Causes of the shadow economy in Central and Eastern Europe

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Abstract

Due to its clandestine nature, quantifying the shadow economy is a challenging task. Concealing incomes leads to large negative externalities: market distortions and loss of tax revenues cause enormous damage worldwide. Countries in Central and Eastern Europe (CEE) are in a precarious situation: their transformation from planned to market economies took place only recently, thus their corporate sector and institutional background do not have such long histories and deep traditions as in some other parts of the world. In our paper, we reveal causes of the shadow economy in CEE in a panel econometric framework by using data of the International Monetary Fund and other global organisations. We apply static and dynamic panel linear models and pay special attention to factors such as socio-economic development, institutional background, income inequalities, and taxation. Our results prove that the CEE region differs from the rest of the world in many aspects of the shadow economy, and points out the persistence of the shadow economy, the short-term nature of the impact of inflation and the long-term effect of income inequalities in the shadow economy. We conclude with some policy recommendations to whiten the shadow economy in CEE.

Keywords: shadow economy, Central and Eastern Europe, panel linear model, dynamic panel model

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1. Introduction

The shadow economy has been a part of everyday life since time immemorial. Historians have found evidence of bribery and corruption of public servants in ancient Rome (Kaufmann, 1998). Even though the shadow economy is such an antique phenomenon, it still does not have a universal definition, most likely because it is a multidisciplinary subject. It is widely researched in economics (Choi & Thum, 2005), political science (Karstedt & Farrall, 2006, and Teobaldelli & Schneider, 2013) and sociology (Wedel, 2011). The social image of the shadow economy is also vague; it is not an absolute negative (some parts are tolerated) or positive experience and sometimes is neutral. For individuals who occasionally participate in the shadow economy, it could yield significant savings, while the value of the illicit or not reported activity does not reach the threshold imposed by the authorities, thus there are no legal consequences. One should not forget that the shadow economy may lead to some positive externalities by calling attention to loopholes and economic and legal segments whose social acceptance is doubtful. The latter is based on the observation that those rules that are widely accepted are generally obeyed, however people might be more encouraged to disobey if the rules are socially not largely accepted. The shadow economy may also have a positive impact by providing some earnings to the low-income social layers.

From a statistical point of view, the economy is dual and can be divided into formal and informal parts. Economic activities must be classified first as:

- subject to registration;
- subject to tax;
- subject to special regulation;
- any combination of the above.

If any of these conditions is not fulfilled by an entity then the activity must be considered as part of the shadow economy. If so, then it is not included in official economic indicators (Schneider & Enste, 2000). According to Kirchgässner and Pommerehne (1994), an activity is a segment of the shadow economy if at least one of the following criteria is fulfilled:

1. The individual does not report her/his own production to the authorities. It is important that the production fulfils the own demand of the individual household only, thus the output is consumed and not sold to any other household (like home gardening and backyard flocks). In the System of National Accounts (hereinafter SNA), this sort of

activities are registered in a separate category and estimated by a large-scale survey (Landefeld & McCulla, 2000).

2. The activity or the transaction is hidden from the authorities because the latter does not have enough capacity, or the registration method is not suitable[3]. Usually, the activity itself is not illegal, however, financial transactions are made that are not reported by the partners. Nevertheless, the principle of good faith cannot always be assumed, because not registering the activity might have tax evasion or avoidance motivations (for example, provision of accommodation at private houses)[4].
3. The legal entity evades reporting the activity on purpose. In that case, the activity itself may be either illegal (like drug trafficking, prostitution etc.) or legal, but the avoidance of registration is illegal (if an activity requires authorisation). In comparison to the second point above, the major difference is that the unregistered action could not be practised legally, or it could have large investment costs (acquiring permits, continuously fulfilling requirements)[5].

In the literature of the shadow economy, it is generally accepted that only 3. above is taken into consideration. This study also follows that principle and all utilised data cover that type of activities only.

Our paper has the following structure: after the introduction in Section 1 and a concise literature review in Section 2, we describe our data and methods in Section 3, present our models and results in Section 4, and Section 5 summarizes and concludes our article.

