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EVALUATION OF THE LEVEL OF SHADOW ECONOMY IN LITHUANIAN REGIONS

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Abstract. The article addresses a topical issue which is extremely relevant in crisis periods – evaluation of the level of the shadow economy in all Lithuanian regions. By applying the MIMIC modelling, three equations were developed for three different periods: economic upturn, economic downturn (crisis) and economic recovery. The number of immigrants, employment rate and population's density were identified as the major shadow economy determinants in Lithuanian regions. The determinants identified are unique in the case of Lithuania because they reveal that the labour market (employment rate, the number of immigrants) and population's density are the key factors that show how municipalities address the issues of the shadow economy. 10 municipalities with respectively high or low levels of the shadow economy were ranked for each period under consideration. The maps developed for different periods illustrate the general trends of the evolution of the shadow economy. This is the first study that estimates the size of the shadow economy in 60 municipalities (a small regional division) with different economic periods taken into account. Scientific novelty manifests through consideration of the regional shadow economy and proving significance of the labour market and immigration in reducing regional disparities.

Keywords: region shadow economy, the level of shadow economy in municipalities, MIMIC model, Lithuanian regions, municipalities, determinants of shadow economy.

JEL Classification: E26, C13, E24.

Introduction

Although scientific literature is rich in the research on different issues of the shadow economy, this topic is still relevant not only because it is primarily linked to unearned budget revenue, but also due to the fact that it distorts income distribution and determines misallocation of public resources.

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While analysing the phenomenon of the shadow economy in the regional context, the questions can arise as to why and how regional shadow economy differs from the national shadow economy. Although regions, especially rural areas, still share a stereotypical image (in particular, in terms of cleaner environment), it should not be forgotten that many regions today are facing major challenges. Previous studies propose that foreign direct investment flows to regions are much less intensive than to cities, especially in the context of neoliberal globalization (Pick et al., 2010; Ramasamy et al., 2017; Li et al., 2018, etc.). Also, regions are forced to deal with such topical issues as the lack of attractive workplaces or workplaces in general (Williams, 2011), wage inequalities (Liu et al., 2011), aging society (Gadsby & Samson, 2016) and unreasonable taxation policies (Li et al., 2014). As it was noted by Gadsby and Samson (2016), despite the fact that the above-mentioned problems have already been recognized for more than a decade, at present regions are approaching the threshold at which a shrinking tax base, an aging infrastructure and a rapidly declining population create the situation when regions can no longer maintain the basic level of services and infrastructure which are necessary to attract and sustain the population as well as businesses. There exists an interdependence between business (economic activities) and population: business is impossible without involvement of the population, while maintenance of the population is not possible without business conduct.

Gadsby and Samson (2016) state that sustainable development cannot be expected without maintaining a balance between urban and regional areas. This view is supported by Reimer (2004) who asserts that urban and regional economies are closely-related: regions supply urban areas with wood, food, minerals and energy that, in their turn, serve urban, and the same time, national economic growth. Thus, if regional economies renew and restore urban population, large shadow economies in regions impede national economic development (Weng, 2015). According to Medina and Schneider's (2017) approach, proposing that the shadow economy is caused by particular financial, regulatory and/or institutional determinants, it can be presumed that the likelihood of the shadow economy is much higher in regions than on a national scale.

Concerning the above-mentioned deep economic and social problems in regions, *the main purpose* of this article is to estimate the size of the shadow economy in Lithuanian regions. For fulfilment of the defined purpose, the following *objectives* were set: 1) to review previous scientific findings on the determinants of the shadow economy in regions; 2) to select and substantiate the methodology of the research; 3) to provide the results of the empirical research on the size and determinants of the shadow economy in Lithuanian regions. The methods of the research include comparative and systematic literature analysis, the MIMIC model.

In the first part of the article the theory of regional shadow economy and its determinants have been analysed. In the second part the empirical research methodology have been presented. In the third part of the paper the empirical results have been described. The article concludes with conclusions.

1. Regional shadow economy and its determinants: theoretical background

According to Gadsby and Samson (2016), regional economies are quite difficult to define because in many cases there are no formal boundaries between regions (e.g. in cases of ethnic regions), and population's affiliation to one or another region is largely determined

intuitively. What inherent features could be employed to identify a particular region still remains a matter of discussions at both academic and political levels. The term "region" is not always related to the distance of the area from large cities, though this interpretation is also popular. Du Plessis et al. (2002) indicate that a regional area may also mean a separate social unit with its inherent population mentality, history and lifestyle. Summarising various interpretations, it can be stated that a regional area can be defined as an area with a smaller population and lower density than those in urban areas, which is remote from urban areas and possesses a specific identity as well as specific socio-cultural relationship.

