ANALYSIS OF EU COUNTRIES' MATERIAL DEPRIVATION RATE

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Abstract

The aim of this paper is to present the results of an analysis of the Material Deprivation Rate (MDR) in European countries. MDR is an indicator of social inclusion and social policy. MDR is defined as the percentage of the population with an enforced lack of at least three out of nine material deprivation items in the economic strain and consumer durables dimension. In terms of the level and variability of the analysed indicator, options for dividing the set of 28 EU member states into significantly different groups – euro vs. non-euro countries and those broken down by the year of EU accession – were examined. In the regression analysis, the time series of the dependent and explanatory variables must be of the same order integrated process. The regression analysis of the MDR indicator and selected measurable socio-economic factors such as GDP, inflation, [un]employment, educational attainment, standard of living, etc. was carried out, applying multivariate time series methodology-based approach.

Key words: European Union, Material Deprivation Rate, multivariate time series regression, Autoregressive Distributed Lag Model

JEL Code: C32, Z13

Introduction

Since poverty and social exclusion represent a critical issue that affects the economy and standard of living, its monitoring, assessment and analysis of the factors impacting on its level and development place high demands on the statistical research. The present paper aims at analysing statistically one of the sets of social deprivation and social policy indicators – the rate of material deprivation. It also explores the possibility of applying the multivariate time-series regression and outlines the relationship between the material deprivation rate and selected socio-economic factors.

The Material Deprivation Rate (MDR) is an EU-SILC indicator expressing the inability to afford to pay for selected items generally considered to be desirable or even essential for an adequate life, referring to the level of economic strain and durable consumption. The MDR index distinguishes between individuals who cannot afford to buy a certain good or service and those who do not have or use it for another reason, for instance, because they do not want or need it. Since social exclusion data are collected mainly from households, the MDR is defined as the proportion of households facing such financial constraints that they are unable to afford a selection of at least three of the following items, namely to

1) pay their rent, mortgage or utility bills;
2) keep their home adequately warm;
3) cover unexpected expenses;
4) have a meal with meat, chicken or fish or vegetarian equivalent every second day;
5) go on one week's annual holiday away from home ;
6) buy a television set;
7) buy a washing machine;
8) buy a car;
9) buy a telephone.

1 Methodology

When analysing the relationship between economic phenomena, the regression analysis is often applied. The dependent and explanatory variables being arranged in time series, it is necessary to decide whether the latter are stationary or non-stationary. Stationary time series are those with an autoregressive model of zero order I(0), also known as short memory ones, non-stationary time series being generated by an autoregressive process of order one I(1) and referred to as long memory ones.

For stationarity testing, the so-called unit root tests of the autoregressive parameter ϕ_1 are used, the most common being the Augmented Dickey-Fuller test (ADF) for the verification of the null hypothesis

H_0: $\phi_1 = 1$, non-stationary I(1) time series,

H_1: $|\phi_1| < 1$, stationary I(0) time series.

ADF test statistics are defined as

$$t = \frac{\hat{\phi}_1 - 1}{S_{\hat{\phi}_1}}, \qquad (1)$$

where $\hat{\phi}_1$ is an estimate of the autoregressive parameter of model $y_t = \phi_1 y_{t-1} + a_t$, $S_{\hat{\phi}_1}$ is an estimate of the standard error of $\hat{\phi}_1$ and a_t is a non-systematic component with white noise characteristics, i.e. the series of uncorrelated random variables $\text{cov}(a_t, a_{t-k}) = 0$, probability distribution $\text{N}(0, \sigma_a^2)$ with zero mean and constant variance $D(a_t) = \sigma_a^2$. The test statistic follows the Dickey-Fuller distribution; for critical values, see (Dickey and Fuller, 1979). The null hypothesis of a unit root is rejected in favour of the stationary alternative if the test statistic is more negative than the critical value. For details, see, e.g. (Arlt, Arltová, 2009), (Hušek, 2007), (Caner, M., Kilian, L., 2001), (Dickey, D., Fuller, W., 1981), (Elliot, G., Rothenberg, J., Stock, J.H., 1996), (Phillips, P.C.B., 1987).