[3] See Abramsky and Drew (2014) for more.
[4] Shared economy is an emerging challenge for statistical accounting (Makovský, 2017).
[5] The impact of health and safety regulations (HACCP) in the food industry is a clear example of cost increases in small enterprises (Hooker et al., 2002).

2. Literature overview

Newer studies of the field usually aim to explore the size of the shadow economy as a percentage of the gross domestic product (GDP), as early methods to gauge the level of illicit activities such as surveys (Hudson et al., 2012; Williams, 2006) or other observational studies (Manz, 1991; Soto, 1990) lacked robustness and internationally comparable results (Fleming et al., 2000). Later, cross sectional studies emerged and revealed a very heterogenous picture of the shadow economy in a wider geographical sense (Julià et al., 2019; Williams, 2008). The reason behind is that qualitative methodologies like surveys and interviews are only able to study the so-called self-reported participation (Yoon et al., 2003), therefore they are likely to underestimate the true level of illicit activities, because surveyors can hardly reach the low and high ends of the societies where participation in the shadow economy is the most prevalent (Schneider & Enste, 2013).

Consequently, other innovative methods have emerged with time. Participation in the shadow economy is cash demanding thus the increased demand for money may be a sign of blooming illegal activities (Ahumada et al., 2007; Herwartz et al., 2016), albeit it can also be the result of other developments in the economy when it is more rational to save in cash rather than in bank deposits (Antón et al., 2021; Engert et al., 2019; Immordino & Russo, 2018).
Another interesting approach is to measure electricity consumption as a proxy of the shadow economy (Kaliberda & Kaufmann, 1996). This method utilises the empirical observation that there is a strong correlation between the electricity consumption and the volume of the GDP, that is the elasticity of electricity consumption with respect to the GDP is close to one. This way of gauging the level of shadow economy is quite prevalent in Central and Eastern Europe (Kyle et al., 2001; Psychoyios et al., 2021), most likely because the corporate sector is usually also highly involved in illicit activities besides the household sector (Putniņš & Sauka, 2015; Schneider, 2013).

Countries in transition from planned to market economies are considered to be a particular case in the field of the shadow economy. Their transformation is well documented since the 1990s, thus one has observed all major segments of the development of the illicit economy. It must be noted that the shadow economy did exist also in the planned economy, moreover some parts were even tolerated by the authorities. Its existence was also a necessity, because it fulfilled the demand of households that the planned economy could not (Paldam & Svendsen, 2002). After

the regime change, the whitening of the economy became the priority for the governments, although the results have been mediocre.

Even though the literature of shadow economy is very rich (Alm & Embaye, 2013; Goel & Nelson, 2016; Herwartz et al., 2015; Schneider, 2011; Schneider et al., 2010; Schneider & Enste, 2000), little attention has been paid to the Central and Eastern European (CEE) region. Eilat and Zinnes (2002) were one of the first authors to analyse the development of shadow economy in CEE countries and found that economic growth in real terms helps reduce the size of the illicit economy, however, real depreciation of the currency increases its size. As more and more data became available for that particular region, several studies emerged on the subject (see for example Elgin & Birinci, 2016; Hudson et al., 2012; Orviská et al., 2006), and many found that economic development, whether measured by GDP growth or productivity, contributes to a smaller shadow economy. Works of scholars on the shadow economy in the CEE region are discussed in Table 1.

