UNBUNDLING THE EFFECT OF INSTITUTIONS ON INNOVATION ACTIVITY

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Submitted to
Central European University
Department of Economics

In partial fulfillment of the requirements for the degree of Master of Arts

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Budapest, Hungary

2009

ABSTRACT

This thesis evaluates relative importance of contracting institutions and property rights institutions for innovation activity. For this purpose I use a cross-country econometric model that assesses an impact of contracting and property rights institutions on innovation activity. To avoid endogeneity and measurement errors associated with OLS coefficients the model is estimated with 2SLS method. At the first stage of the regression, institutions are instrumented with a set of variables including geographical, cultural and political determinants. The main finding of the thesis is that property rights protection has a first order impact on innovation, whereas contraction institutions do not have highly significant effect.

ACKNOWLEDGEMENT

I would like to express gratitude to the people whose help and support was invaluable during my work on this thesis.

Foremost, I am particularly grateful to my academic supervisor Professor Peter Grajzl for advice and encouragement during the period of thesis writing as well as for his enthusiastic and systematic way of teaching.

My special thanks go to Sergey Kim. I appreciate his patience, constant believe in my talents and unflagging optimism.

I warmly thank my family: my parents Elena and Boris and my brother Mikhail, for their love and spiritual support through the years of studying abroad.

I am also grateful to my friends: Nataliia Laptieva, Maria Sharmina, Naila Movsumzade, Anastasia Aladysheva, Kateryna Stelmakh, Humaira Malik and Agota Meszaros for discussions, advice and friendly environment. I also wish to thank Ramiz Rahmanov for his comments at the period of choosing research topic.

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1. Introduction and Background

One of the founders of institutional economics, Douglas North, defines institutions as "the humanly devised constraints that structure political, economic and social interaction. They consist of both informal constraints (sanctions, taboos, customs, traditions, and codes of conduct), and formal rules (constitutions, laws, property rights)" (North 1991, p. 97). The main role of institutions is to reduce transaction and production costs and, consequently, to maximize wealth or utility of economic agents. There is a broad theoretical and empirical literature about the effect of institutions on economic development and different determinants of economic growth. The empirical literature emphasizes the significant positive impact of strong institutions on economic performance (Barro 1991, Knack and Keefer 1995, Hall 1999, Acemoglu and Johnson 2005, Dollar and Kraay 2003).

In the book "Structure and Change in Economic History" North (1981) develops theories about the two types of institutions which impact economy in different ways – "contract theory of the state" and "predatory or exploitation theory of the state". Contract theory explains how institutions help reduce transaction costs through the building of legal system which enforces private contracts. North argues that "a contract limiting each individual's activity relative to others is essential for economic growth" (North, 1981, p. 22). Other researchers (Coase 1960, Williamson 1975 and 1985, Grossman and Hart 1986, Hart and Moore 1990, and Hart 1995) confirm the importance of contract theory. Predatory or exploitation theory states that institutions are the tool which serves for the efficient allocation of resources in the society. According to this doctrine the main function of the state is to extract income from society in the interest of the group which is currently in power. So an institution's role is to limit the power of authorities. The predatory theory and in particular

protection against expropriation by government is discussed in such papers as Jones (1981), De Long and Shleifer (1993), and Olson (2000).

The empirical literature usually studies institutions without disentangling the separate effects of different institutions. However it is important to understand which type of institutions has more significant impact on economics performance. Acemoglu and Johnson (2005) consider separate effects of contracting and property rights institutions on the number of variables associated with economics development. They find that property rights institutions are important for long-run economic growth, investment, and financial development, whereas contracting institutions show the significant impact on financial intermediation. However, the authors did not study the effect of institutions on innovation activity.

It is widely known that innovation activity is one of the main determinants of economic growth and therefore studying innovations and their determinants is important (Solow 1956, Grossman and Helpman 1994, Jones 1995, Romer 1990, Romer 1994). There are many factors which determine innovation activity, institutions are among them. In fact, Rodrik (2000), Sala-i-Martin (2002) and Gradstein (2004) confirm that institutions can affect aggregation of knowledge. Nevertheless, there is lack of literature which directly focuses on this relation. There are few models which study the link between innovation and institutions explicitly (Huang and Xu 1999, Gradstein 2004, Tebaldi and Elmslie 2006). Empirical works are also limited (Tebaldi and Elmslie 2008).

The recent paper by Tebaldi and Elmslie (2008) provides an empirical test of the relations between institutions and innovations. The test is based on the theoretical model developed by authors earlier (Tebaldi and Elmslie, 2006). The authors used four indexes as measures of institutions: Rule of Law, Control of Corruption, Regulatory Quality and Risk of

Expropriation. The results confirm the theoretical hypothesis about positive impact of institutional quality on innovation activity. However, the article lacks comparison of the impact of different types of institutions: contracting and property rights institutional arrangements.

This thesis fills the gap in the research and presents results on the disentangled effect of contracting institutions and property rights institutions on innovation activity. The main research question of this paper is which type of institutions, contracting or property rights, has more effect on the growth rate of innovation. To answer this question cross-county econometric model is used.

The measures of institutions are similar to those used in Acemoglu and Johnson (2005). Property rights institutions are proxied with two alternative measures: protection against risk of expropriation and constraint on executive. The legal formalism index is used to measure contracting institutions. I use patent counts and research and development spending as the measures of innovation.

In order to avoid biases presented in Ordinary Least Squares (OLS) estimations the main econometric method used for the research is Two Stage Least Squares (2SLS). Within this method the measures of institutions are instrumented with a set of variables. Instruments include the following measures: latitude, cost line, legal origin, ethno-linguistic fractionalization of society and religion.

