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SPATIAL ECONOMETRIC APPROACH TO WESTERN DISEASES MODELLING

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Abstract

For years now, developed countries face an epidemic of high blood pressure, diabetes and high cholesterol, risk factors related to heart and circulatory disease, and a suite of psychological disorders ranging from depression, anxiety, to compulsive behaviours. These health risks have traditionally been associated with affluence however by 2008 there is no clear link between national income and these diseases. E.g. according to Danaei, there was no relationship between national income and blood pressure in men, and in women blood pressure was even higher in poorer countries.

Therefore, this paper provides deepen analysis of this correlation applying spatial econometrics tools. The spatial aspect of the prevalence of western diseases does not seem to be obvious and, to our knowledge, is not widely explored in the literature. In particular, the paper investigates the spatial processes of selected diseases of affluence in regions of the European Union. The research covers 261 NUTS 2 regions for the period 2003-2010. This study provides the spatial analysis of Circulatory and Mental diseases. In our opinion, the presented spatial econometric approach may constitutes an important contribution to the field of epidemiology.

Key words: diseases of affluence, health, socioeconomic development, spatial analysis

JEL: I14, I15, O18, O57

1. Introduction

Modern medicine gives us a vast knowledge on microbiology and epidemiology of transmittable diseases. Although, as shown by a scientific evidence this knowledge is insufficient to eradicate all the possible “plagues”. The Asian SARS epidemic in 2003 and epidemic of Ebola virus in 2013, in West Africa are the proof of that. Moreover, despite of our growing knowledge on transmission, symptoms, counter-measurements, and safety procedures ignoring the governmental warnings and directives it is not uncommon. This facilitates the spread of modern plagues firstly to neighbouring regions and countries, and, then across continents. (Scott, Duncan 2007:1-5, Cook, Halsall 2012: 22-24). However, communicable diseases are a typical epidemic problem in poorer and less developed regions, and consequently they are perceived as *diseases of poverty* rather than *diseases of affluence*. Contrary to common and very basic conception, epidemiology is not only a science about epidemics understood as more than the expected number of contagion cases in given time and space. (Porta 2008:79) Nowadays, epidemiology is about transmission of diseases and factors stimulating and inhibiting them. Primarily, they are health-related factors but also other e.g. socio-economic, which is concerned with analysing spatio-temporal patterns of diseases. Moreover, this filed of studies is dedicated not only to analysing prevalence and prevalence associated aspects, but also to preventing and controlling health problems. (Beaglehole, Bonita, Kjellstrom 1992:3-7) Therefore, not only contagious diseases are being considered by the epidemiologists, but also the potential *diseases of affluence*. For years now, developed countries have faced an epidemic of high blood pressure, diabetes and high cholesterol, risk factors related to heart and circulatory disease, and a suite of psychological disorders ranging from depression, anxiety, addictions to compulsive behaviours. These health risks have traditionally been associated with affluence however by the year 2008 there is no clear link between national income and these diseases. For instance, according to Danaei (2013), there was no relationship between national income and blood pressure in men, and in women blood pressure was even higher in poorer countries. On the other hand WHO highlights these non-communicable chronical disorders as major epidemiological risks of XXI c. (WHO Report: ATLAS 2010…: pp.7-22; WHO Report: Global Report… 2016: pp.90-91; WHO Report: Global status…2011: pp.1-160)

There in no one unified definition of *disease of affluence,* also referred to as *Western diseases* and *diseases of XXI c.* (and in Poland as “*civilizational diseases*”), thereby it is difficult to create a list of potential threats. Commonly, among these disorders are mentioned:

cardiovascular diseases, respiratory system diseases, cancer, obesity, diabetes, allergy, mental disorders, and HIV (which has some characteristics of both *diseases of poverty* and *affluence*). The working definition which we adopted for the purpose of this paper states, that the prevalence (understood as a frequency of cases, severity of symptoms, or mortality rate) intensifies with higher socioeconomic development of the country, region, social group, household, or with time. They can be considered as negative but sometimes also as inevitable effects of progress (social, cultural, technological, and economic). (Kotarski 2013: 117-125; Link 2007: 75-76; Aue 2009: 175). The chronic aspect of these illnesses is also a concern, as they last from 3-6 months to even whole life, often being the cause of death. (WHO; Ferrante 2014: 321). Among these numerous affluent diseases and disorders, two are considered in these paper: cardiovascular and mental diseases.