Table 1: Recently published studies on the shadow economy focusing on the CEE region

Scope	**Regional coverage**	**Method utilised**	**Time frame**	**Reference**
Comparative analysis of cross-national variations	Central and Eastern Europe	Correlation analysis	2014	Williams (2014)
Determinants of shadow economy	Central and Eastern Europe	Regression analysis	2003-2016	Navickas et al. (2019)
Determinants of shadow economy	CEE + selected Asian economies	Panel analysis	2002-2015	Luong et al. (2020)
Determinants of shadow economy	Europe with special attention to CEE	MIMIC, panel analysis	2000-2016	Kelmanson et al. (2019)
Drivers of shadow economy	European Union	Panel analysis	1995-2017	Mara (2021)

Causes of shadow economy	Central and Eastern Europe	Panel analysis	2003-2015	Bayar et al. (2018)
Estimating size of shadow economy	Selected OECD countries and countries in transition	DYMIMIC	2000-2001	Schneider (2003)
Cultural factors of shadow economy	Europe	Panel analysis	2005-2015	Achim et al. (2019)
Determinants of shadow economy	CEE + selected developing economies	Bayesian Model Averaging	2006-2014	Zhanabekov (2022)
Determinants of shadow economy	Central and Eastern Europe	Structural equation modelling	2016	Vakhal & Vékás (2021)

Source: own collection

Prior to the 2000s some researchers could only rely on hard macroeconomic data to investigate the shadow economy. Later, several soft economic and social indicators could be included in the models. One of the first applications of economic and political freedom indices in corruption research took place in 2005 (Goel & Nelson, 2005), and later these indicators became part of the analyses (Berdiev et al., 2018; Buehn & Schneider, 2009; Goel & Nelson, 2016; Koyuncu & Ünal, 2019). Most studies agree that policies limiting economic, political or social freedom increase the size of the shadow economy.

Scholars have followed several approaches to include more and more drivers of the shadow economy into their statistical models. However, it is a very complex task since most variables are latent, that is, directly not observable, with interaction terms[6] that make estimation extremely complicated. Frey and Weck-Hanneman (1984) were the first who utilised the Multiple Indicators Multiple Causes (MIMIC) model, originating from Zellner (1970), in which shadow economy was addressed by a structural equation model. A few year later Aigner et al. (1986) extended the model to perform dynamic analysis (DYMIMIC), thus one could analyse

[6] Some independent variables interact with one another and produce additional effects. They generally change the slopes of regression estimates.

panel data by this approach. The MIMIC model was a crucial milestone in the literature of the underground economy, since it could combine latent and observed variables of different scale into one model, by which researchers can get a much wider overview of the topic.

In the MIMIC model a latent output variable is estimated. The target variable itself is unobserved, however one is aware of its assumed causes that are directly quantifiable. With the help of these observable causes, the target variable may be estimated by an assumed system of equations. MIMIC models have received some criticism over time (Breusch, 2005, 2016; Helberger & Knepel, 1988), pointing out its lack of robustness. Breusch (2005) claimed that the MIMIC approach is too deterministic, since it a priori assumes that illicit activities contract in parallel with economic development (thus, the correlation is negative). As a result, developed economies tend to have very low levels of shadow economy, while those of developing and emerging countries will be higher. Scholars have also suggested that the model is very sensitive to the initial set of economies and assumed causes. Despite its weaknesses, MIMIC is still the generally accepted method to estimate the level of the underground economy. According to Dell'Anno and Schneider (2006) most flaws of the model come from the estimating the nominal level of the shadow economy, however, one could offset these by applying benchmarking such as expressing the size of illicit activities as a percentage of the GDP.

General findings of panel data analysis (Achim et al., 2019; Bayar et al., 2018; Luong et al., 2020; Mara, 2021) show that the share of the shadow economy in the GDP tends to taper in many CEE countries in parallel with improving indicators of market economy (competition, foreign trade, etc.), democracy (property rights, civil liberties, rule of law, etc.) and society (literacy, health, etc.). Most studies concur that at the beginning of the transition period in the 1990s shadow economy played a crucial role in everyday business life, because owing to the large indebtedness, general governments could not always provide the necessary public services, thus companies and households were not incentivised to stay outside the shadow economy (Karlinger, 2009). This highlights the importance of democratic values and the significance of public goods; while the intensity of competition correlated positively with the size of the shadow economy in the 1990s, after reaching a certain level of democratic values the correlation became negative, because after a decade, economic actors began to play according to the rules of a democratic market economy.