The empirical estimations presented in this paper show the following results. Property rights institutions have a significant impact on innovation activity. In contrast, contracting institutions do not show substantial effect. After controlling for property rights institutions contracting institutions do not have significantly different from zero impact on innovations. This pattern is shown by the base model and confirmed by the two additional specifications.

The possible interpretation of the result is that in the presence of weak contracting institutions formal contracts can be replaced by informal arrangements between economic agents (Acemoglu and Johnson, 2005). However the property rights protection can be maintained only by the state and in case of weak protection there is no valid substitution for this type of institutions.

The rest of the paper is organized in the following way: Section 2 describes channels and mechanisms which underlie the relations between the two types of institutions considered in the thesis and innovation activity. Section 3 discusses methodology, Section 4 presents results and Section 5 concludes.

2. Influence of Institutions on Innovations: Channels and Mechanisms

There are several theories which describe the mechanism underlying impact of institutions on technical innovation. For example, McArthur and Sachs (2001) summarize some works in this sphere. In particular, they describe linkages between geography, institution, technology and development. In this thesis I consider the channels of influence which are schematically presented on Figure 1. As can be seen from Figure 1 geographical determinants along with cultural aspects of society and colonization variables influence early institutions. On the basis of the historical institutions current ones are developed. Current institutions affect technology. Technology in turn determines economic growth.

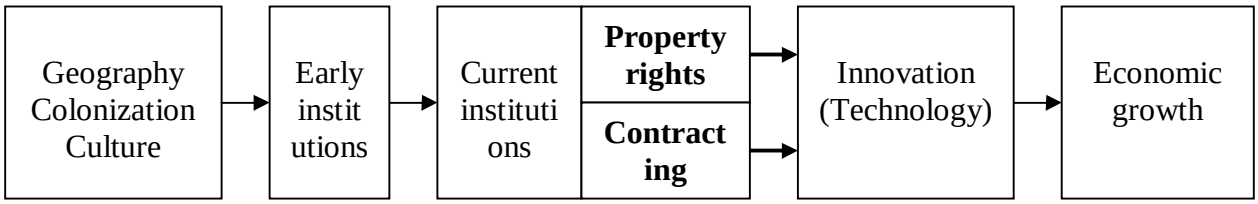

Figure 1. Institutions and Innovation

In my research I consider the effect of two types of institutions on technological innovation (measured as the average number of patents per capita). Following the work of Acemoglu and Johnson (2005) I study the effect of contracting institutions and property rights institutions separately. These two sets of institutional arrangements affect innovation activity in different ways. Below I describe the channels through which the enforcement of the contracts and the protection of property right affect the number of patents.

The effect of property right institutions on patents is quite straightforward. In the environment of the poor property rights protection the profit from the intellectual property can

not be fully extracted by the producer of patents. Therefore it may happen that cost of patenting is higher than profit from the patent. In this case incentives to innovate are poor. Moreover even if the firm produces some inventions which can be implemented it may decide not to patent it to reduce costs. So the production of patents is lower when the protection of property rights is weak.

The mechanism through which contracting institutions impact innovation is the following. As shown by Acemoglu and Johnson (2005) contracting institutions have an effect on financial intermediation. Weak enforcement of the contracts between the borrowers and lenders will lead to high risk of borrower's renege. In that case the total credit decreases and the development of financial markets becomes slower. Consequently the investments decrease. This means that investments in research and development diminish too. As a result of the decreasing investment on R&D the number of patens lowers. Summing up, weaker contracting institutions lead to lower patent production.

In sum, both contracting and property rights institutions may affect innovations though the channels mentioned above. However, which type of institutional arrangements matters more for innovation is still unclear. This thesis explores that question in details. The paper provides empirical estimation to compare the separate impact of contracting and property rights institutions on innovation activity.

3. Empirical strategy and Data

3.1. Base Econometrics model

The main research question of this work is which type of institutions more strongly affect rate of technical innovation. To answer this question the separation of the effect of contracting and property rights institutions is needed. To capture disentangled impact I follow the strategy of Acemoglu and Johnson (2005) and use the two variables estimating two types of institutions within the cross-section model:

$$(1)\ \ln(\Delta A_i) = \alpha_0 + \alpha_1 I_i + \alpha_2 F_i + \mu_i$$

Here ΔA_i is a measure of innovation in country i, I_i stands for property rights institutions and F_i stands for contracting institutions. In the main specification I use patent count as a measure of innovation activity.

The linear functional form of the equation is chosen because previous studies did not find evidence for significant interaction term or quadratic terms (Acemoglu and Johnson 2005, Tebaldi and Elmslie 2008). Absence of control variables in the base equation allows to determine the direct long-run relations between institutions and growth rate of innovation.

In order to check the robustness I include alternative specifications. First, I use the model with control variables used in the work by Tebaldi and Elmslie (2008) to see how the control variables can affect the results. The measure of the stock of technical knowledge and human capital in research and development sector are used as controls. As a second robustness check the model with alternative measure of innovation is discussed. In that model I use research and development spending instead of patent count to measure innovation activity.

3.1.1 Measuring institutions

Following the work of Acemoglu and Johnson (2005) I use similar variables for measuring institutional quality of property rights protection and contracting institutions. To measure property rights institutions two alternative variables are used: Protection against Risk of Expropriation and Constraint on Executive. The variables are highly correlated and therefore used separately. As a proxy for contracting institutions The Legal Formalism Index is used.

