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IBS WORKING PAPER 03/2016
APRIL 2016

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Abstract

Minimum wages continue to be at the centre of the policy debates in both developed and emerging economies. Such policies can only be effective if (1) the existing regulatory system does not have gaps that allow for the payment of wages below the minimum wage, and (2) the existing minimum wage laws are not violated (too often). In this paper we analyse minimum wage violations in 10 Central and Eastern European countries that have joined the EU since 2004, and that have statutory national minimum wages. Utilising EU-SILC data, we use the methodology proposed by Bhorat et al. (2013) to analyse both the incidence of minimum wage violations, as well as the monetary depth of these violations. We find that on average in 2003-2012, the estimated incidence of violations ranged from 1.0% in Bulgaria, to 1.3% in the Czech Republic, around 3% in Romania and Slovenia, 4.7% in Poland and Hungary, 5.6% in Latvia, and 6.9% in Lithuania. The average pay shortfall ranged from 13.7% of the country-year specific minimum wage in Estonia, to 41.7% in Slovenia. In all countries, workers who were female, less-educated, in the service or agricultural sector, in a micro firm, or with a temporary contract were more likely than other categories of workers to earn less than the minimum wage they were entitled to. While higher minimum to average wage ratios were associated with higher levels of non-compliance, this effect was present within countries over time, but not between them.

Keywords: minimum wage, violation, compliance, Central Eastern Europe

JEL Codes: J08, J31, J38

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‡We thank Szymon Górka for his excellent research assistance, Andrea Garnero for reviewing the draft version, as well as the participants of IBS Jobs Conference 2015 in Warsaw and ICRIER International Conference on Jobs for Development in New Delhi for insightful comments. We also thank Attila Bartha, Věra Czesaná, Katarina Gandzalova, Peter Goliáš, Bogusław Grużewski, Lija Luste for providing us with the information about minimum wage regulations in particular countries. This paper was financially supported by the Network for Jobs and Development initiative under the auspices of the World Bank. Usual disclaimers apply. All errors are ours.

1 Introduction

The issue of the minimum wage continues to attract the attention of researchers and policy-makers in both the developed and the developing world. In countries that experience a rapid increase in GDP per capita, workers often demand that the minimum wage be raised. Economies that struggle with in-work poverty or wage inequality may also implement minimum wage policies. The Great Recession sparked a renewed interest in minimum wage policies around the world OECD (2015). Most of the policy debates and the economic literature on minimum wages focus on employment effects (Neumark and Wascher, 2006), and, to a lesser extent, on earnings inequality (Autor et al., 2010) and poverty in a developing (Saget, 2001) or a developed (MaCurdy, 2015) country context. Yet even as commenters on this issue express their hopes and concerns about the impact of minimum wage laws on the labour market, it is important to keep in mind that enforcement of and compliance with these policies are also crucial dimensions of their success. The proper measurement of compliance, as well as the identification of the tactics agents use to violate minimum wage laws, are necessary to explain the functioning of minimum wage policies in particular countries. However, few studies on violations of minimum wages have been conducted, especially in a multi-country setting. These issues are usually analysed for developing countries (see Rani et al. (2013), Bhorat (2014), Bhorat et al. (2015a), Ye et al. (2015)), although Garnero et al. (2015) also provide some evidence on noncompliance (and non-coverage) in the EU countries.

In this paper we seek to contribute to this emerging branch of literature by analysing minimum wage violations in 10 Central and Eastern European countries that joined the European Union in 2004 or later. The CEE countries are especially well-suited for a cross-country study on this issue. All of these countries have national statutory minimum wage systems that cover all dependent workers, and they are at comparable levels of development. The CEE countries also share the recent experience of having joined the EU, which means that they have been integrated into a union in which many of the member countries offer higher wages for low-level work. The existing literature on the role played by minimum wages in the CEE countries is relatively scarce, and focuses on employment effects.[1] To our knowledge, this paper is the first study of minimum wage non-compliance in CEE.[2] In section 3 we outline the minimum wage regulations and developments in CEE. In section 3 we present the methodology, proposed by Bhorat et al. (2013), that we use to analyse both the incidence of minimum wage violations, as well as the monetary depth of these violations. We also discuss the data. In section 4 we present our estimates of the violation measures between 2003 and 2012, the individual- and the firm-level correlates of non-compliance estimated with probit models, and the results of panel regressions at a country level. In the last section we summarise our findings, and discuss the policy implications of our results.