The directions of causality in a model of the shadow economy are generally clear; the more developed the economy and the society, the less the economic actors are inclined to pursue illicit activities. In most cases the shape of the relationship is linear or logistic, that is there is a semi-strict monotone association between the level of shadow economy and most of the socio-economic explanatory variables. However, some macroeconomic indices such as the index of annual inflation and tax-related variables may have non-linear associations with the level of the shadow economy. The role of inflation in the development of the shadow economy is ambiguous. Many scholars have found evidence of a bidirectional relationship between inflation and the shadow economy (Baklouti & Boujelbene, 2019; Blackburn & Powell, 2011; Mazhar & Méon, 2017). Some research has found that the association is non-linear (Canh & Thanh, 2020; Dumitrescu et al., 2022). Non-linearity also highlights the importance of interaction terms because the extrema can be at different points depending on other variables. For example, a wealthier economy may tolerate higher inflation for a longer time before the society begins to orient towards the underground economy, while a country with lower income may have a different threshold. Nonlinearity comes in when inflation is very low, or even deflation occurs. While low consumer price indices are one of the characteristics of a healthy economy, permanently low or negative inflation indicates problems on the demand side, as witnessed during the global financial crisis between 2008 and 2011, when deflation emerged in many economies. This could also incline entrepreneurs and consumers to move into the grey zone of the economy.

Taxation is another widely researched field of the shadow economy and most of the studies show negative correlation between taxation and the level of the shadow economy (Awasthi & Engelschalk, 2018; Lovics et al., 2019). Panel models suggest that taxation policies have different impact on the level of shadow economy depending on the level of economic and financial development of the country (Berdiev & Saunoris, 2016).

3. Data and methods

3.1. Raw data

Our research covers 158 countries of the world and our panel dataset[7] contains variables for the period between 2000 and 2015[8]. The dependent variable of the analysis is the size of the shadow economy as a percentage of GDP, as estimated by Medina and Schneider (2018) based on their most recent MIMIC model. Figure 1 displays these estimates in 2015 in CEE countries.

Figure 1: CEE countries coloured by the sizes of their shadow economies (% of GDP)

We evaluate the impact of the socio-economic variables suggested by the literature review, and also introduce some new ones. We capture economic development by three variables, namely the Human Development Index (HDI), year-on-year growth rate of GDP per capita, and the NASDAQ index. We also include the Gini coefficient to indicate social inequalities, and the following qualitative social development indicators: political rights, civil liberties, property

[7] Panel data is a form of a dataset in which time has a separate dimension. Therefore, while cross-sectional data may be represented by a matrix, panel data has the form of a cuboid (data cube).

[8] As proportions of missing values were much higher before 2000 and our dependent variable representing the estimated sizes of shadow economies was only available up to 2015, we selected the period between 2000 and 2015 for our analysis.

rights, economic freedom, intensity of local competition and the transparency of government policymaking (Teobaldelli & Schneider, 2013). Since social and political instability can induce participation in underground activities (Peksen & Early, 2020; Siddik et al., 2022), we introduce a dummy variable to indicate whether the country is a conflict zone or not. We include six tax-related indicators in our analysis: the level of personal income tax, the tax revenue of the government, the number of taxes to be paid, the time to prepare and pay taxes in hours, the level of the value added tax (VAT) and the average tariff rate on foreign trade. We also include the annual inflation rate, the sign of whose coefficient is ambiguous in the literature.

With the aim of discovering regional characteristics in mind, we include a dummy variable that indicates whether a country is in CEE. We consider the following countries to be part of the CEE region: Albania, Armenia, Azerbaijan, Belarus, Bosnia and Herzegovina, Bulgaria, Croatia, Czech Republic, Estonia, Georgia, Hungary, Kazakhstan, Kyrgyz Republic, Latvia, Lithuania, Moldova, Poland, Romania, Russian Federation, Slovak Republic, Slovenia, Tajikistan and Ukraine.[9]
Table 2 summarises our variables.