Cardiovascular or circulatory system diseases (DCS) cause almost a half of deaths in most developed countries. They include major heart disorders, arterial circulation, and blood vessels. For decades, they have been main cause of death. Nowadays, since more than 80% of prevalence burdens people over 65, increasing people's life span and aging of the populations (higher fraction of elderly in the population) the problem increases. Researches state that cases of circulatory system diseases and deaths caused by them are not necessarily equally distributed over the time and space. Generally, it is observed that mortality is higher in developing countries than in developed ones. The prevalence is determined mainly by the risk factor, e.g. obesity, cholesterol level, and smoking which are more distinct problems in developed countries. Therefore, the socioeconomic development affects mortality in two ways: increasing the risk of becoming ill in the first place, and then reducing mortality by incorporating better health services (Marmot 2005: 3-6; Labarthe 2011:3-32).

Mental and behavioural disorders (MBD) are clinically significant behavioural or psychological syndromes or patterns which increases the risk of suffer, disability or death. Among them, the most common and most known are: schizophrenia, depression, anxiety, bipolar disorders, eating disorders, personality disorders, attention deficit hyperactivity disorder (ADHD), addictions (substance and behavioural) and suicide attempts. The risk factors are both genetic and social (stress and lifestyle), (Farrell 2010: 1-2; Tsuang 2011:2-58; Offer 2006:355).

In the case of communicable diseases spatial patterns are fairly clear. Geographic Information System (GIS), spatial econometrics and spatial statistical tools, such as spatial diffusion (see Suchecki 2010:220-225) are often employed to estimate and forecast the number of infections and spatiotemporal patterns of prevalence. This is possible due to the knowledge of means of transmission, frequency of infections and death as well as the Tobler's First Law of Geography ("Everything is related to everything else, but near things are more related than distant things." Tobler 1970:236). Dr Snow's mapping of cholera infections presented a very innovative approach in XIX c. His work became a foundation for widely used in modern epidemiology tools like spatial statistics, spatial econometrics, and GIS. On the other hand, identification of spatial patterns of non-communicable diseases is not straightforward, but nevertheless recognition of these dependences could be crucial for improving health care systems and prevention technics for some of affluent threads.

Therefore, this paper provides deepen analysis of correlations between economic development and prevalence of chosen diseases of affluence by the means of spatial econometrics tools. The spatial aspect of the prevalence of western diseases does not seem to be obvious and, to our knowledge, is not widely explored in the literature. In particular, this paper investigates the spatial processes of selected diseases of affluence in regions of the European Union for the period 2003-2010. This study provides the spatial analysis of Circulatory and Mental diseases. In our opinion, the presented spatial econometric approach may constitutes an important contribution to the field of epidemiology.

The rest of the paper is structured as follows. Section 2 covers methodology used in the empirical study. It provides a discussion on spatial econometric models and stress out the benefits of preferred model. Section 3 introduces data used in the research and presents the estimates of the models and finally a discussion of the empirical results obtained. Concluding thoughts are offered in the final section.

2. Methodology

In the empirical part of the study we have employed some Spatial Panel Econometric technics. Namely, Spatial Autoregressive Model (SAR) and Spatial Durbin Panel Model (SDPM).

Firstly, let us consider a classic spatial autoregressive SAR model for cross-sectional observations with normal disturbances:

$$\mathbf{y} = \rho\mathbf{W}\mathbf{y} + \mathbf{X}\boldsymbol{\beta} + \boldsymbol{\varepsilon}, \boldsymbol{\varepsilon} \sim N(\mathbf{0}, \sigma^2\mathbf{I}), \qquad (1)$$

where $\mathbf{y}$ (N×1) is a spatially lagged endogenous variable and $\mathbf{X}$ (N×K) matrix of observations on K exogenous variables. Typically, matrix $\mathbf{W}$ is a given *a priori* spatial weight matrix. The elements w_{ij} of $\mathbf{W}$ are ones ($w_{ij} = 1$) if the locations i and j are neighbours and all other, in particular the diagonal elements, are zero. Therefore, the neighbourhood structure is represented by the spatial weight matrix $\mathbf{W}$. The most common weight matrices, in regional science, are those in which neighbourhood is based on distance relationship or contiguity (Anselin, 1988).