2 Minimum wages in Central and Eastern Europe

Of the 28 European Union member states in 2015, 22 had minimum wages established at the national level. Eleven of these member states are Central and Eastern European countries that had joined the EU since 2004: Bulgaria, the Czech Republic, Croatia, Estonia, Hungary, Latvia, Lithuania, Poland, Romania, Slovakia,

[1] See Hinnosaar and Room (2003), Eriksson and Pytlikova (2004), Fialova and Mysíková (2009), Baranowska-Rataj and Magda (2015), Kamińska and Lewandowski (2015).

[2] In this paper we use "violation" and "non-compliance" as synonyms for a situation in which a worker who is covered by minimum wage regulations is paid less than the legal minimum.

and Slovenia. We focus on this group of countries in our paper.[3] For reasons of data availability, we have chosen to exclude Croatia. We call the remaining group the CEE10. The other six EU countries had minimum wages established at the sector (Austria, Denmark, Finland, Italy) or occupation (Cyprus) level, usually as the result of collective bargaining. These kinds of practices were not followed by any of the CEE10 countries. The minimum wage arrangements in the CEE10 are summarised in Table 1.

Table 1: Minimum wage arrangements in CEE10 (2012)

Country	National MW exists	Sub-minimum level	Groups covered by sub-minimum	Higher minimum level	Groups covered by higher minimum
Bulgaria	Yes	No	-	No	-
Czech Republic	Yes	Yes	Youth (until 2012)	Yes	6 higher MW levels for better skilled
Estonia	Yes	No	-	No	-
Hungary	Yes	No	-	Yes	Skilled workers
Latvia	Yes	No	-	Yes	Youth and high-risk occupations
Lithuania	Yes	No	-	No	-
Poland	Yes	Yes	Work experience below one year	No No	- -
Romania	Yes	No	-	No	-
Slovakia	Yes	Yes	Youth	Yes	5 higher MW levels for better skilled
Slovenia	Yes	No	-	No	-

Note: Better skilled jobs / worker groups in Czech Republic, Hungary, and Slovakia cannot be identified using the information available in micro-level datasets, like educational level (ISCED) or occupation (ISCO). In each case, the assignment of a particular position to a job group with a higher minimum wage depends on the hard-to-measure characteristics of the tasks performed, such as the complexity of the cognitive processes involved or the demand for creative or abstract thinking. These rules are suggestive rather than legally binding, or they constitute a reference point for collective bargaining. Moreover, in each of these countries there are special remuneration schemes for particular groups like teachers or scientists that we do not consider here as alternative minimum wage schemes.

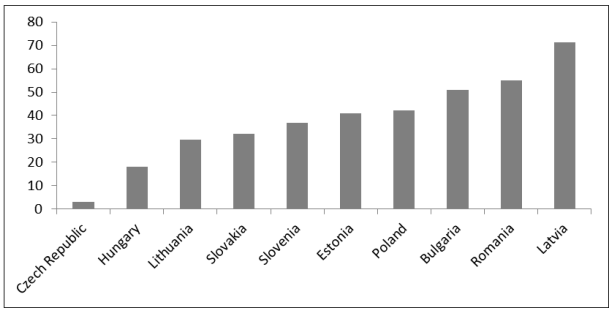
In Latvia, people who work in risky or dangerous conditions are covered by the same monthly minimum wage as regular workers, but their legal weekly working hour limit is 35 hours instead of 40 hours. However, in accordance with the Labour Protection Law, the employer determines whether a particular occupation has risky or dangerous working conditions by carrying out an assessment of the working environment. In practice it is impossible to identify the workers who are covered by the higher hourly minimum wage.

Source: Own elaboration based on OECD (2015), wageindicator.org and country-specific sources.

[3] According to Eurostat, the other EU countries with national minimum wages in 2015 are Belgium, France, Germany, Greece, Ireland, Luxembourg, Malta, the Netherlands, Portugal, Spain, and the United Kingdom. The national minimum wage was introduced in Germany starting 1 January 2015.