Protection against Risk of Expropriation variable is based on the probability of government's confiscation or coercive nationalization of property, the number is averaged over the period 1985-1995. The higher value of the variable corresponds to lower risk of forced confiscation of property by authorities. The original source of data is Political Risk Services. I collected the data from the appendix of the McArthur and Sachs's (2001) work.

Constraint on Executive variable reflects the constraint on the decision making power of authorities. The variable measures the political balance between different forces involved in the decision making process. The value ranges from 1 to 7, where 1 means Unlimited Authority and 7 - Executive Parity or Subordination. In the regression analysis the average values between 1990 and 2007 were used.

Legal Formalism Index is used as a proxy for costs of enforcing private contracts. The index measures the number of legal procedures needed for making a simple legal case. The measure is based on cases of unpaid check or evicting of non-paying tenant. Higher formalism scores imply larger delays in courts and consequently less efficient legal system which prevents efficient enforcement of contracts. So we can see that the Legal Formalism Index reflects the strength of contracting institutions.

3.1.2 Measuring innovation

Usually patent count or research and development spending are used as proxies for innovation activities. However, both measures have some drawbacks. For example, research and development spending can be considered as an input to innovation but not an output. It means that research and development investment does not necessary lead to mere invention and to the implementation of invention which is counted as innovation. Hence the research and development spending may have errors in measuring innovation activity (Morck and Yeung 2001).

The patent counts are considered to be better measure though it is also associated with some problems. The first possible source of measurement error comes from the fact that not all the inventions are patented. It can happen because of some secrecy or because of high cost of patenting procedure. Another problem is that patent count reflects a number of inventions. However, there is distinction between concepts of invention and innovation. Invention is a new idea and innovation is an idea which was successfully applied. Patenting does not necessary followed by implementation of the invention. Hence, patents do not always reflect the number of innovations. Moreover, not all patents are equal in value. Some patents can lead to larger technical progress whereas other patents can mean just modifications of some more significant innovation (Jaffe and Trajtenberg 2002 and Griliches 1990). Therefore even with the help of patent measure, innovation can be measured only with some error.

In spite of the limitations mentioned above the patent count has been used in many empirical works (for example Scherer 1984, Jaffe, Trajtenberg and Henderson 1993, Hall, Jaffe and Trajtenberg, 2000). Following the existing literature the present research uses average patent count per year over period 1970-2007 as a proxy for innovation in the main model. In the additional specification research and development spending per year per capita

is used as a measure of innovation to confirm the results of the main model. The measure of research and development spending is averaged over the period 1996-2005.

3.1.3 Control variables

Following the work of Tebaldi and Elmslie (2008) the present research uses human capital in research and development sphere and stock of technical knowledge as control variables. As a proxy for the stock of technical knowledge I use the variable which counts average book production in the country per year per capita. These variables control for the position of the country relative to the world knowledge frontier. Both variables are measured as average values per capita over the period 1996-2005. In the practical part of the work results with and without control variables are shown.

3.2. Empirical strategy

3.2.1. Justifying 2SLS

As a base empirical model the following equation estimated with the help of Ordinary Least Squares (OLS) could be used:

$$(2)\ \ln(\overline{p}_i) = \alpha_0 + \alpha_1 I_i + \alpha_2 F_i + \mu_i$$

However, there are some problems associated with the OLS estimation of this model. The first problem is potential endogeneity in the measures of institutions and the second caveat is measurement errors.

One of the reasons for endogeneity is the possibility of reverse causality in the model. Increase in innovation positively affects economic development and consequently it can lead to higher demand for strong institutions. So the backward causation can lead to overestimated coefficients (positive bias) under OLS. The broad discussion of reverse causality of

institutional variables in the models of economic growth can be found in the paper by Glaeser, La Porta, Lopes-de-Silanes and Shleifer (2004).

In addition to the reverse causality problem, the measures of institutions can be correlated with some omitted variables which can also cause endogeneity. Possible omitted variables may include some geographical determinants and measures reflecting cultural aspects of society. For example, the cultural divergence of society can be negatively correlated with institutional term. Obviously, in less homogeneous societies it is more difficult to come to compromise decisions and therefore institutions are weaker. On the other hand in the multicultural communities the information flow is higher and therefore it can lead to more broad horizons in terms of knowledge and ideas which can cause innovation activities. Summing up, cultural divergence of society is positively correlated with innovations and negatively correlated with institutions which imply possible downward bias of OLS estimates. However, other potential omitted variables like latitude can lead to positive bias (positive correlation with innovation and institutions). Therefore omitted variable bias can go in both directions.

Another possible problem affecting OLS estimations of the model is the measurement errors. The model has potential measurement errors in the explanatory variables (institutions) as well as in dependent variable (innovation). In fact, the indexes used to measure institutional quality (formalism index, protection against risk of expropriation and constraint on executive) can not be direct measures of the concepts which are supposed to be measured – the strength of contracting and property rights institutions. Under the classical error-in-variables assumption (measurement error is not correlated with the unobserved explanatory variable) OLS gives attenuation bias (Wooldridge, 2003, pp. 306-307). In particular, in case of positive coefficient as can be expected for the measures of property rights institutions the OLS bias is downward, whereas in the estimation of contracting institutions with the expected negative

coefficient the OLS bias is likely to be upward. In addition, as discussed in section 4.1.2 the measures of innovation activity are also subject to measurement error. However, the error in dependent variable (innovations) does not cause severe problems. I assume: 1) zero correlation between measurement error and independent variables and 2) zero mean of measurement error. Under these assumptions the OLS estimation can be considered as unbiased. The discussion about measurement errors implies that measures of institutions are subject to attenuation bias. More specifically, property rights institutions may have downward bias in OLS estimations and for the measures of contracting institution upward bias can be expected in the estimations by OLS.

