04	lik	667.44	715.87	675.46

Table 3: Regression Results using Researchers – Extended Model

	Lag-Model			Durbin-Model		
	I	II	III	I	II	III
LAGT-1	0.5320***	0.9774***	1.1061***	0.5933***	0.5539***	0.9279***
	(7.14)	(14.00)	(10.46)	(7.75)	(7.41)	(10.86)
PATEPO	0.2089	2.9829	0.4885	1.3471	-0.2333	0.4737
	(0.23)	(1.04)	(0.36)	(1.23)	(-0.13)	(0.53)
PATZIT	-1.7037*	6.5726***	24.9893***	-1.3375	4.3330***	20.7063***
	(-1.74)	(3.95)	(7.46)	(-1.17)	(3.34)	(9.16)
PATGEN	0.3086	-1.8594	8.1275***	0.9906	-0.0500	3.5223***
	(0.42)	(-1.41)	(6.04)	(1.13)	(-0.05)	(3.80)
MOBIN	0.1417	0.9827	-0.7521	-0.8265	0.7706	-0.9993**
	(0.27)	(0.72)	(-0.99)	(-1.32)	(0.71)	(-2.03)
MOBOUT	-0.5709	-2.5467	0.5557	-0.1999	-0.6271	0.6870
	(-0.62)	(-1.10)	(0.82)	(-0.28)	(-0.37)	(1.49)
EX	-0.0018	0.0410***	0.0159***	-0.0001	0.0088	-0.0039
	(-0.50)	(4.29)	(3.45)	(-0.03)	(1.42)	(-1.22)
IM	0.0041	0.0239	0.0244***	0.0037	0.0058	0.0113***
	(0.81)	(1.63)	(5.11)	(0.52)	(0.64)	(3.41)
FDI	0.0007	0.0114***	0.0117***	0.0001	0.0070***	0.0007
	(0.53)	(5.25)	(6.07)	(0.05)	(4.01)	(0.53)
GOVPERS	0.1218	0.4927***	1.0444***	0.3458***	1.4068***	1.4075***
	(1.31)	(12.66)	(34.44)	(2.83)	(36.29)	(49.89)
OILGAS	0.0488***	0.0609***	0.0513***	0.0775***	0.0562***	0.0695***
	(3.09)	(6.12)	(9.75)	(4.24)	(8.04)	(13.71)
OPEN	-0.1780***	-0.1476***	-11.3195***	-0.0935***	-0.1710***	5.6484**
	(-4.07)	(-4.58)	(-4.55)	(-5.67)	(-3.49)	(1.98)
STUD	0.0010	0.0019	-0.0017	0.0012	0.0016	-0.0026**
	(0.79)	(0.71)	(-1.05)	(0.83)	(0.72)	(-2.39)
TRDUM	-0.0080			-0.1344***		
	(-0.76)			(-7.35)		
CONST	-0.1632	0.0337***	-0.0100**	-0.6522	-0.0002	0.0036
	(-1.12)	(7.05)	(-2.55)	(-0.41)	(0.05)	(1.39)
λ	0.9683***	0.5316***	0.0591**			
	(35.72)	(15.38)	(2.21)			
WPATEPO				74.0486***	-80.6887	58.3000***
				(4.01)	(-1.47)	(4.43)
WPATZIT				-19.4453	169.2441***	25.0042
				(-1.13)	(4.94)	(0.44)
WPATGEN				45.1487***	13.3786	-18.0638
				(3.07)	(0.51)	(-0.87)
WMOBIN				-45.9673***	0.1547	-50.6418***
				(-5.90)	(0.01)	(-6.80)
WMOBOUT				-10.7531	78.3841**	6.9260
				(-1.44)	(2.11)	(1.49)
WEX				-0.2037***	-0.1223	-0.0947**
				(-4.65)	(-1.00)	(-2.28)
WIM				-0.2669***	-0.5976***	0.2012***
				(-8.87)	(-5.54)	(3.19)
WFDI				0.0800***	-0.0239	-0.0160
				(5.04)	(-0.49)	(-1.09)
WGOVPERS				0.3692	-0.2765***	-0.5196***
				(1.01)	(-3.39)	(-9.59)
WOILGAS				1.7628***	0.8175***	1.2022***
				(7.22)	(4.96)	(11.73)
WOPEN				-2.3512***	-0.9477	-94.5788***
				(-19.04)	(-1.29)	(-6.76)
WSTUD				-0.0001	0.2452***	-0.0963***
				(-0.00)	(-3.29)	(-4.17)
R^2	0.837	0.989	0.997	0.910	0.996	0.998
F-Test	235.09	705.93	872.01	219.58	753.15	554.58

Table 4: Regression Results using Government Personnel – Extended Model

The consistently significant spatial effects reported in Tables 1 and 2 show that there needs to be some kind of interregional link between the regional entities of the Russian Federation. Assuming this link to be based on the diffusion of knowledge is, at least from a Western European

perspective, a viable option.

If the time horizon is cropped to allow for the use of the patents at the EPO[11] and active as well as passive patent citations[12] - as proxies for the in- and outflow of codified knowledge - and inventor inflows and outflows[13] - as proxies for the in- and outflow of tacit knowledge[14]. Tables 3 and 4 capture the results of the extended models[15].

The basic impacts of the variables that were previously implemented do not change and the qualitative indicators also do not change significantly. Thus, knowledge spillovers are rather unimportant for Russian regional growth and Russian regional growth benefits more from domestically generated and available knowledge than from foreign knowledge. The patent variable - a proxy for the generation of new codified knowledge - is only in rare cases significant. Thus, tacit knowledge - researchers and students - plays a more important role in regional growth than codified knowledge.