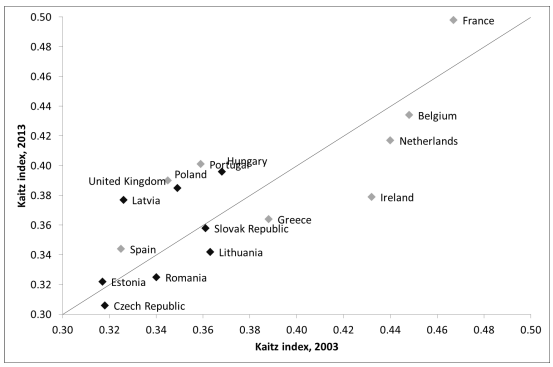
A common feature of minimum wage systems in the CEE10 is that they cover all dependent workers with a single, widely known, country-level minimum wage.[4] In all of the CEE10 countries the minimum wage is set at a monthly rate, although an hourly rate is also explicitly specified in several countries. Some CEE countries (e.g., Poland, Slovakia, and the Czech Republic until 2012) have sub-minimum wage levels for young workers or labour market entrants. In some CEE countries higher minimum wage levels were introduced for particular subgroups, like professionals (e.g., in the Czech Republic, Hungary, and Slovakia), or special rates were implemented for those working in risky or dangerous conditions (Latvia). These additional wage floors were also established at the national level, but they are not clearly defined or strictly binding (see table 1). Thus, in this paper we focus on compliance with basic, country-level minimum wages.

Figure 1: Total real minimum wage growth in the CEE countries between 2003 and 2012.



Source: Own elaboration on Eurostat and OECD data.

Figure 2: Minimum wage to average wage ratio (Kaitz index) in selected European countries, 2003 and 2012.



Source: own elaboration on Eurostat and OECD data.

[4] The self-employed are not covered by a minimum wage in any of the CEE10. This can be an issue in cases of bogus self-employment. Although bogus self-employment represents a broader form of non-compliance with labour regulations, it may to some extent be driven by a desire to circumvent minimum wage laws. Similarly, in Poland the minimum wage is not binding for civil law contracts (a type of temporary contract). However, the use of a civil law contract is prohibited if a worker is dependent on a company. Thus, contracting a dependent worker using a civil law contracts can be interpreted as a violation of labour regulations and as a deliberate violation of minimum wage laws if the worker earns less than the equivalent of a monthly minimum wage. It is impossible to distinguish civil law contracts from other temporary contracts in available survey data as they are clustered together as temporary contracts in EU-LFS and EU-SILC, and not covered by EU-SES.

The procedures used for establishing minimum wages have not changed recently in any of the CEE countries,[5] and the minimum wage levels have been steadily increasing in both real terms and relative to the average (or median) wages (see Figure 1). In 2003, the CEE10 countries had much lower ratios of minimum to average wages (Kaitz index) than the EU15 countries.[6] By 2013 this difference had decreased significantly. Between 2003 and 2012 the Kaitz index rose sharply in Poland, Hungary, Lithuania, and Latvia; but remained relatively stable in Slovakia, Romania, Estonia, and the Czech Republic. Across the CEE region minimum wages have been increasing at least as fast as average wages, which has not been the case in Western and Southern Europe. As real wage growth was strong in the CEE10 between 2003 and 2012, minimum wages increased in real terms by more than 30% in eight of the CEE10, and by more than 50% in three of these countries.

The simplicity of minimum wage regulations is especially desirable in countries in which levels of contract enforcement are relatively low, and modern labour market institutions have a relatively short history; as is the case in the CEE10 countries.[7] However, the question to what extent employers in the CEE10 comply with minimum wages and their hikes is empirical in nature, and we address it in this paper.

3 Methodology and data

We use a set of minimum wage violation measures developed by Bhorat et al. (2013) that account for both the incidence and the degrees of violations. Non-compliance with the minimum wage law has traditionally been measured by looking at the fraction of all covered workers who are paid less than the relevant minimum wage. However, as such a measure provides no information about the extent of the underpayment, cases in which workers earned slightly below the minimum wage are assigned the same weight as cases in which large violations occurred. Using only the headcount (share) violation measure may also lead to an incomplete assessment of minimum wage increases. A minimum wage hike may lead to higher levels of non-compliance when the standard measure is used. However, the wages of workers who earn below the minimum rate may also increase due to "spillover" effects or partial compliance (Bhorat et al., 2015b). In such cases a measure that takes into account the extent of underpayment would provide additional insight.