For all the reasons mentioned above OLS method will not give reliable results. The coefficients will be subject to either upward biases because of reverse causality and omitted variables or downward biases due to omitted variables and measurement error. To avoid problems associated with OLS Two Stage Least Squares (2SLS) method is applied. For the first stage of the 2SLS model a set of variables is needed to instrument institutions. The instrumental variables should be correlated with institutional measures and uncorrelated with the error term.

3.2.2. Choosing Instrumental Variables

According to Acemoglu, Johnson and Robinson (2001) Early European Settler Mortality Rate is an important instrument that determines institutional quality. They argue that in the colonies with high level of mortality Europeans preferred not to settle. Therefore the institutions which were set in these colonies were „extractive". It means that colonizers do not set property right protection institutions; instead they try to extract all the resources from the colonized country. In contrast, at the places where the climate was not severe Europeans

arrange settlements and establish legal rules and social system similar to ones in their home countries.

The settler mortality variable proves to be a reliable instrument for institutions. Though in the framework of my research using this instrument shrinks the sample substantially, it has only 68 observations. Therefore it leads to insignificant estimations. Actually settler mortality rates highly depend on climate and are linked with the geographical variables. For example, Canada and the USA have similar climate conditions to Europe and the mortality was relatively low there. Therefore colonizers settled in that regions and established strong institutions. In contrast, sub-Saharan Africa, Central America and South Asia have severe hot climate and consequently population was subject to many infection diseases that led to high mortality rates among European settlers. Taking into account high positive correlation of Early European Settler Mortality Rate and climate I decide to substitute Settler Mortality in the regression with a bunch of geographical determinants. This allows controlling for the effect of early institutions and increases the sample. There are many empirical works which use the geographical variables as instruments for institutions – for example, William and Levine (2003), Hall and Jones (1999) and McArthur and Sachs (2001). In the econometrics model in my research I use two geographical variables – Latitude and Cost Line. Latitude variable shows the relative distance from equator, variable ranges from 0 to 1. Cost Line variable measures the share of land within the 100 km of sea cost.

Another important determinant of institutional quality is Legal Origin. The importance of this variable was discussed in many papers by La Porta et al. (1997, 1998, 1999), also the variable was used as a determinant of institutions by such authors as Acemoglu, Johnson (2005), Glaeser, La Porta, Lopes-de-Silanes and Shleifer (2004) and others. According to La Porte, Lopez-de-Silanes, Shleifer, and Vishny (1999) legal systems can be considered as an allocation of power between the state and the property owners. The Legal Origin variable is

based on the classification of the Commercial Law of each country. In my work I use three dummy variables for legal origin: English, French, and German.

La Porta et al. (1999) state that political heterogeneity in a society can affect the government's performance. To control for political divergence I include measure of ethno-linguistic fractionalization of society. Ethno-linguistic diversity variable is composed of several indices measuring the probability that two randomly selected people will belong to different language groups. This variable was used in works by Hall and Jones (1999) and Dollar and Kraay (2003). More specifically, works by Mauro (1995), Easterly and Levine (1997) show that ethno-linguistic fractionalization is associated with corruption and rent seeking.

Finally, according to cultural theories of institutional determinants (La Porta et al., 1999) cultural characteristics are among factors affecting the development of institutions. To assess the impact of the cultural features religion variables (Catholic and Muslim) are included into regression. The variable shows the percentage of the population affiliated with a certain religion. These measures are working as a proxy for such characteristics of the society as work ethic, tolerance and trust. The importance of the religion as a determinant of investor protection and consequently of property rights institutions is discussed in the paper by Stulz and Williamson (2001). The religion variable can be chosen as IV because it does not have a direct impact on innovation activity, but only through the channel of past institutions (see Figure 1).

After choosing the set of instruments the following IV equation for measuring institutions is set:

$$(3)\ T_i = \alpha_1 + \alpha_2 G_i + \alpha_3 L_i + \alpha_4 E_i + \alpha_5 R_i + \mu_i$$

In this equation T stands for either contracting or property rights institutions (Legal Formalism or Protection against Risk of Expropriation or Constraint on Executive), G is Geographical determinants (Latitude and Cost Line), L is Legal origin (English, French and German), E stands for Ethno-linguistic diversity of society, R is Religion (Catholic and Muslim). Sources of data are presented in Table 11 in Appendix.

4. Results

4.1. Descriptive statistics

Descriptive statistics are presented in Table 1 in Appendix. Mean value, standard deviation and number of observations are shown for every variable used in the research. Data on control variables (human capital in R&D, stock of technical knowledge) have many gaps and tend to decrease the sample size. Therefore regressions are presented in several alternative specifications with and without controls. In addition, the table contains data on log European Settler Mortality. We can see that the sample for this variable is small due to missing data (68 observations) in comparison to the data on geographical variables – latitude has 207 observations and the data on cost line contains 150 observations. Therefore I use the geographical measures instead of the settler mortality rates to avoid shrinking of sample.

Table 2 shows means for the main variables of interest – patents and institutions for high and low latitude countries. It reveals that the countries which are closer to equator have higher formalism index, higher risk of expropriation and looser constraint on executive. So for the states in a relatively hot climate overall institutional quality is lower and patent production is lower too. It indirectly confirms the hypothesis of the effect of geography on institutions and on innovations through the channel of institutions.