In the regression analysis, the time series of both variables must be of the same order integrated process. The “classical” regression model can be used when the analysed time series are zero order stationary ones. Applying the unit root tests, it can be concluded that the series are not of the same order, showing no relationship.

Validation of the calculated regression model is performed using diagnostic tests of the non-systematic component of the model. To verify the normality, the Jarque-Bera test is employed, autoregressive conditional homoscedasticity and autocorrelation being verified by ARCH(1) and Breusch-Godfrey LM tests respectively. For details, see, e.g. (Jarque, C., Bera, A., 1980).

When the non-systematic component is autocorrelated, the Autoregressive Distributed Lag (ADL) model with time-shifted variables is utilized for estimation. Generally, it can be written as

$$Y_t = c + \sum_{i=1}^{p} \alpha_i Y_{t-i} + \sum_{i=1}^{q} \boldsymbol{\beta}_j (B^{j-1}) \mathbf{X}_t + a_t . \qquad (2)$$

where Y_t is the dependent variable in time t, Y_{t-i} is the dependent variable in delay $t\text{-}i$, where $i = 1,\ldots, t\text{-}p$, $\mathbf{X}_t$ is the matrix of explanatory variables in time t and delay $t\text{-}j$, where $j = 1, t\text{-}q$, α and $\boldsymbol{\beta}$ are parameters in the model and c is a constant, a_t has a white-noise characteristic, i.e. it is the series of uncorrelated random variables with $\text{cov}(a_t, a_{t-k}) = 0$, the probability distribution

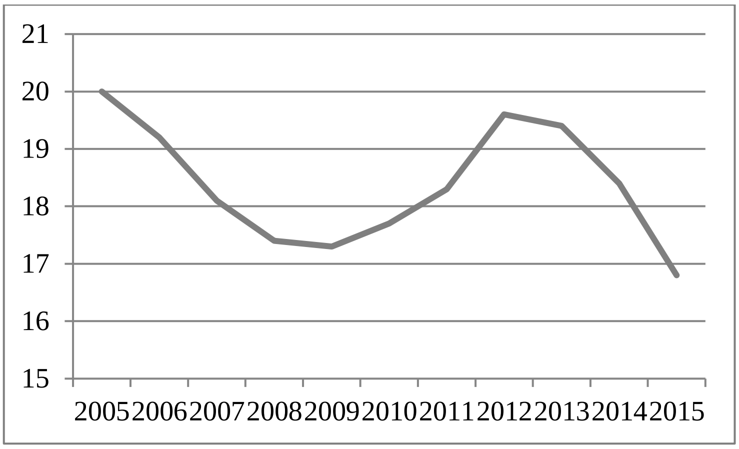
$N(0,\sigma_a^2)$ with zero mean and constant variance $D(a_t)=\sigma_a^2$. For more details, see (Arlt, 1998), (Arlt, Arltová, 2009), (Hušek,2007), (Hendry, D., Pagan, A., Sargan, J. ,1984):

2 Analysis of MDR indicator development from 2005 to 2015

The analysis is based on 2005–2015 data from the 28 European Union member states. All the data have been adopted from the Eurostat database, calculation performed using Statgraphics statistical software and Excel.

As you can see in Fig. 1, the Material Deprivation Rate index (MDR) in the 28 EU member countries was decreasing steadily before the economic crisis, hitting its low in 2009. Presumably, the economic downturn led to MDR increase between 2009 and 2012. By the year 2015, MDR value fell to 16.8 %.

Fig. 1: MDR development between 2005 and 2015 (%)



Source: data Eurostat, own elaboration

A detailed MDR analysis was conducted for the first and last reference years 2005 and 2015. Significant differences between the EU member states are obvious from Fig. 2, persistent discrepancies being caused by a combination of factors including MDR. Its level varies greatly across the EU countries – from 71.4 % (in Bulgaria) to 3.9 % (Luxembourg) in 2005, and from 49.1 % (Bulgaria) to 2.8 % (Sweden) in 2015. In most EU countries, MDR declined over the period 2005–2015. However, in some countries (Greece, Ireland, Italy, Cyprus and Spain in particular) the rate of material deprivation increased.