Table 2: Variables in our panel dataset

Variable	**Scale**	**Source**	**Description**
Shadow economy	0-100	Medina and Schneider (2018)	The level of shadow economy as a percentage of the GDP
HDI	0-1	United Nations Development Program	Human Development Index. A composite indicator of life expectancy, education and per capita income indices.
GDP per capita growth	-inf to +inf	World Bank	Year-on-year growth percentage of the Gross Domestic Product (the total value-added a country produces in a year).
Inflation	-inf to +inf	World Bank	Annual inflation rate

[9] Kosovo, Montenegro, North Macedonia, and Serbia are left out due to limitations of data availability.

Political rights	7 (weak) - 1 (strong)	The Freedom House	The evaluation of elections, political pluralism and government functioning
Civil liberties	7 (weak) - 1 (strong)	The Freedom House	The evaluation of freedom of expressions, organisational rights and the rule of law
Income tax	0-100	World Bank	Taxes on income, profits and capital gains (% of revenue)
Gini	0-100	World Bank	The measure of income inequality in the society
Property rights	0-100	Heritage Index of Economic Freedom	Assessment of how much a country's legal framework allows individuals to freely accumulate private property
Tay payments	0 to +inf	World Bank	The number of taxes to be paid by a firm
Time to prepare tax reports	0 to +inf	World Bank	Time to prepare and pay taxes (hours) per year
Economic Freedom	0-100	Heritage Index of Economic Freedom	The assessment of fundamental rights of every human to control his or her own labour and property
Local competition	0-7	World Economic Forum	The intensity of local competition
Transparency	0-7	World Economic Forum	How transparent is the governmental policymaking
Conflict zone	0 or 1	Uppsala Conflict Data Program (2022)	1 if conflicts caused at least 1000 deaths in the given country and calendar year
VAT	0-100	World Bank	The level of value-added tax
Tariff rate	0-100	World Bank	The average level of tariff rate on foreign trade
NASDAQ	0 to +inf	NASDAQ, Inc.	Average of NASDAQ index in a given year
CEE	0 or 1	–	1 if the economy is in the CEE region, else 0.

3.2. Imputation of missing values

As missingness proved to be largely dependent[10] on variables representing the economic development and political systems of countries, for which we had available data, we assumed an underlying missing-at-random (Rubin, 1976) mechanism and imputed missing values by predictive mean matching and flexible additive models (van Buuren, 2012) on bootstrap samples of the data, as recommended for panel data and implemented in the *argImpute* function of the popular *Hmisc* package of the R programming language (R Core Team, 2020). We obtained a complete, balanced panel dataset by this imputation procedure. The proportion of imputed values was below 5% for every variable one by one.

3.3. Data preparation

Political rights and civil liberties are originally measured on ordinal scales ranging from 1 to 7, but due to sample size considerations, we decided to merge their seven categories into just three for each variable: ’free’ for values 1 to 2, ’partially free’ for 3, 4 and 5 and ’not free’ for 6 to 7. We used natural logarithms of the shadow economy, tariffs, inflation rates and the NASDAQ index due to the skewness of the original variables, and extended the set of regressors with the square of the logarithm of the inflation rate in order to investigate its potentially non-linear impact, as suggested by the literature. We also created interactions of the dummy variable representing CEE countries with all other variables one by one in order to point out how determinants of the shadow economy in the CEE region differ from the rest of the world.

[10] McFadden’s R^2>0,3 in logit models.

3.4. Methods[11]

3.4.1. Static panel models

A panel linear regression model with homogeneous coefficients may be written with suitable restrictions of the following general formulation:

$$y_{it} = \alpha_{it} + \sum_{j=1}^{p} \beta_j x_{ijt} + \varepsilon_{it},$$

where i is the index of individuals, j is the index of regressor variables, t is the time index and ε_{it} is a random disturbance with mean 0.

If α_{it} depends neither on i nor on t and is deterministic then we have a pooled model that can be estimated by ordinary least squares (OLS). This kind of model does not take characteristics of individuals or time periods into account.