According to quantitative proof of the hypothesis raised in Polovyan's (2015) study, the size of the shadow economy in a country is the sum of the shadow economies of its regions. Regional shadow economy can be affected by a variety of determinants. Previous findings concerning the main determinants of the shadow economy in regions are reviewed in Table 1.

Table 1. The review of some previous findings on the determinants of the shadow economy in regions (source: compiled by the authors)

Author(s), year	Research method(s)	Countries and periods	Findings
Kireenko et al., 2017	Factor analysis and MIMIC modelling	Russian Federation 2002–2013, Ukraine 2004–2013	Shadow economy is determined by demographic and criminogenic factors; the impact of standard of living can vary from country to country
Remeikiene et al., 2018	The MIMIC model	Lithuania, 2012–2016	Shadow economy is affected by population's income, taxation, crime-related determinants and particular demographic factors
Kireenko and Nevzorova, 2019	Analysis of the approximation curves	Russia, 2002–2013	The size of the shadow economy directly correlates to the share of the agricultural sector as percentage of GDP
Gasiūnas, 2018	The MIMIC model	Europe, 2010–2017	Shadow economy is mainly determined by economic (GDP per capita, unemployment rate), taxation (tax burden, social protection expenditure) and social (poverty risk, gender wage gap) factors
Gonzalez-Fernandez and Gonzalez-Velasco, 2015	Currency Demand Approach	Spain, 1987–2010	Shadow economy is to the greatest extent affected by the personal income tax
Prytula et al., 2019	The MIMIC, expert survey	Ukraine, 2000–2018	Main determinants of the shadow economy include tax burden and social protection, regulatory measures, the quality of social services, the number of self-employed
Polovyan, 2015	Complex economic and mathematical models, based on the major factors of Doing Business	Ukraine, 2001–2012	Shadow economy is defined by the reliability of right protecting institutions and the level of the tax burden

End of Table 1

Author(s), year	Research method(s)	Countries and periods	Findings
Buček, 2017	The MIMIC model	The Czech Republic, 2005–2014	Shadow economy is determined by labour market and number of people with at least one distraint
Buszko, 2017	The MIMIC model	Poland, 2006, 2011 and 2016	The differences in the size of the shadow economy in regions are determined by the differences in regional economic efficiency
Bilonizhko, 2006	The MIMIC model	Russia, 2001–2003	Most significant shadow economy determinants include tax pressure, specialization and unemployment rate
Vorobyev, 2015	Cross-section regression model, augmented electricity dynamics approach	Russia, 2004–2011	There exists high positive correlation between the size of the shadow economy and corruption, unemployment, and especially dependency of regional budget on Federal transfers
Weng, 2015	Synthesis of academic and grey literature, conceptual exploration, in-depth case studies	Sub-Saharan Africa, research period not indicated	Shadow economy in regions is promoted by customary rights and norms, insufficient regulation and socio-economic determinants
Williams and Horodnic, 2017	Face-to-face interviews, multilevel logistic regression analysis	28 EU member states, 2013	Costs of engaging in shadow work outweigh the benefits, low perceived penalties, low risk of detection and low tax morale raise the size of the shadow economy
Schwettmann, 2020	Systematic literature analysis, statistical data analysis, in-depth country case studies	Sub-Saharan Africa, 2020	The shadow economy is driven by poverty, gender gaps, ethnicity, disability
Gillanders and Parviainen, 2018	Enterprise Surveys	Sub-Saharan Africa, Europe and Central Asia, Latin America and Caribbean, 2006–2010	Corruption is strongly positively correlated to the shadow economy at the sub-national level
Davydova et al., 2020	Systematic literature analysis, critical analysis	Russia, Irkutsk region, research period not indicated	The informal economy is driven by actor profits, insufficiency of regulation, lack of governmental intervention, tax burden

As it can be seen in Table 1, the determinants of the shadow economy may vary from region to region, although some general tendencies can be envisaged: many authors highlight the significance of taxation (Bilonizhko, 2006; Tafenau et al., 2010; Buehn, 2012; Polovyan, 2015; Gonzalez-Fernandez & Gonzalez-Velasco, 2015; Gasiūnas, 2018; Remeikiene et al., 2018; Davydova et al., 2020), standard of living (Kireenko et al., 2017; Remeikiene et al., 2018), labour market (Bilonizhko, 2006; Tafenau et al., 2010; Buehn, 2012; Vorobyev, 2015; Buček, 2017; Prytula et al., 2019), institutional factors (Polovyan, 2015) and corruption (Vorobyev, 2015; Borlea et al., 2017; Gillanders & Parviainen, 2018). Nevertheless, the results of some studies are contradictory, for instance, Buček's (2017) study found no evidence to prove the importance of particular types of taxes (e.g. corporate taxes).