In Table 3 simple correlations between patent counts and institutional measures are shown. The correlations have intuitively predicted signs. Formalism index is negatively correlated with production of patents, and both property rights institution measures are positively correlated with innovation: lower risk of expropriation and higher executive constraint is associated with higher patent count.

4.2. Empirical Results

4.2.1. OLS

First, I consider Ordinary Least Squares (OLS) estimations of the baseline model with patent count as a measure of innovation.

$$(4)\ \ln(\overline{p}_i) = \alpha_0 + \alpha_1 I_i + \alpha_2 F_i + \mu_i$$

The results for the OLS regressions are presented in Table 4. I consider regressions of the effect of the two institutional arrangements (contracting and property rights) on innovation first separately (columns 1-3) and then both measures together (columns 4, 5). The sample varies from 77 to 128 countries. Most of the results are significant and have the predicted sign.

Column 1 indicates that one standard deviation decrease in the formalism leads to 67% increase in the number of registered patents. Columns 2 and 3 imply that the stronger protection against expropriation and constraints on executive cause an increase in patenting activity. According to the estimations, the effect of protection against expropriation is higher. One standard deviation increase in protection against expropriation measure leads to the 72 % increase in the patent count, the effect of constraint on executive is 56%.

In column 4, I consider the model where protection against expropriation and formalism are presented. Interestingly, the sign for the coefficient on formalism is counterintuitive. It can be explained by small sample and by possible correlation of formalism index with error term. For example, omitted legal system measures can influence the results of the regression. Column 5 shows the effect of both formalism and protection against expropriation on innovation. In that specification the signs of the coefficients are intuitive.

Ideally I would compare effect of different types of institutions in both specifications which include both measures of institutions, i.e. columns 4 and 5. But column 4 (with Average Protection against Risk of Expropriation proxying property right institution) always gives counterintuitive sign on Formalism Index. Therefore I measure effect of institutions only based on column 5 in all the specifications.

Estimations from column 5 give the following results. The effect of one standard deviation of both measures on innovation is quantitatively similar. Decrease in formalism implies 51% increase in patenting and increase in constraint on executive gives 57% increase in patenting.

Summing up, OLS results do not give a clear answer which institutional arrangement is more important: property rights or contracting institutions. The measured effects of institutions are quantitatively quite similar. However, OLS regressions are subject to endogeneity problem and therefore the results are not very reliable. To consider institutions exogenously the IV estimations are used within the frame of the Two Stage Least Squares method.

4.2.2. 2SLS

Table 5 provides the first stage results for the measurements of institutions. Equation (3) is estimated with OLS method. First column shows that the most important determinant of formalism index is legal origin. The coefficient on the variable representing English legal origin is highly significant and has a predictable sign. It shows that countries with English Legal Origin tend to have lower degree of formalism and therefore stronger contract enforcement. The result fits the existing literature. For example this result is in line with the findings of La Porta, Lopez de Silanes, and Shleifer (2008).

Columns 2 and 3 show the estimations for the measures of property rights protection. The results imply that for property rights protection initial institutions and cultural arrangements are more important than legal origin. Strong coefficients on latitude and cost line measures confirm the importance of the "European settler's mortality" theory, saying that institutions are stronger in the countries with less hot climate where the mortality rates were lower. In addition, the hypothesis of institutional impact on economy through the cultural mechanisms is supported by significant results for religion and ethno-linguistic fractionalization of society. The results imply that in the framework of colonization theory of institutions the more important determinant for property rights arrangement was the way of colonization "extracting" or "settling" and not the legal system which was set. Overall, the results from the first stage regression are similar to the ones of Acemoglu and Johnson (2005) who find that the formalism measure are based on the legal origin instruments and the property right protection is based on the settler mortality instruments.

Table 6 shows the results for the second stage of 2SLS where institutional measures are instrumented with the set of IVs. The absolute values of the coefficients are on average about 60% higher than the OLS estimations. This implies that OLS regressions substantially underestimate the effect of institutions on innovation due to attenuation bias. This in turn indicates that significant measurement error exists in OLS estimations. In addition, it implies that impact of reverse causality associated with the upward bias is weaker than the effect of measurement error and omitted variables associated with the underestimation of the coefficients by OLS. The probable reasons and the possible directions of the bias are discussed in the section 3.2.1. The findings of substantially higher values of IV estimates are in line with the results from Acemoglu, Johnson and Robinson (2001) and Acemoglu and Johnson (2005). In these works the coefficients are approximately doubled after using instrumental variables for institutions.

Columns 1 to 3 of Table 6 present the results for institutional measures separately. The coefficients are significant and have intuitive signs. The interpretation of the results in columns 1-3 is the following. Half of standard deviation decrease in formalism index causes about 100% increase in the patent number. For half of standard deviation increase in expropriation measure and the constraint on executive measure lead to 76% and 94% respective increase in patents number.

In the remaining columns the results for the simultaneous effect of both types of institutions are shown. Column 4 gives the results on the effect of formalism index and protection against expropriation. As OLS regressions 2SLS method also gives counterintuitive sign of the coefficient for formalism index, though the estimation is not significant.

The positive sign of the coefficient on formalism index (as in column 4), the decrease in value of coefficient (between columns 1 and 4 or 1 and 5) and the insignificant estimation (column 4 and 5) at the presence of the measures of property rights institution can mean that there is a correlation between the measures of contacting institution and the measures of property rights institutions. The strong results for the estimation of Formalism Index when it is measured separately can be explained by the fact that in univariate regression part of the effect measured by formalism can be actually the effect of the property right institutions. Therefore after controlling for the property rights the impact of contracting institution becomes smaller in size and insignificant.

