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MULTILEVEL MODELING IN EXPLORING INSTITUTIONAL EFFECTS ON PERFORMANCE

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Abstract

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The article engages in exploring the differences between standard panel regression model and multilevel panel model while estimating growth models on a sample of European food manufacturing companies for period 2004–2013. The article provides an overview of both approaches, critically identifies their strengths and weaknesses and concludes by recommendation on specifics of usage of each of those. Results of models suggest positive impact of political and legal framework and openness of economy and negative impact of government expenditures and economic conditions on firm performance. Comparison of approaches shows that similar results are obtained, though with relative higher significance of multilevel model's coefficient. Theoretical background of Growth Theory and statistical methods suggest preference of multilevel model with a constrain of data availability.

Keywords: multilevel model; institutions; growth model; panel regression; microeconomy; European Union; Solow model

INTRODUCTION

Institutions are crucial fundament that shape human behavior, or "rules of the game in a society or, more formally, are the humanly devised constraints that shape human interaction" (North, 1990, p. 3).

During the last decades, it has been shown that institutions are crucial for development and growth and therefore have been studied by growth theory's scholars who focused on various aspects of institutional framework and their influence on the output, growth, inequity and others. Institutions are part of a larger spectrum of factors, called fundamental factors (see below for the division) along with geography, trade and culture (Xu, 2011). All the factors considered in this paper are institutional factors, with an exception of openness, which is a trade factor. For this reason, variables considered in the paper are often called fundamental, though the particular interest is in institutions.

Though number of studies has been dedicated to macroeconomic performance, it is clear that – if macroeconomic performance is determined by institutions – then also microeconomic performance needs to be influenced by it as well. The reason for this is simply that the economy consists of microeconomic agents (e.g. firms) and therefore their performance will cause macroeconomic performance. This paper is therefore focused on microeconomic performance of economic agents, specifically firms.

Another specifics of the paper are in its relatively short time and similar countries focus – both different to standard growth theory's papers that are considering long periods and countries with different cultural (and other) specifics. This method allows to leave cultural and other differences out of account and also to focus on specific period of business cycle – the economic contraction.

The goal of the paper is to present the impact of selected factors of institutional framework on firm performance with the usage of multilevel modelling and to compare the differences between this approach and method by standard panel regression. The paper does not engage in technical specifics of multilevel modelling as it can be found in a wide range of literature, but rather in application specifics and particular usage in growth theory.

The paper is organized as follows: following chapter provides a brief literature review, third chapter discusses materials and methods, fourth

presents the results and fifth and sixth chapters engage in discussion and conclusions.

Literature review

The role of institutions has been already acknowledged by economists such as Adam Smith and John Stuart Mill (Acemoglu, 2009), but largest development of this field followed criticism of absence – or better said – assumption of the constant role of institutions in Growth Theory. Several factors of economic development/growth were identified in earliest papers such as Harrod's (1939) and Solow's (1956): namely most important capital, labor and exogenous technological change.

Although this has been improvement in the understanding of why some countries are poorer and others richer, several authors focused on the fact that differences in these factors cannot explain economic growth sufficiently. E.g. Mankiw *et al.* (1992) included human capital as one of the first large adjustment to the former Solow model. This adjustment was important, but division between proximate and fundamental sources of economic growth was crucial for institutional factors (e.g. in Snowdon and Vane, 2005). Proximate sources' impact is usually straightforward and clear and accounts for labor, capital, human capital etc. (Romer, 2012). On the other hand, fundamental sources are able to change the productivity of proximate sources (Snowdon and Vane, 2005) and are used to account for those differences in economic growth that cannot be explained simply by proximate sources (Romer, 2012).

During the years, economists have focused on several fundamental factors: e.g. political (Hall, Jones, 1999), legal factors (Clague *et al.* 1999), openness (Barro, 1996), geography (Gallup *et al.* 1999), culture (Alesina *et al.* 2003), economics and finance (Temple, 1999).