Among all other factors, Buček (2017) observes that the labour market and the number of people with at least one distraint are statistically significant determinants of the shadow economy, while Vorobyev (2015) emphasizes the high positive correlation between the size of the shadow economy and dependency of regional budget on Federal transfers. Davydova et al. (2020) focus on insufficiency of regulation and a lack of governmental intervention and state that shadow activities in Russian regions are often hidden by authorities to gain financial benefits. Williams and Horodnic (2017) base their research on rational economic actor and social actor approaches and reveal that the size of the shadow economy in rural areas can be promoted by low perceived penalties, low risk of the shadow activity detection and low tax morale.

Kireenko's et al. (2017) research revealed that the main determinants of the shadow economy in Russia and Ukraine are the demographic factor and the criminogenic factor, although the impact of standard of living was found to be weaker in Russia, but stronger in Ukraine (the estimations exposed that formal employment in Russia weakly correlates to population's monetary income, while in Ukraine the correlation between these two factors is close). Remeikiene's et al. (2018) study confirmed that the size of the shadow economy is related to population's average income and the number of criminal offences. Apart from that, the impact of the share of indirect taxes, the cases of cigarette smuggling, population of women per 1000 men, the number of children in social risk families and the number of tourists was also detected. The significance of demographic factors was also confirmed by Schwettmann (2020) who argues that poverty, gender gaps, ethnicity and disability push most vulnerable social groups into the informal economy.

Gasiūnas (2018), who researched the level of the shadow economy in different European regions by employing the MIMIC model, found that the shadow economy in the northern European region is mainly affected by the proportion of the population at risk of poverty, expenditure on social protection and GDP per capita; the shadow economy in the eastern European region is significantly affected by expenditure on social protection and GDP per capita; the shadow economy in southern European region is to the greatest extent determined by unemployment rate, the proportion of the population at risk of poverty and tax burden; finally, the shadow economy in the western European region is mainly caused by the proportion of the population at risk of poverty and the gender wage gap. The differences observed among the regions in the countries under consideration propose that interdependence between various socio-economic determinants and the level of the regional shadow economy is

conditioned by the gap in the elements constituting a country's economic and social system and ensuring its functioning. These findings are in line with the results provided by Weng (2015) who highlights significance of the role of socio-economic determinants. The author finds that the shadow economy in rural areas is driven by customary rights and norms (informal agricultural activities have historically been seen as legitimate), insufficient regulations to address the needs of rural actors, economic profit and demand from low-income consumers, and such social factors as poverty and income diversification.

It should be noted that unlike in urban territories, the size of the shadow economy in regions, in particular, in rural areas, can be significantly affected by the share of the agricultural sector in the total economy (or GDP). For instance, Kireenko and Nevzorova's (2019) study disclosed that there exists a direct correlation between the level of the shadow economy and the share of the agricultural sector as percentage of GDP in Russian regions. A noticeable correlation was identified between the size of the shadow economy and the share of rural population in the total population, while the correlation between the size of the shadow economy and the share of agriculture, hunting, and forestry in the GRP was found to be moderate. These findings can be explained by the fact that a substantial part of regional population, declining as a result of urbanization, are still dependent on agricultural activities (forestry, crop and livestock production, hunting, etc.), not efficient in terms of employment, although an increase in informal employment is as well observed in the non-agricultural sector.

There are manifold arguments to explain the differences observed in both the size of the shadow economy in regions and the determinants of the regional shadow economy. According to Buszko (2017), these differences are primarily determined by varying regional economic efficiency (Buszko, 2017). Bilonizhko (2006) puts the emphasis on specialization of a region – whether industrial or agricultural, while Polovyan (2015) links the differences to the factors of Doing Business, a region's economic structure and system-wide elements, such as property right, investor right protection or enforcement of contracts, that substantially affect the behaviour of economic agents.

Having compared the key determinants of the shadow economy identified by Schneider and Buehn (2016) with the determinants provided in Table 1, we can conclude that tax burden and institutional factors are the same affecting the shadow economy either at the national or regional level. Scientific studies that focus on regions as a smaller territorial unit provide more determinants of the shadow economy at the sub-national level. The major groups of these determinants include demographic (population of women per 1000 men; the number of children in social risk families) and criminogenic (the cases of cigarette smuggling; the number of criminal offences) factors. The number of tourists, share of the agricultural sector in rural territories and structure of regional budgets were also proved to be the determinants of the shadow economy.

On balance, much like the shadow economy at a national level, the shadow economy at a regional level is mainly affected by the determinants of taxation, standard of living, labour market, public institutions and corruption, although the impact of demographic and criminogenic factors should not also be underestimated. Since a substantial share of regional population are dependent on agricultural activities, the size of the shadow economy in regions can be significantly affected by the share of the agricultural sector in the total economy,

which in not inherent to urban territories. The differences previous studies reveal in both the size and the determinants of the shadow economy in regions can be explained by varying regional economic efficiency, regional specialization, economic structure and system-wide factors, i.e. the gap in the elements constituting a region's economic and social system and ensuring its functioning.

