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Estimation of Disproportions in Patent Activity of OECD Countries Using Spatio-Temporal Methods

A b s t r a c t. The article contains a presentation of possibility of using panel-based sample and modelling based on this sample as methods of determining indicators of patent activity. The research was conducted with the help of data from European countries. Results in association with used methodology, which takes into account modern approach to stationary and cointegration for panel-based samples, indicate the usefulness of applied methods.

K e y w o r d s: patent activity, panel model, decomposition of intercept.

1. Introduction

Within the area of innovation, which enjoys an increasing interest of the economists, there are many ways of measurement. In the macro-economics conception – due to the requirements concerning the length of time series – space-time sample or panel sample are used frequently.

Their advantages include, apart from the opportunity to conduct research itself, the possibility of obtaining results which are comparable for various objects, which are received on the basis of decomposition of a random term or intercept. These study are directly connected with the patents based on the inventions understood as "original conception of technical innovation, which contains theoretical possibility of action" (Budnikowski, 1995). The patent activity is one of the most accessible measures of innovation activity due to the possibility of obtaining fairly comparable data, which is a result of the legal framework behind the acceptance and granting patents. The available information comes mainly from the World Intellectual Property Organization (WIPO) and the European Patent Office (EPO). Putting aside the character of explanatory variables, the equation used to describe the patent activity with the use of panel data enables obtaining, as a result of decomposition, specific indices of patent activity. The differences between these values have a direct influence on the theoretical values of the dependent variable (depending on the model – additive or multiplicative) diversifying its value for various objects with the same basic assumptions.

2. Assumptions

In the present research the following assumptions were accepted:

- the measure of patent activity is the number of patent applications submitted with the EPO per one thousand professionally active persons,
- the determinants of patent activity are gross outlays for the research and development activities as well as the researchers working within the research and development area,
- the measurement (test) is of time cross-sectional character, and the data concern the periods from 1995–2005 and the European countries belonging to the OECD (together with Latvia and Estonia); on the one hand the use of longer sequences is impossible – lack of data, on the other hand there is a threat of disruption of the present relations by the introduced system changes, particularly in the Central and Eastern Europe area,
- the possibility of interpolation is accepted in the case of occurring incidental lack of data or reproducibility of collected results less frequent than annual. Depending on the form of studied process, the segment method or a fitted trend function which has possibly most simplified analytical form (it concerns mainly a degree of a polynomial) are used,
- source data coming from the analyses of the EUROSTAT, OECD, WIPO and national statistical offices is not directly corrected in the cases of suspected errors or inaccuracies.

3. Introductory Calculations

At the initial stage the space-time sequences which were supposed to form the basis of the model construction, were taken into consideration. Time series of 11 annual observations, despite they are short, seem to be sufficient to observe non-stationarity. What is more important, we want to treat the conclusions based on final calculations as independent of time factor. In this situation non-stationarity of these series should be researched, assuming that integration order is not higher than 2 in the case of annual data (Gruszczyński, Podgórska, 2004). In order to realize it, the procedures contained in the Eviews package were used. These procedures enable a relatively fast evaluation of possible lack of stationarity or the evaluation of the integration order. The tables below present the results of a few unit root tests, which indicate the existence of unit root.

Table 1. The results of unit root tests for levels (H_0: $\delta = 0$)

Variable	Estimator: / Method:	Newey-West		Andrews	
		statistic	p-value	statistic	p-value
PET	Levin, Lin & Chu t*	-7.1708	0.0000	-7.0058	0.0000
	Im, Pesaran and Shin W- statistic	-1.9999	0.0228	-1.9999	0.0228
	ADF - Fisher χ^2	69.8771	0.0331	69.8771	0.0331
	PP - Fisher χ^2	118.7770	0.0000	83.3070	0.0022
GERD	Levin, Lin & Chu t*	-1.1929	0.1165	-8.4510	0.0000
	Im, Pesaran and Shin W- statistic	0.8544	0.8036	-5.4559	0.0000
	ADF - Fisher χ^2	51.6001	0.4110	123.3190	0.0000
	PP - Fisher χ^2	54.5887	0.3044	121.3650	0.0000
RECH	Levin, Lin & Chu t*	-3.0271	0.0012	-9.5927	0.0000
	Im, Pesaran and Shin W- statistic	1.6752	0.9531	-5.5232	0.0000
	ADF - Fisher χ^2	39.2213	0.8641	120.3260	0.0000
	PP - Fisher χ^2	42.0529	0.7804	117.9310	0.0000

Note: * assumes common unit root process.