This paper is focused on political, legal and economic factors and internationalization, because other ones – such as geography and culture – are said to be rather similar in observed countries. This does not mean that there is no reason to include them, but their impact is supposed to be stronger when observing more geographically and culturally different countries.

Political and legal factors are influencing behavior of economic agents by stating borders to their behavior. Therefore, they affect investment in capital and technology (Acemoglu, 2009). Political factors are usually approximated by numbers of assassinations, riots etc. (Alesina and Perotti, 1994) or government expenditure and their structure (Temple, 1999). Legal factors are approximated by more complex indicators and often include also political environment. Kaufmann *et al.* (1999) provided evidence that their World Governance Indicator (WGI) strongly correlates with economic outcome. Knack and Keefer (1995) consider indicators such as Business Environment Risk Intelligence or International Country Risk Guide to be better approximations to the legal and political framework then simple indicators such as riots, coups etc. They also provide similar results as Kaufmann *et al.* (1999) with WGI. The impact of government on economic growth is stressed out also by Olson *et al.* (2000).

There are two commonly used indicators for determining the impact of openness on economic growth – Sachs-Warner index (Hall and Jones, 1999) and black-market premium (Barro, 1996). Barro (1996) provides an evidence of the negative impact of black-market premium on economic performance.

Economic and financial factors are affecting country performance by influencing investment (Temple, 1999) and easing of exchange and trade in an economy (Levine, 1997). These factors can be represented by a variety of indicators such as GDP, inflation, unemployment or composite indicators – e.g. Misery-index or LIMEP (presented in Moesen and Cherchye, 1998). Financial factors can be further approximated by liquidity and development of financial markets. They are clearly linked with an economic growth (Levine and Zervos, 1998).

Various methods are used in discovering the impact of factors on economic performance or growth. One of them is regression analysis with an option of multilevel modelling.

Multilevel modelling has its advantages in empirical analysis as it allows us to model micro and macro level simultaneously (Oort *et al.*, 2012) which is more appropriate to growth studies that need to account for various sources of growth. Complexity of structures in the modern world as one of the reasons of multilevel analysis is presented by Jones (2004). Multilevel analysis is often used in studies exploring the effect of institutions on agents' behavior, though not many of them are explicitly focused on growth or performance. As for some examples could be cited agglomeration economics and urbanization (Oort *et al.*, 2012), investment behavior (Farla, 2013), level of trust (Wang and Gordon, 2011) and more.

Multilevel models, in general, can be thought as an improvement to standard regression models for various reasons – it can be essential when trying to predict future development, it can be useful for data reduction and, most important to this paper, helpful for causal reference. It is able to differentiate between group and individual effect, therefore, to specify the effects of framework that individual lives in (Gelman, 2006). The same author stresses out that the causal links cannot be deduced just based on multilevel model usage, therefore careful research design must be applied as well.

Multilevel models, compared to standard regression, are improvement for the possibility of generalization of results (in our case to generalize from one industry to the economy or at least to more similar industries or to generalize to more economies), fewer parameters needed (multilevel

regression can be substituted by dummy variables to some extent) and more (Buxton, 2008).

MATERIALS AND METHODS

This paper is based on thought that factors influencing microeconomic performance can be deduced from those that affect macroeconomic performance as microeconomic agents sum up to the economy.

The paper uses two methods to obtain results and then compare the outputs between themselves – multilevel regression model is compared with panel regression with fixed effects. Both of these approaches will be described below.

Firm data are obtained from the Amadeus database (Bureau van Dijk, 2014) for companies within Austria, Czech Republic, France, Germany, Poland, Slovakia and Slovenia and in NACE Rev. 2: 10 – Manufacture of food products for years 2004–2013 (data are denominated by producer prices in NACE 10 on year 2010 by OECD, 2015). These countries were chosen because of their relative economic similarity within groups of developed and former transition countries and dissimilarity between these groups and also by the relatively similar impact of 2008 and foregoing contraction. The industry choice is backed by stable phase of industry cycle and relatively neutral impact of contraction as well as the importance of industry in each economy.