Column 5 provides estimation for the impact of formalism and executive constraint. The estimation of Constraint on Executive is large and highly significant. Both coefficients are almost twice as higher than in OLS. The disentangled effect of institutions is calculated from the results in column 5. The effect of one standard deviation increase in formalism index

is 120% increase in patenting activity whereas one standard deviation improvement in constraints on executive leads to 227% increase in patent count.

Summing up, the effects found in 2SLS are much higher than the ones in OLS estimation because of the attenuation bias under OLS. Importantly, the 2SLS results unambiguously indicate that the impact of improving protection of property rights on innovation activity is larger than the impact of improving contracting institutions. Therefore to increase innovation activity the main focus should be done in improving property rights institutions.

The possible explanation of this result can be the fact that the contract enforcement institutions provided by state can be partially substituted by the reputation mechanisms and other private contracting tools, though the protection of the property rights could be hardly substituted by any unofficial method.

4.3. Robustness checks

4.3.1. Controlling for stock of technical knowledge and human capital

The next step is to study the results from the model with controls to check robustness. Following the paper by Tebaldi and Elmslie (2008) I use two controls: stock of technical knowledge proxied by average book production (A) and human capital in research and development sector (H). These variables allow controlling for distance from the work knowledge frontier. In Tables 7 and 8 the results for estimation of the following equation are presented.

$$(5)\ \ln(\overline{p}_i) = \beta_0 + \beta_1 I_i + \beta_2 F_i + \beta_3 A_i + \beta_4 H_i + e_i$$

Table 7 shows results of estimation of equation (7) with OLS method. The coefficients measuring the effect of the expropriation index and formalism have expected sign and mainly significant. However Constraint on Executive does not have statistically significant impact on patents. The coefficient on the stock of technological knowledge variable is very significant. The coefficients on human capital are not significant and sometimes have a negative sign.

Table 8 presents results for 2SLS regressions with the two controls. The results in general show the same patterns as in OLS regressions, but the value of the coefficients are higher in 2SLS. In addition, 2SLS coefficients on formalism are not statistically different from zero. These results imply that the stock of knowledge is important determinant of innovation activity and it might capture the most of the effect. Therefore it may cause insignificant and counterintuitive results for contracting institutions and human capital.

I consider column 5 of Table 8 to compare the effects of institutions (Legal Formalism and Constraint on Executive) on patents. The effects of one standard deviation in these two types of institutions have the following values of increase in patenting activity: 66% for Formalism and 207% for Executive Constraint.

Summing up, the alternative model with control variables suggests the following outcome. The estimation with controls shows that formalism has significantly smaller impact on innovation in comparison to property right institutions. Hence specification with control variables confirms the result from the main model.

4.3.2. Proxying technological progress with R&D spending

For the additional robustness check, I use equation with research and development spending as a measure of innovation instead of the patent count. The independent variable is logarithm of the average research and development spending per year per capita.

$$(6)\ \ln(RD_i) = \delta_0 + \delta_1 I_i + \delta_2 F_i + u_i$$

The disadvantages of research and development spending variable as a measure of innovation are discussed in the section 4.1.2. In spite of some problems associated with this variable, I use this specification too to confirm the results given in the model with patent counts.

The results are presented in Tables 9 and 10. Estimations with OLS and 2SLS show that measure of contracting institution does not have any significant impact on the research and development spending when controlling for property rights institutions. In contrast, proxies of protection of property rights have positive significant coefficients. In short, the model with research and development spending as a measure of innovation confirms the results given by the main model: property rights institutions have larger and more significant impact on innovation activity than the contracting institutions.

5. Conclusion

Within the framework of the institutional theory, the concepts about contracting and property rights institutions were first emphasized by North (1981) and later by other economists (Coase, 1960, Williamson 1975 and 1985, Grossman and Hart, 1986, Hart and Moore, 1990, and Hart, 1995, Jones, 1981, De Long and Shleifer, 1993, and Olson, 2000). However, the empirical literature about separation of impact associated with different types of institutions is limited. In recent paper Acemoglu and Johnson (2005) extracted the unbundled effect of property rights and contracting institutions for a number of different measures of economic performance, though innovation activity was not considered. This thesis filled that gap and continued previous research by Acemoglu and Johnson (2005). More specifically, I studied the question of relative importance of contracting versus property rights institutions for the development of innovation activity.

In this thesis I estimated a cross-country econometric model to evaluate an impact of contracting and property rights institutions on innovation activity. Due to the potential endogeneity of the institutional variables and possible measurement errors, the OLS method is not considered as a reliable one. The main econometrics method is 2SLS with the set of instruments for the measures of institutions. The estimation of main model is supplemented with the two additional specifications for the purpose of robustness check.

My research revealed that property rights protection has strong positive effect on innovation activity, whereas contracting institutions have much less impact on innovations. This result was shown by the baseline model and confirmed by the model with control variables. In addition a similar outcome is produced by the specification with the research and development spending as a measure of innovation. More limited role of contracting institutions in comparison to property rights institutions can be interpreted in the way

mentioned by Acemoglu and Johnson (2005). The reputation mechanisms and other private contracting tools can partially replace contracting institutions enforced by government. On the contrary, the protection of the property rights can not be easily substituted by any unofficial tool. Therefore the effect of contracting institution might be not as significant as the impact made by property rights institutions.