The alternative model is a Spatial Error Model – econometric model with spatially correlated error term (Anselin, 1988). In this model each error term u_i for each location is spatially correlated with error terms in other locations:

$$\mathbf{y} = \mathbf{X\beta} + \mathbf{u}, \mathbf{u} = \lambda\mathbf{Wu} + \boldsymbol{\varepsilon}, \quad \boldsymbol{\varepsilon} \sim N(\mathbf{0}, \sigma^2\mathbf{I}) \tag{2}$$

where $\mathbf{y}$ ($N\times1$) is a spatially lagged endogenous variable and $\mathbf{X}$ ($N\times K$) is a matrix of observations on K exogenous variables and $\mathbf{W}$ is a spatial weight matrix. Variable $\mathbf{u}$ is an N-dimensional vector of spatially correlated error terms and $\boldsymbol{\varepsilon}$ is a white noise process with $\sigma^2\mathbf{I}$ representing variance-covariance matrix. λ is a parameter of error term spatial autocorrelation, where assumption: $|\lambda|<1$.

Though very popular, those models does not allow for enough flexibility in specification of the model and as a result they increase probability of obtaining a misspecification. Indeed, as in SAR model the spatial autocorrelation can exhibit only through the coefficient ρ, the standard tests (Anselin, 1988) favour the Spatial Error Model. However, let us notice that spatial autocorrelation of error term is often produced spuriously by model misspecification. Therefore, in recent years, there has been an increase concern about questions related to the methodology in Spatial Econometrics, and especially the problem in question.

The validity of the models with structures of dependence in the error term has been widely questioned. It seems to be reasonable to find a substantive way to describe cross-sectional dependence relationships in order to avoid residual dependence. In the recent literature there is an agreement that residual autocorrelation is a results of misspecification problem of the equation. This is a consequence of omission of relevant variables on the right-hand side, that is, where lags in the exogenous variable are necessary on the right-hand side of the equation. Solution for this is, what the literature calls, the Spatial Durbin Model. This model is a very helpful and flexible instrument in process of specification of an econometric model, as it can incorporates spatial lags of the exogenous variables on the right-hand side of the equation:

$$\mathbf{y} = \rho\mathbf{Wy} + \mathbf{X\beta} + \mathbf{WX\gamma} + \boldsymbol{\varepsilon}, \quad \boldsymbol{\varepsilon} \sim N(\mathbf{0}, \sigma^2\mathbf{I}). \tag{3}$$

Though the above discussion is devoted to a cross-sectional data, it can be rewritten for panel data in the analogues manner. Hence, in our analysis we will employ Spatial Durbin Model, however for its panel counterpart - Spatial Panel Durbin Model, as a better instrument specification of the spatial process of western diseases.

3. Empirical results and discussion

All the data used in the below analysis are taken from the Eurostat Database. The data covers 261 regions of European Union for the period 2003-2010. Due to the lack of data, on the prevalence of chosen diseases, we considered standardised death rates (per 100 000 inhabitants) caused by Mental and Behavioural Disorders and Diseases of the Circulatory System as three years average. Gross Domestic Product (GDP) is expressed in Purchasing Power Standard per active population. GDP is taken for the first year of each three-year average correspondingly to the three years average of causes of deaths. This reflects the possible gap between the change in affluence and getting ill or dying because of these diseases. All data are presented in the natural logarithms. Table 1. presents basic statistics of variables used in the analysis.