Country variables are obtained from Eurostat (2015) and some replacement are made in order to obtain the full country dataset (replacing missing values with closest value) as well as omission of illogical data (negative values in some cases etc.).

Human capital is calculated as average personnel costs divided by country median wage – this approximation is based on idea that companies that are paying higher wages (relative to the rest of the economy) will require a higher level of human capital. Outsourcing ratio is approximated by the value added divided by sales; and operational leverage as depreciation and interest divided by depreciation, interest, material and personnel costs. Variables that have negative values are accompanied by dummy variable in order to be able to adjust them by logarithm. Every variable (but WGI, LIMEP and dummy variables) are adjusted by logarithm. The model also includes dummy variable for each year in order to control for year's fixed effects.

World Governance Indicator (WGI) (Kaufmann *et al.* 2014) describes a political and legal framework; government expenditures are an approximation of government politics (particularly in income distribution); export account for openness of

I: *Overview of variables.*

Variable name		Variable description	Source
Proximate	labor	Number of employees	Company
	capital	Fixed assets	Company
	human_capital	Average_wage_in_company / median_wage_in_country	Company, Eurostat (2015)
Fundamental	WGI	World Governance Indicator	Kaufmann *et al.*, (2014)
	gov_exp	Government_expenditures / GDP	Eurostat (2015)
	export	Export / GDP	Eurostat (2015)
	LIMEP	Composite indicator of GDP growth, unemployment, inflation, current account BoP	Eurostat, calculation based on Moesen and Cherchye (1998)
Control	ROA	Rentability of assets	Company
	liquidity	Current liquidity	Company
	inv_turnover	Inventory turnover	Company
	equity	Equity / assets	Company
	interest	Interest / sales	Company
	outsourcing	See the text above	Company
	op_leverage	See the text above	Company

an economy; and LIMEP is an index indicating economic conditions of a particular country.

The dependent variable is also in a form of logarithm and is based on total factor productivity calculation with CES production function. The calculation is based on Ahmed (2009).

RESULTS

Panel regression

Panel regression with fixed effects estimated by OLS is standard econometric method used in many cases. It will serve to our purposes as a comparison example to multilevel model.

First, it is needed to argue about the model specifics itself. The panel model has been used with regard to the fact that the panel data structure provides more information than a simple cross section or time series data. Fixed effects are one of the possibilities (along with random effects) that can be used at panel models. There are basically two essential reasons why fixed effect are used – (1) there may be some unobservable effects that may affect the dependent variable, but are not included in the model and (2) there is a correlation between independent variable and error term (therefore random effects cannot be used).

The regression function can be seen below:

$$lnprod_{i,t} = \alpha_i + \beta_{1,i,t} labor_{i,t} + \beta_{2,i,t} capital_{i,t} + \beta_{3,i,t} human\_cap_{i,t} + \beta_{4,i,t} WGI_{i,t} + \beta_{5,i,t} gov\_\exp_{i,t} + \beta_{6,i,t} \exp ort_{i,t} + \beta_{7,i,t} LIMEP_{i,t} + \boldsymbol{\beta}_{8...k,i,t} \boldsymbol{X}_{8...k,i,t} + \gamma_t + u_{i,t}$$

where i = 1,2,...,F for each firm, t = 2004,...,2013 of each year, lnprod is the logarithm of productivity, labor is the logarithm of employee countdown, capital is the logarithm of fixed assets, human_cap is logarithm of the human capital ratio, WGI is average of WGI indices, gov_exp is the logarithm of expenditures over GDP ratio, export is the logarithm of export over GDP ratio, LIMEP is the ratio of macroeconomic performance, X is vector of control variables and α, γ, u are fixed effects and error term.