The probabilities for Fisher test are computed using an asymptotic Chi-square distribution. All other tests assume asymptotic normal distribution.

Table 2. The unit root tests results for first difference (H_0: $\delta = 0$)

Variable	Estimator: / Method:	Newey-West		Andrews	
		statistic	p-value	statistic	p-value
PET	Levin, Lin & Chu t*	-10.2833	0.0000	-10.4350	0.0000
	Im, Pesaran and Shin W- statistic	-6.2851	0.0000	-6.2851	0.0000
	ADF - Fisher χ^2	133.2590	0.0000	133.2590	0.0000
	PP - Fisher χ^2	150.2810	0.0000	142.5140	0.0000
GERD	Levin, Lin & Chu t*	-9.7824	0.0000	-8.4510	0.0000
	Im, Pesaran and Shin W- statistic	-5.4559	0.0000	-5.4559	0.0000
	ADF - Fisher χ^2	123.3190	0.0000	123.3190	0.0000
	PP - Fisher χ^2	144.5690	0.0000	121.3650	0.0000
RECH	Levin, Lin & Chu t*	-11.0622	0.0000	-9.5927	0.0000
	Im, Pesaran and Shin W- statistic	-5.5232	0.0000	-5.5232	0.0000
	ADF - Fisher χ^2	120.3260	0.0000	120.3260	0.0000
	PP - Fisher χ^2	131.2820	0.0000	117.9310	0.0000

Note: * assumes common unit root process.

Regarding the endogenous variable (PET), all the tests results indicate stationarity. The remaining variables are characterized by different results, particularly the ones obtained with the use of Newey-West estimator. The Andrews estimator, produce more stable bandwidth estimates than the Newey-West procedure (indicating the stationarity in this situation), which could be expected taking into account the PP test and the previous research conducted by Yin-

Wong Cheung and Kon S. Lai (1997). Therefore, taking into account possible existence of unit roots, we can assume that our variables are integrated on order 1, ~ I (1) (what is suggested by the consistent results of all tests). Hence assuming the integration order is common for all the variables, we try to test the existence of cointegration in the assumed system, i.e. equation with *PET* as dependent variable and *GERD* and *RECH* as independent variables.

The estimation with the use of Eviews programme gives the possibility of obtaining (in the case of using summarised results) the evaluation of statistics for seven tests. However, the use of these tests is difficult, as they can give (and such is our case) different results. It is connected with the size of applied panel. Pedroni (2004), who researched situations of this kind with the use of Monte Carlo simulation, indicated that the use of panel test-v and group test-rho gives bad results even in the case when the length of time series in the panel is smaller than 20 observations. In such cases, the group test – ADF and panel test – ADF are more appropriate.

The test results are tabulated in Table 3.

Table 3. The results of cointegration test for Pedroni residuals in the model of PET on GERD and RECH variables

Alternative hypothesis: common AR coefficients (within-dimension)				
Model type	No deterministic trend		No deterministic intercept or trend	
Test type	statistic	p-value	statistic	p-value
Panel v-Statistic	-0.8536	0.8033	0.9798	0.1636
Panel rho-Statistic	2.3876	0.9915	0.3700	0.6443
Panel PP-Statistic	-0.0985	0.4608	-1.7103	0.0436
Panel ADF-Statistic	-0.4230	0.3361	-1.8798	0.0301
Alternative hypothesis: individual AR coefficients (between-dimension)				
Test type	statistic	p-value	statistic	p-value
Group rho-Statistic	3.0116	0.9987	1.9235	0.9728
Group PP-Statistic	-5.0759	0.0000	-3.5982	0.0002
Group ADF-Statistic	-2.5234	0.0058	-3.4899	0.0002

Only the results based on “group” tests- (recognized as being more powerful than “panel” tests when conducting a research on smaller samples (cf. Pedroni, 1995)) – indicate the existence of cointegration. Excluding the existence of intercept, tests based on *v* and *rho* do not reject the H_0 of the lack of cointegration what is undesired from the point of view of this research.