The results of this extended model show that the results discussed above remain stable - not alone regarding their signs but also regarding the coefficients - showing that they are independent of interregional knowledge spillovers[16].

In light of the fact that most of the spillover variables are insignificant in at least one sub-period it not possible to deduce a consistent result as to the impact of knowledge spillovers. One minor insight arises as both patent citation variables are positive and, at least in the later years, also significant. Patent citations can also be viewed as an indirect indicator of the presence of a significant research structure which generates the patents and a pool of qualified inventors that are involved in the respective research. Therefore, this positive impact can be viewed as a sign that a better research system and better legislation regarding practical research will be beneficial for the economic development of a region.

Finally, as the spatial term remains highly significant even though not all of the spatial interactions are covered by knowledge spillovers. Especially since the importance of the spillovers is rather marginal there are more important links between the regions besides knowledge flows that have not been explicitly included into the model.

Conclusions

The present study analyzed economic growth dynamics across the regions of the Russian Federation. Besides proving the path-dependency of Russian economic growth on a regional level, as well as its dependence on oil and gas, it has been shown that knowledge does and always has played an important role in the regional economic growth process. Here it is mostly researchers and to some very minor degree the amount of students - as proxies of the stock of tacit knowledge - that enhance economic growth while the amount of new patents - as a proxy of the codified knowledge generated in each period - and most knowledge inflows or outflows do not influence the economic development in any way.

In particular it has been shown that the impact of a doubling of the output of the oil and gas sector does generate less additional economic growth than a doubling of the number of researchers. Considering the future development of the Russian Federation it is an important insight especially since the result remains stable even during the transition years. It shows not only that science intensive sectors are benefactor of economic growth but also that the main dynamics of economic growth work comparably to Western European economies. Russia can therefore learn from their growth strategies and structural change programs to switch from being a resource-based to being a

knowledge-based economy.

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[1]See Machlup (1960) or Machlup (1962).

[2]While the results in Netter and Megginson (2001) strengthen this argument, for the Russian Federation Berkowitz and DeJong (2003) show that ownership has no impact on firm performance; they instead highlight more the firms' distance from Moscow, which in this study is implicitly included in the fixed effects.}

[3]It would be more suitable to include a variable like the *Corruption Perception Index*, or the *ICRG index of corruption* advocated by Kim (2010) or the *Bribe Payers Index* advocated by Ofer (2010); however, they are not available on a regional level for a continuous span of years. Note as well the arguments by Brown and Shackman (2007) who link corruption and the long-term development of the GDP per capita and a continuing deterioration of law and order.

[4]Refer for the resource curse hypothesis to Auty (1993), for example.

[5]For the Russian Federation Popov (2001) for example stresses the importance of the level of export shares for the regional performance.

[6]See Doehrn and von Westernhagen (2003) as one article that stresses the importance of FDI for growth in transition economies.

[7]See Blundell and Bond (1998) and Bond et al. (2001) who consider the Blundell-Bond estimator to be superior to the Arellano-Bond estimator in a growth related context.

[8]In total 80 regions have been considered. The three sub-regions of the Tyumen Oblast have been jointly considered as well as Archangelsk and the Nenetsia Autonomous Okrug.

[9]For reasons of a better readability the coefficients for the openness variable has been multiplied by the factor thousand.

[10]In other words raising the number of researchers by one percent leads to rise in GDP by 0.32% while a one percent rise in oil and gas output only leads to a rise in GDP by 0.05% to 0.07% - considering that researchers are measured absolutely and production of oil and gas in thousand tons.

[11]As only a version of the Patstat database from early 2008 has been available, comprehensive patent data has only been available up to 2006.

[12]An active patent citation takes place if an inventor from the region under consideration cites another patent, whereas a passive patent citation takes place if a patent is cited of which one inventor is registered living in the region.

[13]An inventor inflow is registered if a patent is granted with an inventor being listed as living in the region who has been listed in a previous patent as living in a different region. Inventor outflows are

defined vice versa.

[14]All patent citation as well as inventor flow variables are calculated based on EPO patent data, thereby accounting only for internationally important knowledge.

[15]For a better readability the coefficients of the patent and the four spillover variables have been multiplied by a factor of thousand.

[16]Only the students variable - before significant and positive in the later years - becomes insignificant in the extended model.

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Appendix

A.1 Abbreviation of Variables

The abbreviations used in the presentation of the econometrical results are summarized in the following table. It also contains the data sources of the variables.

Abbreviation	Variable	Source
CONST	Constant	-
GRPPC	Gross Regional Product per Capita	Rosstat (2012), Surinov (1999), Worldbank (2012)
EX	Exports	Rosstat (2012)
FDI	Foreign Direct Investment Flows	Rosstat (2012)
IM	Imports	Rosstat (2012)
INMOIN	Inflows of Inventors	EPO (2007)
INMOOU	Outflows of Inventors	EPO (2007)
LAGT-1	One Year Lagged Dependent Variable	-
OPEN	Openness	Own calculations and Rosstat (2012)
PATSTO	Stock of Patents at the EPO	EPO (2007)
RES	Researchers	Rosstat (2012)
SHADOW	Share of Shadow Economy	Own calculations and Rosstat (2012)
SME	Share of Small and Medium sized enterprises	Rosstat (2012)
STUD	Students	Rosstat (2012)
TRDUM	Dummy Variable for the Transition Years	-
λ	Spatial Lag Effects	-

Table 5: Abbreviation of Variables

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