2. Research methodology

MIMIC model, namely multiple indicators and multiple causes model is a special case of Structural Equation Modeling (Zellner, 1970; Hauser & Goldberger, 1971). Structural Equation Modelling presents how sets of variables define latent variables and how these latent variables are related to each other applying regression, path and confirmatory factor analysis. Structural Equation Modelling estimates the parameters considering similarity between the sample covariance matrix which is calculated from data and the implied covariance matrix. The similarity between these matrices which is also a model fit criterion is evaluated using chi-square statistic.

MIMIC model consists of structural and measurement equation system. Structural model reflects the relationships between the latent variable (ζ) and observable causes (X_q). Measurement model links the observable indicators (Y_p) with latent variable. Frey and Weck-Hanneman (1984) are the first researchers that consider the size of the shadow economy as a "latent variable".

The latent variable, Shadow Economy, is linearly determined by exogenous causes and disturbance:

$$\zeta = \alpha_1 X_1 + \alpha_2 X_2 + ... + \alpha_q X_q + \varepsilon. \tag{1}$$

Observable endogenous indicators are determined by latent variable and disturbances:

$$\begin{aligned} Y_1 &= \lambda_1 \zeta + \varepsilon_1; \\ Y_2 &= \lambda_2 \zeta + \varepsilon_2; \\ &\cdots \\ Y_p &= \lambda_p \zeta + \varepsilon_p, \end{aligned} \tag{2}$$

where ζ is a latent variable (Shadow Economy), ε is the structural disturbance and ε_i corresponds to measurement errors. Since the SEM model and thus the MIMIC model is obtained based on the covariance matrix, it is important to investigate the existence of outliers, asymmetry and skewness that affect the covariance matrix.

When the studies that estimate the shadow economy in the literature are examined, it is seen that there is no method considered as the best. However, when the recent studies are examined, it is seen that studies estimating the shadow economy with MIMIC model are frequently used. It is an important advantage that the MIMIC model takes into account the multiple indicator and causal variables at the same time and allows prediction when estimation based on the maximum likelihood method. On the other hand, the MIMIC model has several disadvantages (Schneider & Buehn, 2016; Giles & Tedds, 2002; Helberger & Knepel, 1988): The most common criticism is the fact that the MIMIC model is a confirmatory analysis, that

is, it is not in an exploratory structure that examines which model is appropriate, and that the theoretical assumptions behind the selection of variables are required and this situation limits empirical studies. Another criticism is that the estimates lead to unstable coefficients depending on the sample size. However, the economic literature using the MIMIC model is aware of these limitations, but these limitations do not prevent the use of the MIMIC model in studies on shadow economy, on the contrary, these problems should encourage further research in this area (Schneider & Buehn, 2016).

The dataset used in this study consists of annual observations between the years of 2001 and 2019 for 60 municipalities of Lithuania. The evaluated variables are partitioned into two groups, namely:

- Indicators: number of enterprises (NMR), number of beneficiaries (NB), municipality budget in total (TBUD), municipality budget for education (EBUD), municipality budget for social security (SBUD), municipality budget for health (HBUD). The above-mentioned parameters are selected as indicators taking into account that the level of the shadow economy should reduce the number of business enterprises, raise the number of beneficiaries, reduce the municipality budget in total as well as its separate components, i.e. budgets for education, social security and health.
- Causes: employment rate (EMP), unemployment rate (UNEMP), wages-salary (WAGE), population (POP), population density (POPD), immigration (IMM), emigration (EMI), number of nonfinancial corporation (FIN), number of pensioners beneficiaries (PEN), expenditures on benefits of families raising children (CHILD).

The theoretical reasons of the causes in the MIMIC model are as follows:

Employment rate. The higher is the shadow economy, the lower is employment rate, *ceteris paribus* (Medina & Schneider, 2017).

Unemployment rate. The higher is unemployment rate, the higher is the probability to work in the shadow economy, *ceteris paribus* (Medina & Schneider, 2017).

Wage. An increase in the minimum wage could create a competitiveness problem in the context of a relatively high level of informal economic activities in the long run; the empirical results, however, do not support any effect of an increase in the minimum wage in the short run (Davidescu & Schneider, 2017).

Population / Population density. Densely populated areas tend to have lower levels of the shadow economy (Buček, 2017).

Immigration. Firstly, illegal immigrants are forced to work in the shadow economy. Secondly, many legal immigrants are employed in the low-skilled sector, where jobs are less secure and more likely to be irregular. Finally, the wider availability of illegal workers may concur to the establishment of a job-market equilibrium, which is more reliant on illegal work (Bosh & Farre, 2013).