The Index of Violation (Bhorat et al., 2013) builds upon the standard Foster-Greer-Thorbecke poverty measurement technique, and applies it to minimum wage analysis. This family of indices emphasise to differing degrees the depth of violations, and the traditional measure is a special case. The measure v_α of an individual violation is defined as

$$v_\alpha = v_\alpha(w_{\min}, w) = \left(\frac{w_{\min} - w}{w_{\min}}\right)^\alpha \tag{1}$$

[5] In all of the CEE countries minimum wages are determined by governments following consultations with, agreements between, or recommendations by social partners. It is possible that the priorities, the targets, the consensuses, and the outcomes of these processes have been changing over time, even if the basic determination procedure has remained *de jure* the same. We are not, however, able to deal with this issue quantitatively.

[6] Based on the OECD data. Thus, Figure 1 includes only the EU countries that also belong to the OECD, and have minimum wages set at the national level. Because the Eurostat data on the ratio of minimum to average wages apply to industry and services in 2003 and to industry, construction, and services in 2012, they cannot be directly compared (see Figure 13 in the appendix for the comparison of the OECD and the Eurostat Kaitz indices over time).

[7] In the 2015 World Bank Doing Business report, the CEE countries had the following rankings in the ease of enforcing contracts dimension (out of the 189 countries covered): Lithuania was 3rd, Estonia was 11th, Hungary was 23rd, Latvia was 25th, Romania was 34th, Poland was 55th, the Slovak Republic was 63rd, the Czech Republic was 72nd, and Slovenia was 117th.

where w is worker's wage, $w_{\min}$ is the relevant minimum wage, $\alpha > 0$, and v_α is positive when $w < w_{\min}$, and zero otherwise. When $\alpha = 1$, v_1 is the gap between the actual wage and the $w_{\min}$, expressed as a percentage of $w_{\min}$, and for greater values of $\alpha > 1$ the violation function places a greater emphasis on cases in which the degree of underpayment was greater. In order to obtain the standard headcount measure, we also define v_0 as an indicator function that takes a value of one when $w < w_{\min}$, and of zero when $w \geq w_{\min}$. A straightforward method for aggregating these individual violation measures is to take the expectation of v over the entire wage distribution. The overall violation V_α is then defined as

$$V_\alpha = \mathrm{E}\left[\left(\frac{w_{\min} - w}{w_{\min}}\right)^\alpha\right] \tag{2}$$

For the headcount violation measure v_0, the overall measure is a share of underpaid workers defined as $V_0 = \mathrm{E}[v_0]$. In this paper we focus on three measures: namely, *incidence of violation*, which refers to V_0; *depth of violation*, which refers to V_1; and *average shortfall*, which is defined as $\frac{V_1}{V_0}$ and measures the depth of the violation per underpaid worker. All of these measures can be calculated for monthly or hourly wages.

The available data that can be used for the multi-country analysis of minimum wage violations in the CEE10 (and similarly in the European Union) are very limited. The harmonised version of the EU Labour Force Survey (EU-LFS) provided by Eurostat does not contain information on wages. The EU Structure of Earnings Survey (EU-SES) has data on wages, but it is conducted only every four years, and it covers only firms that employ at least 10 employees. Moreover, the information in the EU-SES is provided by employers, who might underreport violations of rules pertaining to wages or hours. Hence, the share of workers who earn up to the minimum wage is likely to be underestimated in the EU-SES. If we look, for example, at the case of Poland, we can see that the share of workers who were earning wages at or below the minimum wage in the total economy was estimated at 13% in 2013 in a special survey conducted by Polish Central Statistical Office, but at only 5% in the EU-SES survey.