Multilevel regression

Multilevel model is ought to be better in theory, because it can distinguish between individual levels in which data are stored. In this case, in an ideal example of balanced panel, data are stored as follows: observations are within firms (10 observations per firm) and firms are within countries (*i* firms in each country and therefore 10**i* observations in each country). Of course, this is idealistic and there will be missing data so the panel would not be balanced but the basic idea stays.

In multilevel model, there are 2 parts – fixed and random. In this case, all the variables are included in the fixed part and random part is used only for specification of levels. This is not strictly a doctrine, but it allows us to see the impact of individual levels.

Multilevel model can also provide answers on whether the differences between individual levels are significant.

The formula for multilevel model is following. It is nearly the same as in panel regression with fixed effects, but some differences make it multilevel:

$$lnprod_{i,c,t} = \delta_c + \alpha_{c,i} + \beta_{1,i,c,t} labor_{i,c,t} + \beta_{2,i,c,t} capital_{i,c,t} + \beta_{3,i,c,t} human\_cap_{i,c,t} + \beta_{4,i,c,t} WGI_{i,c,t} + \beta_{5,i,c,t} gov\_exp_{i,c,t} + \beta_{6,i,c,t} \exp ort_{i,c,t} + \beta_{7,i,c,t} LIMEP_{i,c,t} + \boldsymbol{\beta}_{8...k,i,c,t} \boldsymbol{X}_{8...k,i,c,t} + \gamma_t + u_{i,c,t}$$

II: *Output of regressions of lnprod (reduced output).*

Variable	Panel model	Multilevel model	
WGI	0.048 (0.930)	0.177 *** (4.200)	
gov_exp	–0.108 ** (2.570)	–0.039 (1.320)	
export	0.692 *** (9.820)	0.799 *** (15.230)	
LIMEP	–0.066 *** (4.750)	–0.066 *** (5.360)	
Const.	–4.648 *** (34.730)	–6.138 *** (27.170)	
Country: sd(const)		0.574	SE: 0.155
Company: sd(const)		0.340	SE: 0.003
Sd (residual)		0.192	SE: 0.001
Number of observations:	41,337		
Number of groups:	11,675		
R2 (within, between, overall)	0.7397; 0.1679; 0.1413		
F-test (25;11,674)	580.67 ***		

note: p < 0.1 *, p < 0.05 **, p < 0.01 ***, sd is the standard deviation, lnprod is the logarithm of productivity, labor is the logarithm of employee countdown, capital is the logarithm of fixed assets, human_cap is logarithm of the human capital ratio, WGI is average of WGI indices, gov_exp is the logarithm of expenditures over GDP ratio, export is the logarithm of export over GDP ratio, LIMEP is the ratio of macroeconomic performance. The model also includes other control and fixed effect variables that are specified in chapter 3. Values in brackets are t-tests, z-tests respectively. Source: Olbrecht, 2015 (full results in appendix).

where $i = 1,2,...,F$ for each firm, $t = 2004,...,2013$ for each year, $c = 1,...,7$ for each country, lnprod is the logarithm of productivity, labor is the logarithm of employee countdown, capital is the logarithm of fixed assets, human_cap is the logarithm of the human capital ratio, WGI is average of WGI indices, gov_exp is the logarithm of expenditures over GDP ratio, export is the logarithm of export over GDP ratio, LIMEP is the ratio of macroeconomic performance, X is vector of control variables and α, δ, γ, u are fixed effects and error term.

The models estimations are presented below:

Political and legal environment, approximated by WGI, is positively correlated with microeconomic productivity. This result is in line with theoretical foundation, although it is not a significant variable in the fixed effects panel regression.

The impact of political environment approximated by government expenditures is negative, therefore neoclassical theorem about the negative effect of expenditures on economy holds place. Rising government expenditures actually decrease the microeconomic performance of firms, therefore are making them to operate ineffectively.

The logic would suggest that increasing exposure of foreign competition will press companies to change their internal processes in order to achieve higher productivity to be competitive in – now larger – marker. This is the case as can be seen from the export and performance relationship.