Although the impact of emigration, the number of non-financial corporations, the number of pensioners beneficiaries and expenditures on benefits of families raising children has not thus far been comprehensively researched in scientific literature, the authors of this article are of the opinion that the above-mentioned factors need to be considered. Emigration can be expected to raise the level of the shadow economy. The number of pensioners beneficiaries, in case they have addictive habits and their pensions are low, may engage in the consumption of smuggled goods and/or contribute to the pension through informal employment. Benefits

for families raising children promote consumption; the income from these benefits can be spent in informal markets.

Data were obtained from Statistics Department of Lithuania and Employment Services Under the Ministry of Social Security and Labor of the Republic of Lithuania.

Indicator variables related with municipality budget and number of enterprises (NMR) are not available before the years 2004 and 2005, respectively. Due to these missing observations, potential effects of outliers and the aim of providing unbiased results the sample was split into three subsamples over the periods 2001–2006, 2007–2010 and 2011–2019. While determining these periods, the 2007 crisis was taken into consideration and divided into "pre-crisis", "crisis period", and "post crisis". Median values were obtained for each district over the relevant years for each period examined. The reason for using the median instead of the arithmetic mean is that the median values represents the data better in the presence of outliers.

Before employing the MIMIC model for each period, the presence of outlying observations that are inevitably encountered in the cross-sectional data and the existence of the multicollinearity problem, which is important in the selection of variables in the MIMIC model, were investigated. The presence of outliers in each variable was checked using boxplots. When all variables are considered, municipalities Vilnius city, Kaunas city, Klaipeda city, Panevezys city and Siauliai city are obtained as outlying observations in the dataset. Since the existence of outliers have effects on Pearson correlation matrix, the correlation values between indicators and between causes investigated using the robust weighted-MCD correlation matrix for the evaluation of multicollinearity. MCD is one of the high-breakdown estimator of covariance matrix which is resistant to outliers (Hubert & Debruyne, 2010). According to robust MCD correlation matrix (Appendix), strong correlations which are above 0.8 can be summarized as follows: Between employment rate (EMP) with budget related variables (municipality budget in total (TBUD) – municipality budget for education (EBUD) – municipality budget for social security (SBUD), POP, number of enterprises, CHILD and FINANCE, between POP with EMG, CHILD and FINAN, between EMIG and CHILD.

In MIMIC model, the assumption of Multivariate normality is essential for preserving the statistical properties of estimators. After the exclusion of the outlying municipalities from the dataset, "multivariate normality is confirmed by Mardia's test. Furthermore, in each MIMIC model, Mahalanobis distance squared values of observations confirmed the existence of multivariate normality as another indicator of normality assumption.[1] Considering the high correlation values between causes, MIMIC model has been employed to each period. Table 2 only reports the results for MIMIC models which have better diagnostic statistics. As is known, small values of root mean square error of approximation (RMSEA, <0.05), large values of goodness of fit (GFI, >0.90) and comparative fit index (CFI, >0.90) indicate good model. During the evaluation process of models besides RMSEA, GFI and CFI diagnostics, "chi-square/ degrees of freedom" criteria is also evaluated. Chi-square test measures the fit of MIMIC model (null hypothesis is; covariance matrix of the predicted model and covariance matrix of the observed data are equal) however since chi square test is effected from

[1] MIMIC model calculations were also employed using robust covariance matrix in AMOS. The findings were similar to Table 2.

the sample size, the ratio chi-square value divided to degrees of freedom (less than 2 or 3) is accepted as an important indicator (Kline, 1998; Ullman, 2001).

3. Results of empirical research

The MIMIC models in Table 2 include the covariance between employment rate (EMP) and immigration (IMM). According to the model fit measures in Table 2, specification 1 and 2 provide satisfactory results for period 1 and period 2. For period 2, only specification 2 provides satisfactory results.

Period 1 – Pre Crisis

Specification 1: Shadow = 0.81*EMP + 0.34*IMM + 0.19*POPD

Specification 2: Shadow = 0.84*EMP + 0.39 IMM

Period 2 – Crisis

Specification 2: Shadow = 0.43*EMP + 0.83*IMM

Period 3 – Post Crisis

Specification 1: Shadow = 0.66 EMP + 0.37 IMM + 0.20 POPD

Specification 2: Shadow = 0.62 EMP + 0.43 IMM

Considering the models, it can be seen that *employment rate (EMP), immigration (IMM) and population density (POPD) variables have a positive effect on the shadow economy.* Since the coefficients are standardized, it is possible to compare the significance of the variables. According to this, it can be seen that *the employment rate (EMP) has a more significant effect than immigration (IMM) in pre- and post-crisis periods, but in the crisis period, on the contrary, immigration (IMM) affects more significantly than the employment rate (EMP).*

Although both model specifications above have yielded good results for period 1 and period 2 (since three periods are considered and compared in this study), instead of the specification containing the population variable, specification 2 whose variables are common in all three models was selected. The models based on specification 2 were used for three periods while examining the shadow economy in each municipality.