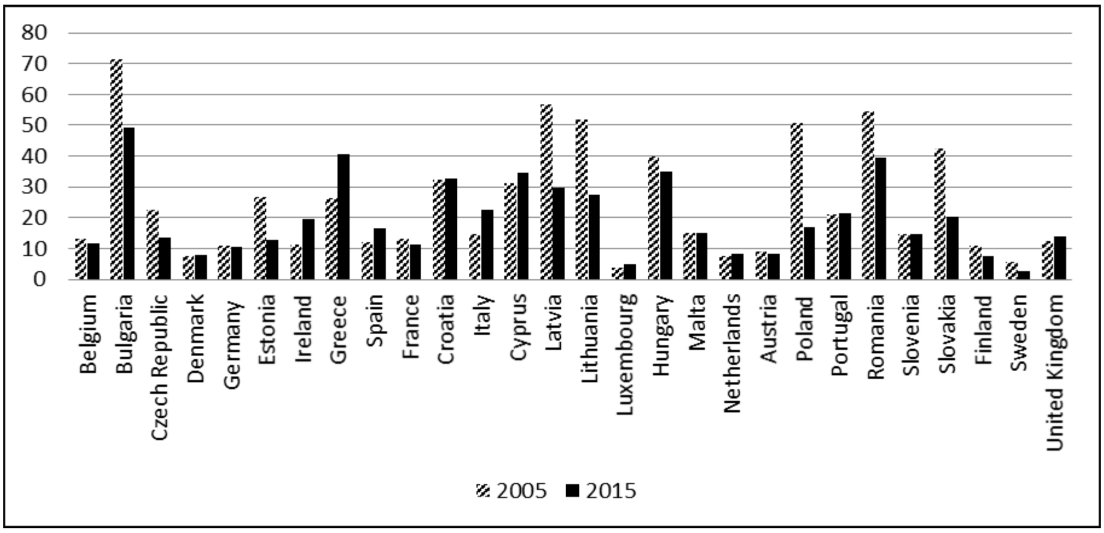
Tab. 1: MDR characteristics in 2005 and 2015

Year	Average.	Median	Variance	Standard Deviation	Skewness	Kurtosis	Minimum	Maximum	Coefficient of variation
2005	24.643	14.95	341.786	18.487	1.029	0.027	3.9	71.4	0.750
2015	19.607	15.85	146.313	12.096	0.825	-0.161	2.8	49.1	0.617

Source: data Eurostat, own calculations

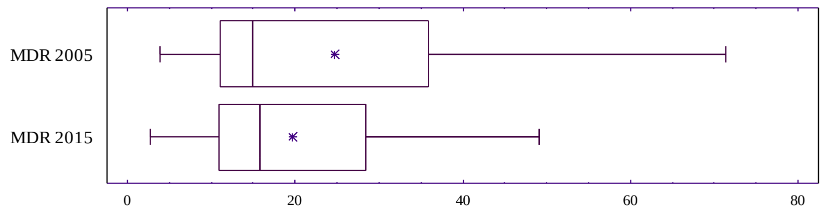
As shown in Tab. 1 and illustrated graphically in Fig. 3, the average level of the MDR indicator decreased from 24.64 % to 19.607 %, MDR variability measured by the coefficient of variation falling significantly from 75 % to 61.7 %.

Fig. 2: MDR in EU member states in 2005 and 2015 (%)



Source: data Eurostat, own elaboration

Fig. 3: MDR box-and-whisker plots in 2005 and 2015 (%)



Source: data Eurostat, own elaboration

In terms of the high variability of the reference indicator, possibilities to divide the 28 EU states into mutually different groups were explored, 2015 data having been analyzed. The countries were divided according to two criteria – euro vs. non-euro countries and the EU accession year (the "old" vs. the "new" member states). Using the standard two-sample t-test and non-parametric Wilcoxon rank-sum test, the MDR difference within the groups of euro vs. non-euro countries was not verified (at 5% significance level). The calculation output is available in Tab. 2. The classification of “old” and “new” EU countries is significant only by the non-parametric Wilcoxon rank-sum test which verifies the equality of medians; this non-parametric test being preferred to the t-test due to a small number of units in particular groups of countries. It can thus be concluded that by the division according to the accession year, significantly different groups of the EU countries can be created.