Table 1. Basic statistics of variables used in the model

Variable	Mean	σ	Min	Max
*ln*M	2.69	1.35	-3.40	4.47
*ln*C	6.14	0.39	5.27	7.27
*ln*GDP	10.10	1.06	6.86	13.13

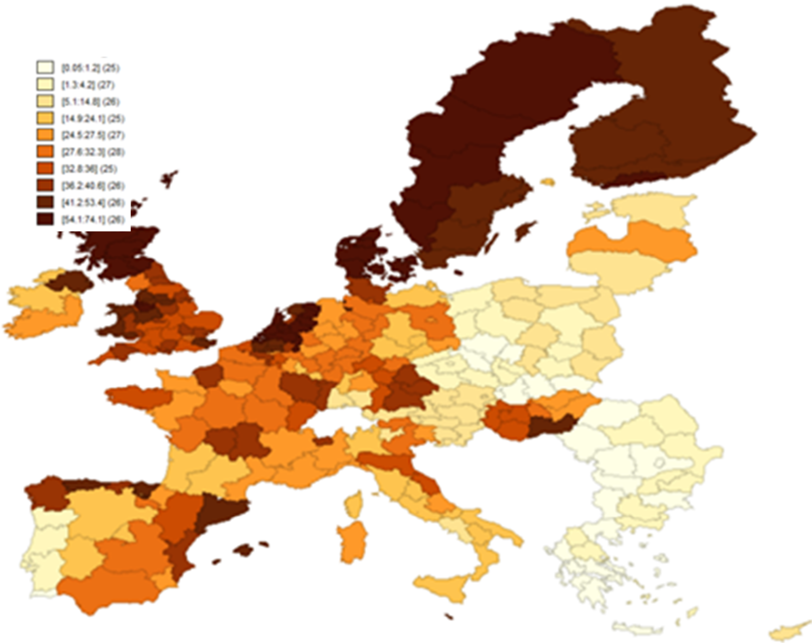
Source: own compilation.

Figures 1 and 2 present spatial distribution of average 2008-2010 standardised death rates for Mental and Behavioural Disorders and Diseases of the Circulatory System, respectively. Mental and Behavioural Disorders take most fatalities in the Northern Europe. Most hazardous regions may be found especially in Scandinavia, Denmark, and Scotland. In general, Western Europe is also at high risk of death from mental diseases. On the other hand, the lowest death rates appear in Central and Eastern Europe. This includes Poland, Balkans and Baltic states. Hungary is the only exception due to the quite high death rates.

Circulatory System diseases create a very distinct line between Western and Eastern Europe. The Eastern and Central Europe, including Poland, Balkans and Baltic states, together with Germany, create a dark cluster of high mortality rates. In contrast, low death rates, are grouped in France, Denmark, some parts of Iberian Peninsula and Italy.

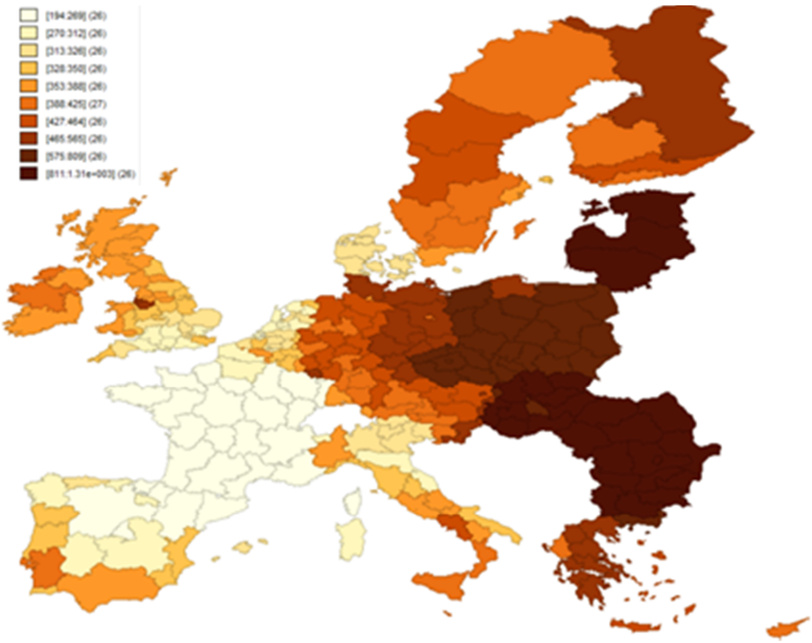
Let us notice, that these two illnesses have very different spatial distributions in EU regions. It is difficult to establish, judging solely by the regional dispersion of the prevalence, weather mental and cardiovascular diseases dependent on the level of affluence, or not.