As can be seen from Table 2, WAGE variable does not appear to have a significant effect on the shadow economy when all three periods are taken into account. Although the population density (POPD) variable appears to have a statistically significant effect for the pre-and post-crisis periods, this is not valid for the crisis period. Logarithms of budget-related variables are included in this model. However, due to the strong correlation values of municipality budget in total (TBUD) and municipality budget for education (EBUD) with number of enterprises, Specification 1 was preferred instead of 2. As a matter of fact, the values in Table 3 and Table 4 were also obtained based on Specification 2.

Considering three periods, it can be said that over time employment rate (EMP) shows an U shaped development, whereas immigration (IMM) shows inverse U shaped development.

The impact of the Shadow economy on number of enterprises (NMR) post-crisis and during the crisis is greater than before the crisis. However, the impact of the Shadow economy on variable number of beneficiaries (NB) increased in the post-crisis period. In all three periods, number of enterprises (NMR) and number of beneficiaries (NB) variables appear to be positively influenced by Shadow economy.

Table 2. Results of MIMIC model estimations (standardized coefficients)

Period	Period 1: 2001–2006				Period 2: 2007–2010				Period 3: 2011–2019			
Specification	1	2	3	4	1	2	3	4	1	2	3	4
Causes												
EMP	0.811*** (3.09)	0.842*** (2.69)	0.64*** (2.81)	0.707*** (3.09)	0.39*** (3.45)	0.43*** (3.41)	0.39** (2.03)	0.37* (1.832)	0.662*** (2.97)	0.622*** (2.69)	0.62*** (2.97)	0.62*** (3.09)
WAGE	–	–	–	-0,09 (0.61)	–	–	–	-0.06 (0.747)	–		–	0.10 (1.35)
POPD	0.192* (1.65)		0.09 (0.89)	0.106 (1.34)	0.05 (0.91)		0.03 (1.11)	0.03 (1.05)	0.196** (2.11)		0.13 (1.59)	0.13 (1.37)
IMM	0.344** (2.37)	0.391** (2.46)	0.30** (2.21)	0.313** (2.39)	0.77*** (3.84)	0.83*** (3.98)	0.67*** (3.29)	0.74*** (3.29)	0.371*** (2.61)	0.431*** (2.88)	0.39*** (3.09)	0.42*** (3.10)
Indicators												
NMR	0.777*** (2.81)	0.731** (2.41)	0.88 (1.14)	0.837* (1.69)	0.85** (2.31)	0.79*** (3.85)	0.94*** (2.65)	0.89*** (2.71)	0.896** (1.99)	0.91*** (2.97)	0.91*** (3.41)	0.89*** (3.21)
NB	0.535*** (2.75)	0.566*** (3.09)	0.66*** (3.29)	0.663*** (2.61)	0.51*** (3,65)	0.46*** (3.61)	0.52*** (2.88)	0.53*** (2.81)	0.89*** (2.58)	0.61*** (2.65)	0.66*** (2.97)	0.62** (2.56)
log(TBUD)		–	0.95*** (3.85)				0.86** (2.51)				0.90*** (3.29)	
log(SBUD)		–	–	0.764*** (2.81)			–	0.58** (2.41)				0.63*** (2.58)
log(HBUD)	0.242*** (2.76)	–		–	0.21* (1.66)				0.667*** (3.29)			
Diagnostics												
RMSEA	0.102	0.001	0.292	0.228	0.193	0.001	0.304	0.279	0.067	0.061	0.145	0.202
GFI	0.931	0.971	0.805	0.803	0.881	0.957	0.832	0.777	0.948	0.989	0.904	0.834
CFI	0.939	0.983	0.804	0.772	0.899	0.949	0.823	0.744	0.981	0.991	0.948	0.812
Chi-square/df	1.636	0.06	5.361	3.414	2.918	0.603	5.791	5.123	1.322	1.314	2.456	3.611

Note: *indicates significance at the 10%level, **indicates significance at the 5% level, *** indicates significance at the 1% level. Absolute z statistics are given in the parenthesis. Df: degrees of freedom.