If $\alpha_{it} = \alpha_i$ and they are deterministic then one has fixed individual effects, and if $\alpha_{it} = \alpha_t$ and they are deterministic then we have fixed time effects. These models take individual or time characteristics into account and can also be estimated by OLS after including individual- or time-specific dummy variables in the matrix of regressors.

If $\alpha_{it} = \alpha + \mu_i$, where α is deterministic and μ_i is uncorrelated with the regressors, then one has random individual effects, whereas if $\alpha_{it} = \alpha + \mu_t$ then one has random time effects. In this case, OLS is consistent but not efficient, and feasible generalized least squares (GLS) estimators are preferred in the literature.

Chow's test may be used to test whether the pooled model is preferred over fixed effects, Hausman's test indicates whether random effects are preferred over fixed effects, and the Lagrange multiplier test examines if individual or time effects are necessary.

Heteroscedasticity of the error terms makes the estimation inefficient, and MacKinnon and White (1985) propose the so-called heteroscedasticity-consistent covariance matrix estimators HC0, HC1, HC2, HC3 in order to remedy this problem. Long and Ervin (2000) perform a simulation study of these and recommend HC3, along with Millo et al. (2017). Multicollinearity

[11] This subsection is loosely based on Croissant and Millo (2018).

has similar consequences, and can be examined using Generalized Variance Inflation Factors (GVIFs).

3.4.2. Dynamic panel models

A first-order autoregressive dynamic panel model may be written as

$$y_{it} = \rho y_{i,t-1} + \mu_i + \sum_{j=1}^{p} \beta_j x_{ijt} + \varepsilon_{it},$$

where the set of regressor variables may include lagged regressors. In contrast with static panel models, this model structure can capture dependencies among contemporaneous and lagged variables.

Arellano and Bond (1991) introduce the generalised method of moments (GMM), a non-parametric method with no distributional assumptions, to estimate this type of models. GMM estimators are known to be asymptotically normal, consistent and efficient (Hansen, 1982). Blundell and Bond (1998) put forward the so-called System-GMM estimator, which is a modified version of the original GMM with additional moment conditions and improved finite-sample performance. A two-step estimation procedure can be used instead of the original one-step procedure to account for the impact of heteroscedasticity and serial correlation in finite samples.

The correctness of the first-order autoregressive specification can be verified by the tests of AR(1) and AR(2) errors, while the Sargan–Hansen test allows for checking the validity of the overidentifying restrictions used in the estimation procedure.

4. Models and results

4.1. Static models

We used the *plm* package (Croissant and Millo, 2008 and 2018) of the R programming language to estimate static panel models of the logarithms of sizes of the shadow economy expressed as a percentage of GDP. We included all other variables as regressors, accounting for heteroscedasticity by using the HC3 estimator implemented for panel models, while monitoring multicollinearity by GVIFs.

Chow's test rejected the pooled model ($p<0.001$), Hausman's test indicated random effects ($p>0.05$), and the Lagrange multiplier test suggested country effects ($p<0.001$) but no year effects ($p>0.05$), so we used random country effects to estimate the model.

We selected a subset of predictors for which Wald's partial F test indicated that the rest of the predictors could be jointly omitted ($p>0.05$) and all remaining coefficients had statistically significant z-tests ($p<0.1$) one by one. Table 3 summarises the coefficients and diagnostics of the resulting model.

Table 3: Coefficients and diagnostics of our final static panel model

Independent variable	Coefficient	z-statistic	p-value
(Intercept)	4.77	51.38	0.0000 ***
HDI	-1.70	-21.09	0.0000 ***
GDP per capita growth	0.00	-6.16	0.0000 ***
Log(NASDAQ)	-0.04	-5.52	0.0000 ***
Economic freedom	0.00	-2.30	0.0216 *
Gini	0.00	4.62	0.0000 ***
CEE	2.06	10.95	0.0000 ***
Conflict	0.02	1.80	0.0723 .