Figure 1. Standardized death rates of Mental and Behavioural Disorders, average 2008-2010, by region of residence, by deciles



Source: own study based on research.

Figure 2. Standardized death rates of Diseases of the circulatory system, average 2008-2010, by region of residence, by deciles



Source: own study based on research.

As a first step in our analysis, we have performed Spatial Autoregressive Panel Models (SAR Panel Model). In those models, the spatial autoregressive terms ($\mathbf{W}ln$M and $\mathbf{W}ln$C) refer to the standardised death rates caused by the diseases in question, occurred in the neighbouring regions:

$$ln\text{M} = \alpha_0 + \rho\mathbf{W}ln\text{M} + \alpha_1 ln\text{GDP} + \varepsilon,\ \ \varepsilon \sim N(0, \sigma^2) \quad (4)$$

$$ln\text{C} = \alpha_0 + \rho\mathbf{W}ln\text{C} + \alpha_1 ln\text{GDP} + \varepsilon,\ \ \varepsilon \sim N(0, \sigma^2) \quad (5)$$

Table 2. presents estimation results of models (4) and (5). Let us notice, that GDP is a significant factor for both diseases of DCS and MBD. In our model, the impact of GDP is negative which suggest that higher GDP, indirectly decreases the mortality rate, *ceteris paribus* (spatial autodependence accounted for). This is presumably due to the better health care, which decreases the mortality rate, but not necessarily the prevalence. It is worth mentioning that in the case of MBD, the standard Pearson correlation coefficient for both *ln*M and *ln*GDP is positive. This was obviously expected as MBD are considered to be diseases of affluence. Yet, the spatial autoregressive model identifies GDP as a negative explanatory factor. Since it identifies the relation between $\Delta\mathbf{y}$ and *ln*GDP, were $\mathbf{\Delta}=\mathbf{I}-\rho\mathbf{W}$, it turns out that higher outcome determines lower MBD related mortality rates as compared to neighbouring regions. This duality in signs of Pearson correlation and model coefficients has not been observed in the case of DCS, presumably due to higher level of awareness and high level of recognition of those illnesses.

Table 2. Estimation results for Mental and Behavioural Disorders and Diseases of the Circulatory System, SAR Panel Model, 2003-2010

	Mental and Behavioural Disorders		Diseases of the Circulatory System	
Variable	Coefficient	t-stat	Coefficient	t-stat
ρ	0.55	24.40	0.87	98.78
*ln*GDP	-0.31	-3.27	-0.14	-10.92
pseudo R^2	0.96		0.97	
N	261		261	
T	6		6	
Spatial fixed effects	YES		YES	

Source: own compilation

The spatial component ρ is a significant factor for both illnesses. This means that the higher the death rate in neighbouring region, the higher death rate in a given region. In addition, the research shows that Spatial Fixed Effects play important role in explaining the spatial process. The goodness of fit measures suggest that both MBD and DCS models capture certain important spatial patterns of the prevalence of Western Diseases. On the other hand, for time period random effects and pooled regression the results were significantly worse.

In next step of our research, we have tested spatial relation between the prevalence of the diseases and the affluence of the given region as well as the neighbouring regions by the means of a Spatial Panel Durbin Model (SPDM). Namely, equations (4) and (5) were extended to the form of the following SPDM relation:

$$ln\text{M} = \alpha_0 + \rho\mathbf{W}ln\text{M} + \alpha_1 ln\text{GDP} + \alpha_2\mathbf{W}ln\text{GDP} + \varepsilon,\ \ \varepsilon \sim N(0,\sigma^2) \quad (6)$$

$$ln\text{C} = \alpha_0 + \rho\mathbf{W}ln\text{C} + \alpha_1 ln\text{GDP} + \alpha_2\mathbf{W}ln\text{GDP} + \varepsilon,\ \ \varepsilon \sim N(0,\sigma^2) \quad (7)$$