Table 3. Municipalities with the 10 smallest shadow economies

First Period (2001–2006)			Second Period (2007–2010)			Third Period (2011–2019)		
	Median	SD		Median	SD		Median	SD
Kazlų Rūdos	16,495	5,746	Molėtų	17,542	7,119	Birštono sav.	10,485	3,525
Kupiškio	17,183	7,154	Elektrėnų	18,800	4,505	Varėnos r.	11,532	3,324
Kalvarijos	17,600	5,107	Zarasų raj.	19,745	9,587	Akmenės raj.	11,552	3,474
Neringos	17,934	8,135	Lazdynų raj.	19,987	7,243	Rietavo	11,777	3,791
Akmenės raj.	18,500	21,517	Pakruojo raj.	20,070	6,275	Pagėgių	12,661	3,007
Birštono sav.	18,857	6,797	Šilalės	20,131	2,959	Zarasų raj.	12,676	3,666
Panevėžio	20,180	4,250	Anykščių	20,554	3,541	Rokiškio	12,776	3,531
Palangos	20,188	9,745	Biržų raj.	20,744	3,687	Šakių raj.	13,032	3,545
Skuodo	20,374	13,361	Kauno r.	23,495	9,044	Utenos raj	13,249	3,321
Pagėgių	20,376	7,640	Telšių raj.	23,638	3,681	Kazlų Rūdos	13,593	3,105

Note: *SD: Standard Deviation. *Base years considered are 2004, 2009, 2014.

Table 4. Municipalities with the 10 largest shadow economies

First Period (2001–2006)			Second Period (2007–2010)			Third Period (2011–2019)		
	Median	SD		Median	SD		Median	SD
Jonavos r.	25,950	3,451	Jonavos r.	29,467	10,862	Kretingos	17,630	3,677
Šakių raj.	25,953	12,604	Visagino	29,483	10,723	Kalvarijos	17,630	5,173
Kauno r.	26,861	5,523	Kaišiadorių	29,528	7,776	Šiaulių m.	17,767	11,341
Kretingos	27,000	11,646	Plungės raj.	30,142	10,625	Šiaulių raj.	17,944	12,608
Klaipėdos m.	27,089	1,708	Klaipėdos m.	30,488	12,261	Jonavos r.	18,385	2,943
Druskininkų	27,140	6,525	Neringos	30,822	5,261	Šalčininkų	19,140	9,619
Lazdynų raj.	27,582	7,095	Kretingos	32,115	9,058	Klaipėdos	19,611	17,304
Vilniaus m.	31,140	2,852	Ukmergės r.	32,980	8,340	Elektrėnų	19,692	25,749
Zarasų raj.	32,254	4,773	Šalčininkų	33,598	13,147	Neringos	20,665	13,291
Rietavo	33,051	6,748	Širvintų	35,329	18,283	Kupiškio	21,308	5,420

Note: *SD: Standard Deviation. *Base years considered are 2004, 2009, 2014.

Considering the relevant MIMIC models (specification 2), for each period, the level of the shadow economy in percentage of GDP values for 60 municipalities was obtained by using Schneider's et al. (2010) formula:

$$\hat{\eta}_t = \frac{\hat{\eta}_t}{\hat{\eta}_{2004}} \hat{\eta}^*_{2004},$$

where $\hat{\eta}_t$ denotes the value of the MIMIC index at $\hat{\eta}_{2004}$ t; is the value of this index in the base year 2004. The other base years are 2009 and 2014. The same formula was used by Nchor (2021). Due to the unique economic structure of each period, the calculations of the level of the shadow economy in percentage of GDP are based on the three base years that

were extracted from an exogenous estimate (Medina & Schneider, 2017). Based on these calculations, Table 3 and Table 4 present the 10 smallest and 10 largest shadow economies respectively. Tables 3–4 also include the median and standard deviation values calculated over the respective years for each municipality. The reason for using the median instead of the arithmetic mean is the excessive fluctuations observed in some years for some municipalities (especially in 2017, 2018 and 2019). The immigration variable, which describes the Shadow Economy latent variable, explains the fluctuation in these years. For example, immigration in Elektrenai municipality in 2019 increased by 407% compared to 2015. Median is a type of average that is resistant to such kinds of fluctuations.

The large standard deviation values indicate that the changes in the series, in other words, the fluctuations, are high. Table 3 indicates that the standard deviation for Akmenes is 21.52, although Akmenes is in the list of those municipalities with the lowest shadow economy values. This situation can be explained by the increase in the immigration to Akmenes by 176% in 2005 compared to 2004. Silales is the least fluctuating municipality during the crisis period. As seen in Table 4, Elektrenai, one of the municipalities with the highest shadow economy in the third period, also has the highest standard deviation value. Elektrenai, however, is the second municipality with the lowest shadow economy during the crisis. Considering the fact that the shadow economy values for Lithuania in the base years were 25.65 (in 2004), 24.29 (in 2009) and 17.62 (in 2014) respectively, and leaning on Medina and Schneider's (2017) calculations, it is seen that all municipalities in Table 4 are above the base year values. A striking point in the above-mentioned tables is that the shadow economy values in the third period are lower than those in the previous two periods.