The results are in line with the previous research by Acemoglu and Johnson (2005). Authors found that property rights institutions affect the three main determinants of the long-run economic growth and contracting institution affect only the development of the financial sector. My research shows similar picture for innovation: property right institutions play a first order role in determining innovation activity.

Policy implications are suggested by the thesis results. To increase the long-run rate of innovation activity the improvement of property rights institutions is more important than contracting institutions. Therefore property rights protection should be preferential in terms of improving institutional quality.

The current research is subject to some caveats. The main problem is data limitation. In fact, data for some variables is not available for a number of countries. This leads to the missing data and significantly shrinks the sample. For example, one of the most important variables used in previous literature - the European Settlers Mortality in Colonies - can not be applied for this reason.

Further research is needed to find the particular channels through which the two considered types of institutions, and in particular property rights institutions, affect innovation. For example, more detailed unbundling of the effect of property rights institutions can give some more information on the channels. More specifically, property rights institutions can be divided into political and non-political groups of institutional arrangement.

This direction of research can shed more light on the explanation of the results discussed in the thesis.

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Appendix

Table 1 Descriptive statistics

			Mean	Std. Dev.	Number of Observations
Innovation		Logarithm of average patent per year per capita	3.61	2.14	142
		Logarithm of average research and development spending per year per capita	-3.39	1.97	104
Institutions	Contracting	Legal Formalism	3.68	0.94	109
	Property rights	Protection Against Risk of Expropriation	7.02	1.82	118
		Constraint on Executive	4.45	2.12	163
IV variables	European Settler Mortality Rate		4.65	1.26	68
	Geographic	Latitude	0.35	0.74	206
		Cost line	0.35	0.35	150
	Legal origin	English	0.34	0.47	206
		French	0.44	0.5	206
		German	0.03	0.18	206
	Religion	Catholic	32.28	36.24	206
		Muslim	22	35.35	206
	Ethno-linguistic diversity		0.32	0.30	160
Controlls	Log Human capital in research and development sector		3.54	2.61	87
	Log Stock of technical knowledge		4.78	2.12	92

Table 2 Statistics for high and low latitude

	Latitude	
	>0.45	<0.45
Logarithm of average patent count per year per capita	5.46	2.85
Legal Formalism	3.52	3.77
Protection Against Risk of Expropriation	9.04	6.48
Constraint on Executive	5.84	4.00

Table 3 Simple Correlation of Institutional Measure and Patent Count per capita

	Legal Formalism	Protection Against Risk of Expropriation	Constraint on Executive
Logarithm of average patent per year per capita	-0.26	0.64	0.43

Table 4 Main model. OLS

Dependant variable is logarithm of average patent per year per capita					
	(1)	(2)	(3)	(4)	(5)
Legal Formalism	-0.323			0.318 **	-0.286
	(0.21)			(0.14)	(0.19)
Protection Against Risk of Expropriation		0.979 ***		1.116 ***	
		(0.07)		(0.09)	
Constraint on Executive			0.629 ***		0.597 ***
			(0.08)		(0.10)
Constant	5.508 ***	-3.447 ***	0.437	-5.592 ***	1.990 **
	(0.82)	(0.55)	(0.41)	(1.00)	(0.93)
Number of observations	95	97	128	77	88
R-Squared	0.02	0.64	0.34	0.70	0.30

Notes:
1. Standard errors are in parentheses.
2. ***, **, * denote statistical significance at 1%, 5% and 10% level respectively.
3. All regressions are cross-sectional with one observation per country.
4. For sources and details of indicators used see Table 11

Table 5 Main model. 2SLS. First Stage Results

	Dependent Variables		
Independent Variables	Legal Formalism	Protection Against Risk of Expropriation	Constraint on Executive
Legal Origin - English	-0.962 ***	0.653	-0.075
Legal Origin - German	-0.162	1.563 **	0.741
Legal Origin - French	0.441	0.074	-0.699
Ethno-linguistic diversity	0.422	0.255	-1.042 *
Religion - Catholic	0.005	0.001	0.012 *
Religion - Muslim	-0.002	-0.011 *	-0.019 **
Latitude	-0.824	5.995 ***	0.218
Cost line	-0.047	0.426	1.057 **
Constant	3.944 ***	5.027 ***	4.993 ***
Number of observations	80	107	120
R-Squared	0.54	0.54	0.40

Notes:
1. ***, **, * denote statistical significance at 1%, 5% and 10% level respectively.
2. All regressions are cross-sectional with one observation per country.
3. For sources of indicators used see Table 11

Table 6 Main model. 2SLS. Second Stage Results

Dependant variable is logarithm of average patent per year per capita					
	(1)	(2)	(3)	(4)	(5)
Legal Formalism	-0.63 **			0.35	-0.45
	(0.33)			(0.22)	(0.31)
Protection Against Risk of Expropriation		1.38 ***		1.43 ***	
		(0.11)		(0.13)	
Constraint on Executive			1.09 ***		1.34 ***
			(0.15)		(0.20)
Constant	6.52	-6.36 ***	-2.11 ***	-8.05 ***	-1.74
	(1.28)	(0.83)	(0.79)	(1.50)	(1.68)
Number of observations	75	91	100	75	74
R-Squared	0.05	0.61	0.37	0.65	0.35

Notes:
1. Standard errors are in parentheses.
2. ***, **, * denote statistical significance at 1%, 5% and 10% level respectively.
3. All regressions are cross-sectional with one observation per country.
4. For sources of indicators used see Table 11

Table 7 Model with controls. OLS.