Given these limitations, we have chosen to use data from the European Union Survey of Income and Living Conditions (EU-SILC), which is a household survey that covers workers in all types of companies.[8] However, the focus of the EU-SILC is on household income. Data on the income (wages) of individual workers are available, but only on an annual basis. The respondents in the CEE10 countries reported total income from dependent employment from previous calendar year. The point at which the survey was carried out constitutes the reference period for the information concerning employment characteristics, such as the hours usually worked. The reference periods for the information on wages and for other job-related information do not overlap.[9] These are well-recognised limitations for the use of EU-SILC data for the analysis of wages, see Brandolini et al. (2011), Iacovou et al. (2012), Jenkins and Kerm (2014), Massari et al. (2015). To deal with these limitations, we follow a strategy described in the literature that recognises the need to use EU-SILC data for the analysis of monthly wages, see Engel and Schaffner (2012): we consider only the workers who at the time of the survey (i) were employed full-time and actually worked at least 40 hours per week (statutory full-time hours in all of the countries studied),[10] (ii) had only one job, and (iii) were

[8] See Table 6 in the appendix for exact information on the years available for each country.

[9] We name the data points according to the reference period of the wages; e.g., Estonia 2003 refers to data from the EU-SILC 2004 round in Estonia.

[10] The vast majority of the full-time workers in the CEE countries were working at least the statutory full-time weekly schedule (40 hours). Among the respondents in our sample with self-reported full-time employee status, the share who were working at least 40 hours per week was 94%. This share was highest in Slovenia (98.3%), followed by Bulgaria (97.8%), Romania (96.6%), Hungary (96.2%), Latvia (95.3%), Estonia (94.4%), Poland (93.3%), the Czech Republic (92.0%), Lithuania (89.7%), and Slovakia (81.0%). Some occupations, such as teacher or police officer, have specific full-time hours schedules, but we excluded such groups from our analysis.

employed full-time in all months of the previous calendar year. While such an approach leads to a decrease in the number of observations (see table 7 in the Appendix), it allows for a direct interpretation: if the yearly income of a person who was working full-time in all months of a given year was lower than the yearly equivalent of the full-time minimum wage, than there must have been at least one incidence of non-compliance with the monthly minimum wage rules. We also exclude from the sample the respondents under age 25, as the yearly data we use do not allow us to determine precisely when a worker moved from being covered by a sub-minimum wage for young workers or labour market entrants to being covered by a regular minimum wage. We apply equations 1-2 to monthly wage, w^{m}, and monthly minimum wage, $w^{\mathrm{m}}_{\mathrm{min}}$, to obtain measures of monthly minimum wage violations v^{m}_{α} and V^{m}_{α}.

A violation of the monthly minimum wage rules by definition translates into a violation of the hourly minimum wage rules.[11] However, non-compliance with the hourly wage rules also affects workers who earn at least the monthly minimum wage, but earn less per hour than the hourly equivalent of a relevant hourly minimum wage because of their (long) work hours. Because in all of the analysed countries the full-time working schedule was 40 hours per week, we calculate minimum hourly wages as $w^{\mathrm{h}}_{\mathrm{min}} = \frac{w^{\mathrm{m}}_{\mathrm{min}} * 12}{52 * 40}$. Following Engel and Schaffner (2012) we construct hourly wages assuming that for each individual the currently reported number of hours usually worked applies to the entire previous calendar year. In the next step we apply equations 1-2 to the hourly wage, w^{h}, and to the hourly minimum wage equivalent, $w^{\mathrm{h}}_{\mathrm{min}}$, to obtain measures of the level of hourly minimum wage non-compliance v^{h}_{α} and V^{h}_{α}. As the assumptions required for hours worked are rather strict, we treat these results with caution, and as complementary to estimates of non-compliance with monthly minimum wage rules.