Tab. 2: Two-sample t and Wilcoxon run-sum tests of MDR indicator

	EU 28	“Old” member states	“New” member states	Euro ctrs.	Non-euro ctrs.	t-test	Wilcoxon run-sum test
Number	28	15	13	18	10	“old” vs. “new” member states	“old” vs. “new” member states
Average	19.607	13.860	26.238	17.244	23.86		
Variance	146.313	89.9	135.361	95.672	226.965	t =-3.0559 d.f. 26 p = 0.056	W = 160 p = 0.0043
Standard Deviation	12.096	9.483	11.634	9.781	15.065		
Minimum	2.8	2.8	12.8	4.8	2.8		
Maximum	49.1	40.7	49.1	40.7	49.1	Euro vs. non-euro ctrs.	Euro vs. non-euro ctrs.
Median	15.85	11.1	27.3	14.95	22.05		
Skewness	0.825	1.709	0.461	1.084	0.252	t = -1.4120 d.f. 26 p- = 0.1698	W = 112 p = 0.3026
Kurtosis	-0.161	3.786	-0.781	0.706	-1.077		
Coefficient of variation	0.617	0.684	0.501	0.567	6.314		

Source: data Eurostat, own calculations

3 Analysis of MDR and selected indicators’ relationship from 2005 to 2015

The analysis is based on 2005–2015 data on the 28 EU member states available in the EU-SILC data set. All the data as well as definitions of the indicators were adopted from the Eurostat database and calculations done using EViews 9 statistical software package. The regression analysis of multivariate time series was carried out, MDR representing the dependent variable. Other selected socio-economic indicators (such as GDP, inflation, [un]employment, educational attainment, standard of living, etc.) were employed as explanatory variables; see Table 3.

Initial analysis using a unit root test, namely the Augmented Dickey-Fuller one, identified stationary and non-stationary time series respectively. In Table 3, ADF test values and relevant p-values are presented. Obviously, the dependent variable MDR is stationary (t_{ADF} = -3.5573; p = 0.0329), among the selected explanatory variables only “real GDP per capita growth rate" (t_{ADF} = -2.4875; p = 0.0189), "lower secondary educational attainment" (t_{ADF} = -1.997; p =0.0495) and "people living in households with very low work intensity" (t_{ADF} = -4.1278; p = 0.0406) being stationary as well. Figure 4 shows the time series of these indicators over the period 2005–2015.

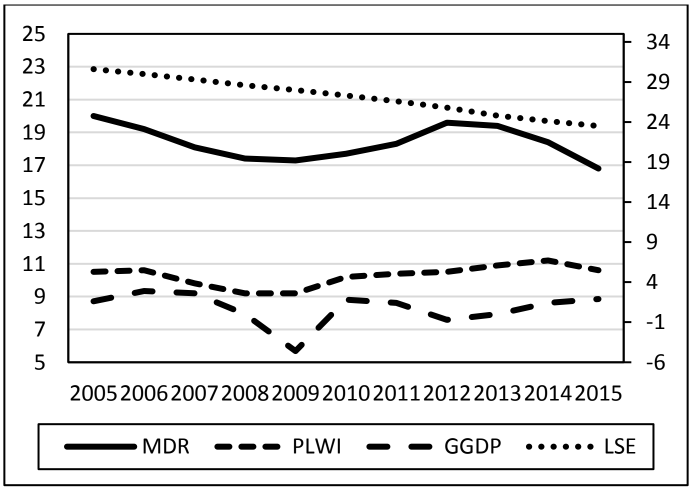
Most of the time series (rates of [un]employment, inflation, household saving, at-risk-poverty, housing cost overburden) are non-stationary. Since the time series are to be of the same integrated process type, it can be concluded that there is no relationship between the rate of material deprivation and the indicators whose time series are non-stationary.