Tax payments	0.00	3.05	0.0023 **
VAT	0.00	3.58	0.0004 ***
Log(Tariff rate)	0.02	3.21	0.0014 **
Civil liberties = not free	0.04	1.97	0.0491 *
Civil liberties = partly free	0.02	2.34	0.0192 *
Log(Inflation)	-0.04	-3.49	0.0005 ***
*Log(inflation)*Log(Inflation)*	0.28	3.06	0.0022 **
*CEE*HDI*	-2.38	-13.27	0.0000 ***
*CEE*GDP per capita growth*	0.00	-1.68	0.0925 .
*CEE*Log(Tariff rate)*	-0.02	-2.90	0.0038 **
CEE(Political rights = not free)*	0.12	2.94	0.0033 **
CEE(Political rights = partly free)*	0.12	3.58	0.0003 ***
CEE(Civil liberties = not free)*	0.17	3.20	0.0014 **
CEE(Civil liberties = partly free)*	0.08	2.76	0.0058 **
*CEE*Log(Inflation)*	-0.05	-2.39	0.0171 *

The signs of the general coefficients and *z*-statistics of the regressors (excluding interactions) in Table 3 are in line with our literature overview: assuming that all other variables are unchanged, on the one hand, increasing economic development (as measured by the HDI), a favourable economic environment (as measured by GDP per capita growth), a capital market boom (as measured by the NASDAQ index) and increasing economic freedom all tend to correlate with the contraction of the shadow economy, while on the other hand, increasing income inequalities (as measured by the Gini coefficient), being situated in the CEE region, being in a conflict zone, a more complex system of taxation (as measured by the number of tax payments), increasing VAT and tariffs, and limiting civil liberties all tend to correlate with an increase in unreported economic activity. The impact of inflation is non-linear in our model: it

can be described by a convex parabola with a minimum at the inflation rate of 7,15%, and assuming that all other variables are unchanged, increasing inflation in a deflationary or low-inflation environment below this minimum tends to correlate with a contraction of the shadow economy, yet at the same time, further inflation beyond this point correlates with an increased share of clandestine operations in the economy.

The coefficients of the interaction terms in Table 3 imply that some of the regressors have different effects in the CEE region than in the rest of the world: assuming that all other variables are unchanged, the impacts of HDI, GDP per capita growth and civil liberties have the same direction in CEE as in the rest of the world but are more pronounced, while tariffs have no overall impact. Unlike in the rest of the world, limiting political rights in this region is correlated with an increased share of the shadow economy, and the impact of inflation is quadratic in CEE, as well, yet its minimum occurs at a higher rate of 16,03%.

4.2. Dynamic models

We proceeded with estimating dynamic panel models of the logarithmic estimates of the shadow economy as a percentage of GDP using the open-source statistical package gretl (Tarassow, 2019). We applied the System-GMM procedure of Blundell and Bond (1998) and the two-step estimation procedure while monitoring multicollinearity by GVIFs.

Estimating the model with two or more lags of the independent variables on the right-hand side was not possible due to nearly exact multicollinearity, so we had to limit the number of lags to two and preselect lagged regressors by economic considerations, namely assuming that past values of variables related to taxation have no direct impact on the size of the shadow economy due to the rationality of the actors in the economy.

After estimating the resulting dynamic panel equation, we selected a subset of predictors for which Wald's partial F test indicated that the rest of the predictors could be jointly omitted ($p>0.05$) and all remaining coefficients had statistically significant z-tests ($p<0.1$) one by one.

We checked the validity of the resulting model by the AR(1), AR(2) and Sargan–Hansen tests ($p<0.0001$, $p=0.81$ and $p=0.73$, respectively), which support the first-order autoregressive specification and the overidentifying restrictions in the estimation procedure.

Table 4 summarises the coefficients and diagnostics of our final dynamic panel model.