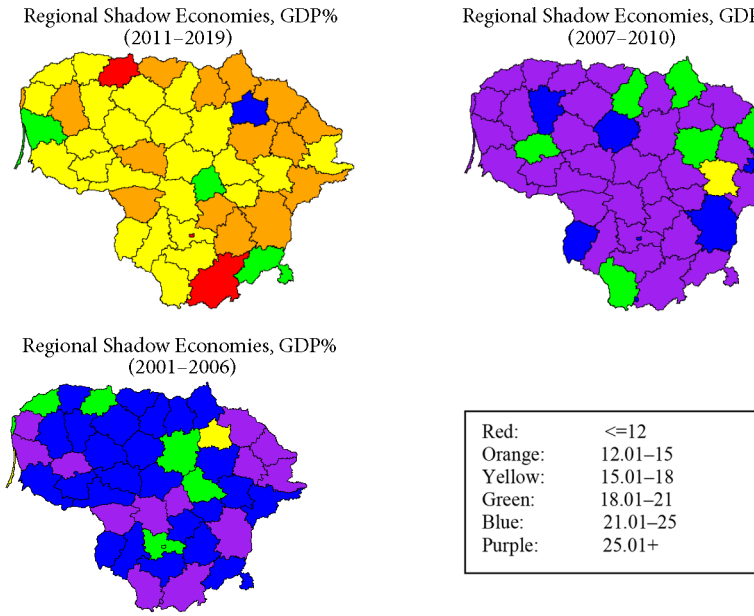

Figure 1. Maps of the regional shadow economies for three periods (own calculation)

As can be seen from Figure 1, while the levels of the shadow economies in most of the municipalities are between 21 and 25 in the period before the crisis, they are mostly larger than 25 during the crisis period. Nevertheless, the municipalities with the levels of the shadow economies between 15 and 18 are tended to have the highest rates after the crisis.

Conclusions

Summarising, it can be concluded that in the context of this study, the level of the shadow economy for Lithuanian municipalities over three periods under consideration – economic upturn (2001–2006), economic crisis (2007–2010) and economic recovery (2011–2019) – has been estimated for the first time. The number of immigrants, employment rate and population's density were identified as the major shadow economy determinants in Lithuanian municipalities. All the determinants affected the level of the shadow economy in all regions in a single direction which was either positive or negative. Thus far, scientific research has hardly considered the impact of official immigration; it has mainly focused on the negative impact of unofficial immigration on "the shadow" in the labour market. The finding that employment rate also raises the level of the shadow economy encourages the authors to delve into the causes of employment, for instance, envelope wages, cheating on the taxes paid on employees, etc. The empirical estimations have revealed that the worst situation could be observed during the crisis period when the highest levels of the shadow economy were recorded in Širvintų, Šalčininkų, Ukmergės and Kretingos district municipalities (the level of the shadow economy amounted to 32–35 percent of GDP).

The results of this research can be useful to the public institutions (municipalities, the Employment Service, Immigration Department) that are responsible for promoting regional socio-economic development by reducing the size of the shadow economy in particular municipalities. Further research on this issue can address the causes pushing the unemployed to get involved into the informal labour market as a structural part of the shadow economy with consideration of the role smuggling cigarettes and other excisable goods.

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Author contributions

All authors contribution is equal.

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APPENDIX

Table 1. Robust MCD Correlation Matrix for period1

	EMP	WAGE	TBUD	EBUD	SBUD	HBUD	REC	POP	POPD	IMM	EMG	NMR	PENS	CHILD	FINAN	UNEMP
EMP	1															
WAGE	–0.05	1														
TBUD	0.96	0	1													
EBUD	0.95	–0.01	0.98	1												
SBUD	0.83	0.1	0.88	0.83	1											
HBUD	0.53	0.06	0.49	0.39	0.34	1										
REC	0.55	0.1	0.6	0.54	0.78	0.14	1									
POP	0.96	–0.04	0.98	0.98	0.86	0.45	0.59	1								
POPD	0.7	0.21	0.67	0.69	0.68	0.31	0.3	0.7	1							
IMM	0.58	0.55	0.59	0.56	0.66	0.28	0.57	0.59	0.72	1						
EMG	0.85	0.14	0.83	0.82	0.86	0.4	0.62	0.84	0.72	0.67	1					
NMR	0.88	–0.05	0.87	0.89	0.7	0.4	0.4	0.91	0.74	0.55	0.76	1				
PENS	0.76	–0.1	0.79	0.81	0.53	0.41	0.35	0.81	0.45	0.35	0.53	0.75	1			
CHILD	0.86	–0.14	0.88	0.85	0.91	0.34	0.63	0.88	0.65	0.46	0.81	0.8	0.59	1		
FINAN	0.87	–0.02	0.83	0.87	0.69	0.35	0.36	0.88	0.75	0.53	0.76	0.96	0.75	0.79	1	
UNEMP	–0.16	0.14	–0.11	–0.16	0.21	–0.38	0.53	–0.12	–0.14	0.09	0.05	–0.31	–0.25	0	–0.27	1