Macroeconomic indicators (GDP, unemployment, inflation, balance of payment) presented by LIMEP are negatively correlated with microeconomic performance. This result might be striking on the first sight, but the direction of influence is from macroeconomic to microeconomic performance, nor reversely, and in this case, the result might actually hold. If the agents, say managers, seem macroeconomic indicators (most observed GDP, inflation, unemployment, rarely balance of payments) to get worse, they might actually think of economic slowdown or crisis that may affect their firms and therefore start to adjust internal processes in order to achieve higher performance in these observed difficult times.

What is actually very important to notice, are the differences between the two models – fixed effects panel regression and multilevel regression. Orientations of coefficients as well as their magnitude for fundamental variables are the same or similar in many cases, but their significances differ. In general, it can be said that all the coefficients (but government expenditures) have increased in significance at multilevel model, sometimes extensively. One of the key result is that WGI is now significant variable which is more common to the theoretical and empirical reasoning of many authors.

The structure of data in standard OLS panel data estimation is regardless of their levels, therefore, it is implicitly assumed that the structure of data is irrelevant. This may result into biased coefficients and their standard errors. These problems are covered in multilevel regression because it takes into account both levels (firm and country) and therefore its coefficients and standard errors should be more trustworthy.

As we can see from the table, multilevel model has placed 41337 observations into 11675 categories at first level (company) and 7 categories at second level (country). From this can be seen that countries include companies and companies include observations. From the parameters at the bottom of the table can be seen that the differences among individual levels' standard deviations are significant (it is important to note the relatively high standard error at country deviation). For this reason, the specification of the multilevel model seems reasonable in this case, because it is able to provide more accurate information.

DISCUSSION

Positive effects of political and legal framework were discussed also in Hall and Jones (1999), though "social infrastructure" (similar term to the fundamental framework with little differences, see the paper for an explanation) was examined. Similar link is obtained also by Acemoglu *et al.* (2001).

Government expenditures have a negative impact on performance as shown for example by Afonso and Jalles (2011) or Hansson and Henrekson (1994) who aggregated large number of studies to discover this negative link.

Openness with its positive effect on performance is discussed e.g. by Edwards (1998) or Yanikkaya (2003).

However, it is also important to discuss the results obtained by authors who have used multilevel analysis. Goedhuys and Srholec (2015) focused mostly on technology infrastructure and educational system as parts of institutional framework and discovered that those elements have a significant effect on performance through link of generating a productivity premium. They consider multilevel modelling useful tool in the performance and growth analysis mainly because of its possibilities to discover complex structures. Another study, performed on a sample of Vietnamese firms, also discovered a link between institutions (subnational) and performance with the use of multilevel modelling (Nguyen *et al.* 2013).

While exploring the possibilities of multilevel modelling, it is to say that, for example in our sample, multilevel model should be preferred at least when indicating the significance of individual variables. Standard errors of multilevel model are more accurate than those of standard regression (Farla, 2013). There are also other statistical advantages of multilevel modelling which were outlined in literature review that go beyond the scope of this paper and can be found in econometric literature.

Taken into account the literature and the results of this particular example of multilevel modelling it can be said that multilevel modelling has its advantages in most areas and that the results obtained from them are better in particularly (for this example) in two ways. First, it is that the standard errors and therefore the significance of variables and model are more trustworthy and second, that the causal references obtained from multilevel models are superior to the standard regression as well as its generalization possibilities. On the other hand, multilevel models require a specific structure of data which does not allow to use multilevel modelling in many cases.

It has to be said that the paper has several shortcomings, such as the data it uses that are of accounting nature and therefore can be questioned by the relevant authority. Also, the variables used are only approximations of aspects of institutional framework and there may be other approximations that could be considered to be better.

Following research may be focused on several areas. Beside of above mentioned relevance of the data it may be also thought about the causality relationship of the above mentioned links. The presented links can be considered as correlations rather than causality relationship and careful research design can contribute to the further development of causal explanations.