Tab. 3: Unit root tests of selected time series

Indicator	Abbreviation	t_{ADF}	p-value
Material deprivation rate	MDR	-3.5573	0.0329
Real GDP per capita growth rate	GGDP	-2.4875	0.0189
Inflation rate (HICP)	IR	-1.1103	0.2237
Employment rate	ER	-2.6241	0.1231
Unemployment rate	UR	-1.8041	0.3556
Lower secondary educational attainment	LSE	-1.9972	0.0495
Household saving rate	HSR	-1.6583	0.4203
Housing cost overburden rate	HCOR	-1.7741	0.3700
At-risk-poverty rate	RPR	-1.3316	0.8071
People living in households with very low work intensity	PLWI	-4.1278	0.0406

Source: data Eurostat, own calculations

Fig. 4: Time series of MDR, GGDP, PLWI and LSE indicators (%)



Source: data Eurostat, own elaboration

Since most time series are non-stationary, only GGDP, PLWI and LSE explanatory variables are included in the regression analysis, GGDP indicator being eliminated because of an insignificant parameter estimate (at 5% significance level).

For the PLWI and LSE model, diagnostic tests confirmed that the non-systematic component has a normal distribution (Jarque - Bera test t = 0.7998, p = 0.6704), being homoscedastic (ARCH = 0.0157, p = 0.9034) but autocorrelated (Breuch - Godfray LM test F = 6.4779, p = 0.0317). Owing to the autocorrelation of the non-systematic component, the ADL model was applied. The final model (see Tab. 4) was created after gradual elimination of the time series with statistically insignificant parameter estimates. The estimated ADL model has the form

$$M\hat{D}R_t = -4,2677 + 100884 PLWI_t - 4,3103 LSE_t + 4,6106 LSE_{t-1} \qquad (3)$$

Thus, the material deprivation rate in the EU-28 in time *t* depends directly on the proportion of people living in households with very low work intensity in the same *t* period, is inversely proportional to people with a lower secondary education or less in the same year *t* and directly dependent on the proportion of people attaining the above level of education in the previous year (*t*-1).

Tab. 4: Final ADL model

Variable	Coefficient	Standard Error	t-statistic	Prob.
C	-4.267673	5.831193	-0.731870	0.4918
PLWI	1.088387	0.353251	3.081061	0.0216
LSE	-4.310345	1.622863	-2.656012	0.0377
LSE(-1)	4.610617	1.636490	2.817381	0.0305

Source: data Eurostat, own calculations

The model explains 78 % of the time series MDR dynamics, its determination index is 0.7818, the F-test being significant (F = 7.1654; p = 0.0208). This model is acceptable from the statistical point of view – diagnostic tests (see Tab. 5) comfirming that the non-systematic component has a normal distribution (Jarque-Bera test t = 2.2066, p = 0.3318), it is homoscedastic (ARCH = 0.4666, p = 0.5164) and not autocorrelated (Breuch-Godfray LM test F = 3.0489, p = 0.1569).

Tab. 5: Diagnostic tests of final ADL model's non-systematic component

Test	Test statistic	Prob	p-value
Breusch-Godfrey serial correlation LM test	3.0489	Prob F(2,4)	0.1569
Normality test: Jarque-Bera	2.2066	Prob	0.3318
Heteroskedasticity test: ARCH test	0.4666	Prob F(1,7)	0.5164

Source: data Eurostat, own calculations

Conclusion

The Material Deprivation Rate indicator refers to the "economic strain and durables" aspects, expressing the inability to afford some items considered by most people as desirable or even necessary for a decent life. Having been decreasing steadily prior to the economic downturn of 2007–2008, MDR in the 28 EU countries reached its bottom in 2009, the growth between 2009 and 2012 being followed by a continuous decline since then.

Using a standard two-sample t-test and non-parametric Wilcoxon rank-sum test, the MDR difference between the countries inside and outside the Eurozone was not verified (at 5% significance level). However, according to the criterion of the EU accession year, significantly different groups of countries can be created.

Upon performing the unit root test, stationarity of MDR time series was identified. Since the time series are to be of the same integrated process type, it can be concluded that there is no relationship between the material deprivation rate and indicators whose time series are non-stationary (such as the rates of employment, unemployment, inflation, household savings, at-risk-poverty and housing cost overburden).

Due to the autocorrelation of the non-systematic component, the ADL model was applied. The EU-28 material deprivation rate in time *t* depends directly on the proportion of people living in households with very low work intensity in the *t* period, being in inverse proportion to those with lower secondary or lower education in the same year *t* and directly dependent on the proportion of people with secondary or lower level of education in the previous year (*t*-1) respectively.

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