Table 4: Coefficients and diagnostics of our final dynamic panel model

Independent variable	Coefficient	*z*-statistic	*p*-value
(Intercept)	0.57	3.91	0.0000 ***
Log(Shadow economy)(t-1)	0.86	28.93	0.0000 ***
HDI	-0.22	-3.72	0.0002 ***
GDP per capita growth	-0.01	-5.97	0.0000 ***
Economic freedom	0.00	-2.58	0.0099 **
Gini	0.00	3.02	0.0025 **
Gini(t-1)	0.00	2.48	0.0131 *
Gini(t-2)	0.00	1.85	0.0641 .
VAT	0.00	1.63	0.0998 .
Log(Inflation)	-0.04	-2.33	0.0196 *
Log(Inflation)(t-1)	0.05	2.76	0.0058 **
CEE	0.40	3.03	0.0024 **
*CEE*HDI*	-0.44	-2.54	0.0111 *
*CEE*Income tax*	0.00	2.30	0.0212 *
CEE(Civil liberties = free)*	-0.04	-2.46	0.0139 *

The fact that the lagged dependent variable has the largest absolute *z*-statistic in Table 4 is evidence of the strong persistence of the shadow economy.

Just like in our static model, the signs of the general coefficients and *z*-statistics of the regressors (excluding interactions) in Table 4 were in line with our prior expectations based on our literature overview: assuming that all other variables are unchanged, increasing economic development (as measured by the HDI), a favourable economic environment (as measured by GDP per capita growth) and increasing economic freedom all tend to correlate with the reduction of the shadow economy, yet at the same time, increasing income inequalities (as measured by the Gini coefficient), being situated in the CEE region and increasing VAT all tend to correlate with an increase in the shadow economy. A new finding here that undetectable by static models is that two lags of the Gini coefficient also have significantly positive coefficients, implying that increasing income inequalities correlate with a long-lasting growth of the shadow economy. Another additional result is that increasing inflation correlates with a decrease in the shadow economy in the present year but also with an increase back to near the original level in the next period, which implies that reductions in the shadow economy due to increasing inflation may be temporary at best.

Assuming that all other variables are unchanged, the coefficients of the interaction terms in Table 4 imply that the impact of HDI has the same direction in CEE as in the rest of the world but is more powerful, just like in our static model. Unlike in the rest of the world, increasing income taxes in CEE is correlated with increased hidden economic activity, while increasing civil liberties is associated with a reduction in the shadow economy according to our dynamic model.

It is best to think of the dynamic model as a complement rather than a substitute of the static framework: it has pointed out some more nuanced relationships, but the impact of some variables may be suppressed by the dominant presence of the lagged dependent variable among the regressors.

5. Summary

Our results for the world in general coincide neatly with previous studies on causes of the shadow economy: economic development, economic growth and economic freedom are all associated with reductions in the shadow economy, while income inequalities and value-added tax rates are correlated with increases in clandestine economic activity. Being situated in CEE is also a contributing factor. These relationships are supported by both our static and dynamic models.

Additionally, the impacts of capital market booms and increased civil liberties are favourable, whereas conflicts, a more complex system of taxation and increased tariffs are associated with increases in the shadow economy according to our static model.

The dynamic model points out the strong persistence of the shadow economy, which implies that it may have deeply ingrained cultural and behavioural roots, since old habits die hard, as the adage goes. The impact of income inequalities is long-lasting according to our dynamic model.

Inflation has a quadratic impact in our static model, while the dynamic model additionally suggests that whitening of the economy due to increased inflation may be temporary at best.

The favourable impact of human development and civil liberties on the shadow economy are stronger in CEE than in the rest of the world according to both our static and dynamic models, while the impact of economic growth is stronger and increasing tariffs and limiting political rights in CEE contributes to a growth in the shadow economy according to the static model, whereas increasing income taxes may expand the shadow economy in CEE according to our dynamic model.

If long-term economic policy in the CEE region aims to decrease the size of the shadow economy then our results suggest that it should focus on promoting human development, economic and capital market growth and economic freedom while decreasing income inequalities, simplifying the system of taxation and lowering VAT rates, tariffs and income taxes to the extent that it is possible and does not conflict with other economic policy goals.

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Data and code availability

The authors are happy to share their data and specific chunks of code on request.

Authors' contribution statement

The two authors were equal contributors in all phases of this research.