CONCLUSION

The article engages in the effects of the external environment on performance of economic agents – firms.

Its contribution is mainly in the development of the multilevel microeconomic approach in exploring the impact of institutions on performance in countries of the European Union.

Main findings include the positive effect of political and legal framework and openness of the economy on firm performance and negative impact of government expenditures and macroeconomic indicators. These conclusions are in line with other findings of the empirics of growth theory.

The contribution of this article is also in an area of multilevel modelling where it can be said, based on its preferences also by other authors and its more accurate statistical results, as well as advantages in the area of potential causality conclusion, that this approach is supposed to be more preferred by researchers. On the other hand, multilevel modelling has a higher need for data which may be limiting factor of a large number of studies with data (or their structure) limitations.

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Appendix: Full regressions of lnprod

Variable	Panel model	Multilevel model
labor	0.219*** (11.730)	0.299*** (91.840)
capital	–0.289*** (36.650)	–0.226*** (90.890)
human_cap	0.612*** (24.930)	0.707*** (160.800)
WGI	0.048 (0.930)	0.177*** (4.200)
gov_exp	–0.108** (2.570)	–0.039 (1.320)
export	0.692*** (9.820)	0.799*** (15.230)
LIMEP	–0.066*** (4.750)	–0.066*** (5.360)
roa	0.012*** (8.710)	0.016*** (15.540)
roa_dummy	–0.119*** (–27.030)	–0.173*** (–54.380)
liquidity	0.053*** (8.710)	0.112*** (38.990)
inv_turnover	0.065*** (9.990)	–0.002 (–1.090)
equity	–0.004 (–1.140)	0.000 (–0.230)
eq_dummy	–0.065*** (–6.540)	–0.067*** (–10.870)
interest	–0.004 (–1.610)	–0.010*** (–7.600)
outsourcing	0.775*** (42.830)	0.509*** (130.830)
op_leverage	–0.076*** (–9.230)	–0.108*** (–33.340)
2005	0.005 (1.490)	–0.001 (–0.310)
2006	0.007 (1.420)	–0.007 (–1.310)
2007	0.047*** (7.610)	0.035*** (6.200)
2008	0.125*** (16.780)	0.119*** (23.220)
2009	0.263*** (25.220)	0.270*** (41.540)
2010	0.184*** (26.650)	0.164*** (32.450)
2011	0.172*** (22.140)	0.139*** (24.060)
2012	0.170*** (17.650)	0.135*** (18.180)
2013	0.208*** (12.900)	0.170*** (13.060)
Const.	–4.648*** (34.730)	–6.138*** (27.170)
Country: sd(const)		0.574
Company: sd(const)		0.340
Sd (residual)		0.192
Number of observations:	41,337	41,337
Number of groups:	11,675	7;11,675
R2 (within, between, overall)	0.7397; 0.1679; 0.1413	
F-test (25;11,674)	580.67***	Wald chi2 (25): 81,124.12***

note: p < 0,1*, p < 0,05**, p < 0,01***, sd is the standard deviation, *lnprod* is logarithm of productivity, *labor* is logarithm of employee countdown, *capital* is logarithm of fixed assets, *human_cap* is logarithm of human capital ratio, *WGI* is average of WGI indices, *gov_exp* is logarithm of expenditures over GDP ratio, *export* is logarithm of export over GDP ratio, *LIMEP* is ratio of macroeconomic performance, *roa* and *roa_dummy* are logarithm of ROA and its dummy, *liquidity* is logarithm of current liquidity, *inv_turnover* is logarithm of inventory turnover, *equity* and *eq_dummy* are equity over assets ratio and its dummy, *interest* is logarithm of interest costs over assets, *outsourcing* is logarithm of outsourcing ratio, *op_leverage* is logarithm of operation leverage and *2005–2013* are dummy variables for individual years. Values in brackets are t-tests, z-tests respectively.
Source: Olbrecht, 2015

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