However, taking into account the remarks of Pedroni, we find the results of ADF tests as the more appropriate ones, which reject the H_0.

However, taking into account the remarks of Pedroni, we find the results of ADF test which indicate the rejection of H_0 as more appropriate. Hence, the existence of cointegrating vector can be stated.

It is worth emphasizing that the PP test also gives expected result. It should be remembered that the "group" tests, in contrast to the "panel" ones, assume that the autoregression coefficients do not have to be homogenous for all objects (Hsu-Ling and others, 2008). Therefore, assuming the low power of the group test-rho, the results of remaining group tests indicating the existence of cointegration are accepted

The achieved results do not offer the possibility of making an unambiguous decision by the researcher. On the one hand we can assume that the cointegration vector exists, if we exclude the intercept in our model. However, it should be remembered that this model, due to the panel construction, will have the decomposed intercept. This intercept, depending on the significance of its particular parts will be "complete" intercept (consisted of so many parts as many countries contains the model) or will be equivalent of a few dummies variables included in the model.

On the other hand, having in mind the fact of PET stationarity, the recognition of PET variable as integrated of first order seems to be misused.

In connection with the indicated doubts concerning the existence of cointegrating relations, the error correction model was proposed which in such cases is one of the most popular tools (Strzała, 2005).

Ids additional advantage is taking into account both short- and long-term relationships. As a result, the interpretation of the decomposed intercepts (fundamental in this research) is more precise. The possible dynamic dependencies are more visible in the estimates of structural parameters (for independent variables).

The following form of model was proposed**:**

$$\begin{aligned}\Delta \log PATA_{it} = a'_i + (\rho_1 - 1)(\log PATA_{it-1} - \delta_1 \log GERDP_{it-1} \\ - \delta_2 \log RECHA_{it-1}) + \beta_1 \Delta \log GERDP_{it} \\ + \beta_2 \log RECHA_{it} + \xi_{it},\end{aligned} \tag{1}$$

where: a'_i denotes the intercept decomposed into $i = 25$ objects – countries,

$PATA_{it}$ – number of patents application, submitted by the residents of a given country *i* per number of professionally active persons in the period *t*,

$GERDP_{it}$ – gross expenditures on research and development (R+D) activities per the R+D staff working on full-time basis in the country *i* in the period *t*,

$RECHA_{it}$ – persons employed as researchers on full time basis in comparison to the number of professionally active persons in the country *i* in the period *t*,

4. Results

In accordance with the accepted assumptions the estimated model (with the full decomposition of intercept) has showed dependence for logarithms of variables (Szajt, 2006). Due to the differences in the directions of dependencies between the particular variables for different countries, 16 countries were qualified to the final test. The Gretl programme was used to estimate the model. At the beginning a test for variability of intercept was used. The test statistics F(15, 140) = 3.814 with the value p = 1.15252e-005 confirms the validity of estimation of panel model with fixed effects. During the estimation process the insignificant variable $GERD_{t-1}$ was removed from the model. The final results are presented in the Table 4.