Table 3. Estimation results for Mental and Behavioural Disorders and Diseases of the Circulatory System, SPDM, 2003-2010

	Mental and Behavioural Disorders		Diseases of the Circulatory System	
Variable	Coefficient	t-stat	Coefficient	t-stat
ρ	0.56	25.49	0.86	91.78
lnGDP	-0.94	-4.59	-0.03	-1.45
$\mathbf{W}ln$GDP	0.76	3.47	-0.13	-5.29
pseudo R^2	0.96		0.98	
N	261		261	
T	6		6	
Spatial fixed effects	YES		YES	

Source: own compilation

Table 3. presents the estimation results of models (6) and (7). Let us notice, that though the level of GDP in the neighbouring regions ($\mathbf{W}ln$GDP) is a significant factor for both diseases of DCS and MBD, for DCS, the GDP the direct effect for a given region (lnGDP) is barely so. The positive impact of GDP in neighbouring regions for MBD suggest that more affluent neighbours stimulate the number of deaths (and probably occurrences) in a given region. On the other hand, the negative impact of GDP in neighbouring regions for DCS suggest that more affluent neighbours decreases the number of deaths (not occurrences) in a given region, probably due to better health services. Therefore we can conclude that though the level of affluence of the region has direct positive impact on the occurrence of the illness (due to the pollution, etc.), the accessibility of the health service is wider because of health migrations and unified country-specific health policy.

Spatial coefficient ρ turned out to be significant for both of the illnesses. As previously, Spatial Fixed Effects proved to play an important role in explaining the spatial process in question. The goodness of fit measures indicate slight improvement of the models in comparison to the SAR models for both MBD and DCS diseases.

4. Conclusions

Western diseases are recognized as a growing threat to the modern world. As a consequence, there is a great need for carrying out analyses which might be helpful in understanding the determinates and the consequences of western diseases. Apart from the medical one, researches did not have established yet, reliable and flexible methodological approach to the diseases of affluence. Therefore, this paper aims to be a trial of incorporating spatial econometrics to the epidemiology of these illnesses. Essentially, the purpose of this research was to verify the dependence between the standardised death rates of circulatory and mental diseases with the economic development (GDP per active population), within the region in question and for its neighbours. Generally, the results from the spatial panel models employed (SAR and SPDM) show statistical significance of GDP and spatial interactions as well as very high level of goodness-of-fit. Therefore, we conclude that the spatial econometrics is useful in researching the patterns of the diseases of affluence. However, both SAR and Durbin models indicate that the higher the GDP per active population, the lower the death rate of selected diseases, which does not confirm the hypothesis about Mental and Behavioural Disorders and Diseases of the Circulatory System being the disease of affluence. Though, in the case of Mental Diseases, spatially lagged GDP (**W***ln*GDP) has an opposite sign (and therefore direction of the relation) to the GDP itself.

Let us notice though, that employed model use panel data, so it is assumed by default that all tendencies are constant over time (2003-2010) and space (261 regions of 26 countries). If the opposite is truth and the strength and/or direction of interaction vary over time and/or space, any econometric models will show average value and sign of parameters. It is possible that being the *disease of affluence* my not be stable in time. Perhaps incorporating time variable could influence the outcomes by extracting time change from GDP influence. On the other hand, it is also possible that there are no common tendencies for the *disease of affluence* across the whole EU. Notice, that both models indicate spatial fixed effects for NUTS 2 region. Furthermore, preliminary statistical analysis (see fig. 1 and 2) indicated that distribution is diversified over EU regions. If relation between GDP (also lagged over space) and the prevalence is different for instance for different countries or for Eastern vs. Western Europe, it could be beneficial to add group effects in the model specification in order to account for this heterogeneity. This single research does not confirm that cardiovascular or mental diseases are diseases of XXI c. However further, more detailed analysis may ultimately dismiss or confirm the affluence hypothesis. Finally, spatial panel models proved to be well fitted to empirical data, this attests to their usefulness in carrying out supplementary epidemiological researches of Western diseases.

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