Dependant variable is logarithm of average patent per year per capita					
	(1)	(2)	(3)	(4)	(5)
Log of human capital in R&D sphere per capita	-0.14	0.07	0.00	0.06	-0.12
	(0.10)	(0.10)	(0.12)	(0.10)	(0.12)
Log of book production per capita	0.99 ***	0.65 ***	0.91 ***	0.56 ***	0.97 ***
	(0.17)	(0.15)	(0.21)	(0.18)	(0.23)
Legal Formalism	-0.36 **			0.04	-0.36 **
	(0.16)			(0.15)	(0.17)
Protection Against Risk of Expropriation		0.52 ***		0.57 ***	
		(0.12)		(0.13)	
Constraint on Executive			0.10		0.02
			(0.14)		(0.13)
Constant	1.04	-3.47 ***	-1.07 *	-3.35 **	0.97
	(1.05)	(0.72)	(0.61)	(1.25)	(1.11)
Number of observations	53	48	56	43	51
R-Squared	0.67	0.84	0.71	0.82	0.66

Notes:
1. Standard errors are in parentheses.
2. ***, **, * denote statistical significance at 1%, 5% and 10% level respectively.
3. All regressions are cross-sectional with one observation per country.
4. For sources of indicators used see Table 11

Table 8 Model with controls. 2SLS.

Dependant variable is logarithm of average patent per year per capita					
	(1)	(2)	(3)	(4)	(5)
Log of human capital working in R&D sphere per capita	-0.04	0.08	0.24	0.10	0.23
	(0.12)	(0.10)	(0.15)	(0.11)	(0.17)
Log of book production per capita	1.02 ***	0.67 ***	0.53 *	0.37	0.29
	(0.18)	(0.18)	(0.30)	(0.25)	(0.35)
Legal Formalism	-0.28			0.17	-0.33
	(0.23)			(0.24)	(0.27)
Protection Against Risk of Expropriation		0.50 **		0.81 ***	
		(0.19)		(0.24)	
Constraint on Executive			0.51 *		0.85 ***
			(0.28)		(0.33)
Constant	0.32	-3.40 ***	-2.15 **	-4.94	-1.56
	(1.36)	(0.99)	(0.80)	(1.92)	(1.76)
Number of observations	41	45	45	41	41
R-Squared	0.74	0.84	0.79	0.81	0.64

Notes:
1. Standard errors are in parentheses.
2. ***, **, * denote statistical significance at 1%, 5% and 10% level respectively.
3. All regressions are cross-sectional with one observation per country.
4. For sources of indicators used see Table 11

Table 9 Research and development spending as a measure of innovation. OLS.

Dependant variable is logarithm of average research and development spending per year per capita					
	(1)	(2)	(3)	(4)	(5)
Legal Formalism	-0.47 *			0.02	-0.33
	(0.24)			(0.21)	(0.210)
Protection Against Risk of Expropriation		0.58 ***		0.66 ***	
		(0.09)		(0.13)	
Constraint on Executive			0.47 ***		0.51 ***
			(0.09)		(0.13)
Constant	-1.54	-8.14 ***	-6.12 ***	-9.00 ***	-5.22 ***
	(0.96)	(2.20)	(0.53)	(1.64)	(1.15)
Number of observations	82	80	98	69	78
R-Squared	0.05	0.32	0.21	0.31	0.21

Notes:
1. Standard errors are in parentheses.
2. ***, **, * denote statistical significance at 1%, 5% and 10% level respectively.
3. All regressions are cross-sectional with one observation per country.
4. For sources of indicators used see Table 11

Table 10 Research and development spending as a measure of innovation. 2SLS.

Dependant variable is logarithm of average research and development spending per year per capita					
	(1)	(2)	(3)	(4)	(5)
Legal Formalism	-0.38 *			0.01	-0.19
	(0.31)			(0.33)	(0.29)
Protection Against Risk of Expropriation		0.81 ***		0.86 ***	
		(0.13)		(0.20)	
Constraint on Executive			0.49 **		0.76 ***
			(0.16)		(0.20)
Constant	-0.31	-10.04 ***	-6.50 ***	-10.53	-5.89 ***
	(1.21)	(1.04)	(0.90)	(2.57)	(1.86)
Number of observations	67	75	80	67	66
R-Squared	0.08	0.26	0.19	0.28	0.19

Notes:
1. Standard errors are in parentheses.
2. ***, **, * denote statistical significance at 1%, 5% and 10% level respectively.
3. All regressions are cross-sectional with one observation per country.
4. For sources of indicators used see Table 11

Table 11 Sources of data

	Variable	Source
Innovation	Patent count	WIPO (World Intellectual Property Organization) Statistics Database, December 2008
	Research and development spending	UNESCO
Controls	Human capital in research and development sphere	UNESCO
	Stock of technical knowledge (book production)	UNESCO
Institutions	Contracting institutions: Legal formalism index	Djankov, La Porta, Lopez-de-Silanes, and Shleifer (2003)
	Property rights institutions: Protection against risk of expropriation	McArthur, Sachs (2001)
	Property rights institutions: Constraint on executive	Polity IV Project http://www.systemicpeace.org/polity/polity4.htm
IV variables	Mortality of Early Settlers	Acemoglu, Johnson and Robinson (2001)
	Religion	La Porta, et al. (1999)
	Ethno-linguistic diversity	La Porta, et al. (1999)
	Legal origin	La Porta, et al. (1999)
	Latitude	La Porta, et al. (1999)
	Coast line	McArthur, Sachs (2001)