Table 4. The values of structural parameter assessments in power model

Variable	Parameter	Parameter estimate	t - statistics	p-value
$PETA_{i,t-1}$	α_1	0.5683	-6.9836	0.0000
$RECHA_{i,t-1}$	δ_2	0.7809	1.9086	0.0584
$\Delta GERDP_{i,t}$	β_1	1.0802	3.5093	0.0006
$\Delta RECHA_{i,t}$	β_2	0.7617	2.6235	0.0097
BE_t	α_{BE}	0.3060	-2.9727	0.0035
CZ_t	α_{CZ}	0.1137	-5.1812	0.0000
DK_t	α_{DK}	0.2999	-2.9377	0.0039
DE_t	α_{DE}	0.4010	-2.5089	0.0133
EE_t	α_{EE}	0.0767	-5.0538	0.0000
IE_t	α_{IE}	0.2281	-3.8027	0.0002
FR_t	α_{FR}	0.3007	-3.0255	0.0030
LV_t	α_{LV}	0.0709	-5.4952	0.0000
HU_t	α_{HU}	0.1259	-5.1246	0.0000
NL_t	α_{NL}	0.3877	-2.8611	0.0049
AT_t	α_{AT}	0.3329	-3.0377	0.0028
PL_t	α_{PL}	0.0597	-5.3160	0.0000
PT_t	α_{PT}	0.0853	-5.2087	0.0000
FI_t	α_{FI}	0.2972	-2.4965	0.0137
SE_t	α_{SE}	0.3160	-2.6370	0.0093
NO_t	α_{NO}	0.1891	-3.3407	0.0011

It should be noted that all the estimates concerning the decomposed intercept are highly statistically significant, which is to a large degree the objective of this estimation. What is even more important, in connection with the form of function, the intercept has multiplicative character.

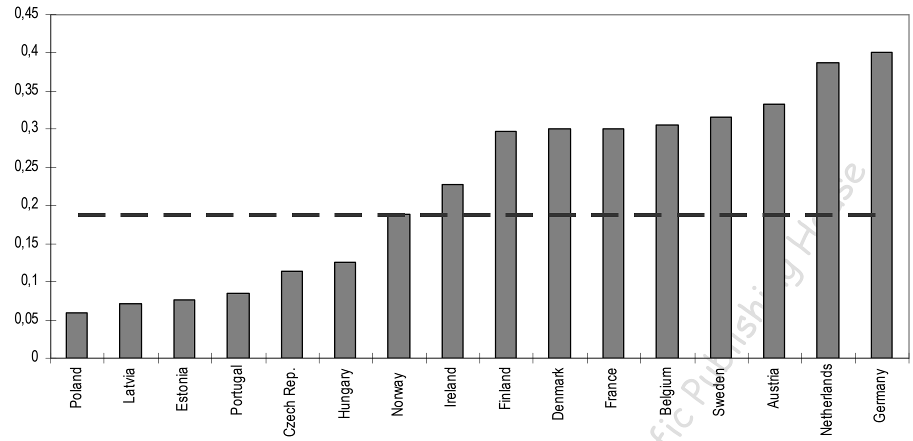

Figure 1. The values of assessments of decomposed intercept (for simple countries)

Presented on the Figure 1 constant level 0.1873 reflects the estimated in a test common intercept (an equivalent of the average level of patent activity) for the whole group. In comparison to it, such countries as Germany or the Netherlands turned out to be absolute leaders, whereas Poland, Latvia and Estonia were outsiders. The consequents of such conclusions are important. In practice, with equal factors determining the patent activity, difference of final reaction – in the long -run - will be close to differences presented on Figure 1 Therefore, a very high or low patent activity of particular countries can be found.

As it is seen, this simple method (using panel sample construction) enables obtaining very valuable, comparable indicators. It is also important that, their estimates usually are not strongly sensitive on the changes of main determinants of studied process. In extreme cases, together with characteristic values (for chosen countries) we can obtain "typical" values represented by a common (for all countries) intercept.

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Szacowanie dysproporcji w aktywności patentowej państw OECD z wykorzystaniem metod przestrzenno-czasowych

Z a r y s t r e ś c i. W artykule przedstawiono możliwość zastosowania próby panelowej i modelowania w oparciu o nią jako metody wyznaczenia wskaźników aktywności patentowej. Badanie przeprowadzono z wykorzystaniem danych dla państw europejskich. Otrzymane wyniki w zestawieniu z zastosowaną metodologią uwzględniającą nowoczesne podejście do badania stacjonarności i kointegracji dla prób panelowych, wskazują na użyteczność stosowanych metod.

S ł o w a k l u c z o w e: aktywność patentowa, model panelowy, dekompozycja wyrazu wolnego.