Our estimates of the minimum wage violation can be treated as lower-bound estimates because some types of workers were excluded from the sample: e.g., those who were working part-time, were working for various employers, or had spells of unemployment or inactivity during the calendar year before the survey. These kinds of workers may be expected to be at greater risk of being underpaid than full-time workers who were continuously employed by a single employer (Marx and Salverda (2005), OECD (2013)). On the other hand, our results can be affected by errors in the reporting of wages and working hours, in particular by the under-reporting of wages and the over-reporting of hours, which would lead to an overestimation of non-compliance. On a positive note, the literature suggests that the under-reporting of earnings in surveys happen mainly at the upper end of the distribution. Using a unique matched dataset of survey (EU-SILC) and administrative data on incomes and wages in Estonia, Paulus (2015) showed that earnings reported in surveys tend to be higher than the earnings reported in the tax records when the latter have relatively low values, and that the opposite is the case when the latter have relatively high values. Using the same approach as we have to calculate the monthly wages of dependent workers, he also found that the incidence of minimum wage non-compliance is higher in the tax data. Nevertheless, in order to perform cross-country and over-time comparisons, we need to assume that reporting bias does not differ between countries and over time. We perform two robustness checks. First, we compare our calculations of the Kaitz indices with those published by the OECD and Eurostat. We find that despite using a sub-sample of workers, the magnitudes and the trends of the estimated Kaitz indices are consistent with those reported by the OECD and Eurostat over the entire analysed period (see Figure 13 in the appendix). This is shown to be the case for the Czech Republic, Estonia, Hungary, Lithuania, Latvia, and Poland in particular. The only country for which we observed a non-negligible discrepancy between our calculations of the Kaitz indices and the OECD and Eurostat estimates is Romania. Thus, we also perform an analysis of macro-level determinants of minimum

[11] If we analysed part-time workers or workers with statutory full-time schedules of less than 40 hours per week, this would not be the case.

wage violations for the country-level dataset that excludes Romania. Second, we further estimate all of the non-compliance measures for 75% of the minimum wage threshold (following OECD (2015)), as well as for 125% of the minimum wage threshold. This allows for a 25% joint reporting error in wages and hours.

We use Eurostat data on monthly minimum wages, which are defined as the monthly minimum wage levels for a person who worked the entire year and was paid a minimum monthly wage, as stated in the law. The minimum wages provided by Eurostat also include the additional pay required by law in particular countries (e.g., the 13th or the 14th wage), recalculated to monthly terms. This approach is in line with the definition of income from dependent employment reported in the EU-SILC. We do not account for higher minimum wage levels for occupations that require higher skills.The reasons are two-fold. First, the primary focus of the paper is to estimate the extent of minimum wage violations that happen at the lower end of the earnings distribution. Second, in the CEE10 these higher levels (if they exist) are indicative, but not binding. The question of how the existence of higher minimum wage levels for better educated and skilled workers affects the wages or the extent of compliance is also relevant from the perspective of policy-making, but addressing this question lies beyond the scope of this work, and may be an avenue for further research.

4 Minimum wage non-compliance in the CEE10

4.1 The scope of minimum wage violation in the CEE10

We find that the incidence of non-compliance among full-time workers in the CEE10 countries was moderate, but varied considerably between countries. During 2003-2012, the average estimated incidence of violations of monthly minimum wage (V_0^{m}) ranged from 1.0% in Bulgaria to 1.3% Czech Republic, around 3% in Romania and Slovenia, 4.7% in Poland and Hungary, 5.6% in Latvia, and 6.9% in Lithuania (see Figure 3). In international comparisons these values are not large. Levels of non-compliance are usually much higher in developing countries. Bhorat et al. (2015a) studied countries in sub-Saharan Africa, and found that the incidence of violations ranged from 36% in Zambia to 80% in Tanzania, with an average of 58%. Rani et al. (2013) analysed 11 developing and emerging countries in Africa, Asia, and Latin America,[12] and estimated that the incidence of violations ranged from 5% in Vietnam and 9% in Mexico, to 50% in Turkey and 51% in Indonesia (in the late 2000s). Kanbur et al. (2013) estimated that the incidence of violations in Chile was 18% on average between 1990 and 2009. On the other hand, Ye et al. (2015), found that the incidence of violations among full-time workers (in formal-sector firms) in China was 3.5%, or close to our results for the CEE10. Evidence on this issue for the developed countries is scarce. OECD (2015) found that on average across the OECD countries with available data, 5.5% of workers earned at or below the minimum wage in 2010. However, this figure reflects both non-compliance and non-coverage. Garnero et al. (2015) found that in the EU countries with national statutory minimum wages, the shares of workers earning below the minimum levels ranged from 1% in Bulgaria and Romania to 4% in Poland and 8% in France in 2008-2010.[13] BLS (2014) showed that in the US 2.3% of workers who were over age 15 and were paid by the hour earned less than the hourly federal minimum wage in 2013.[14]

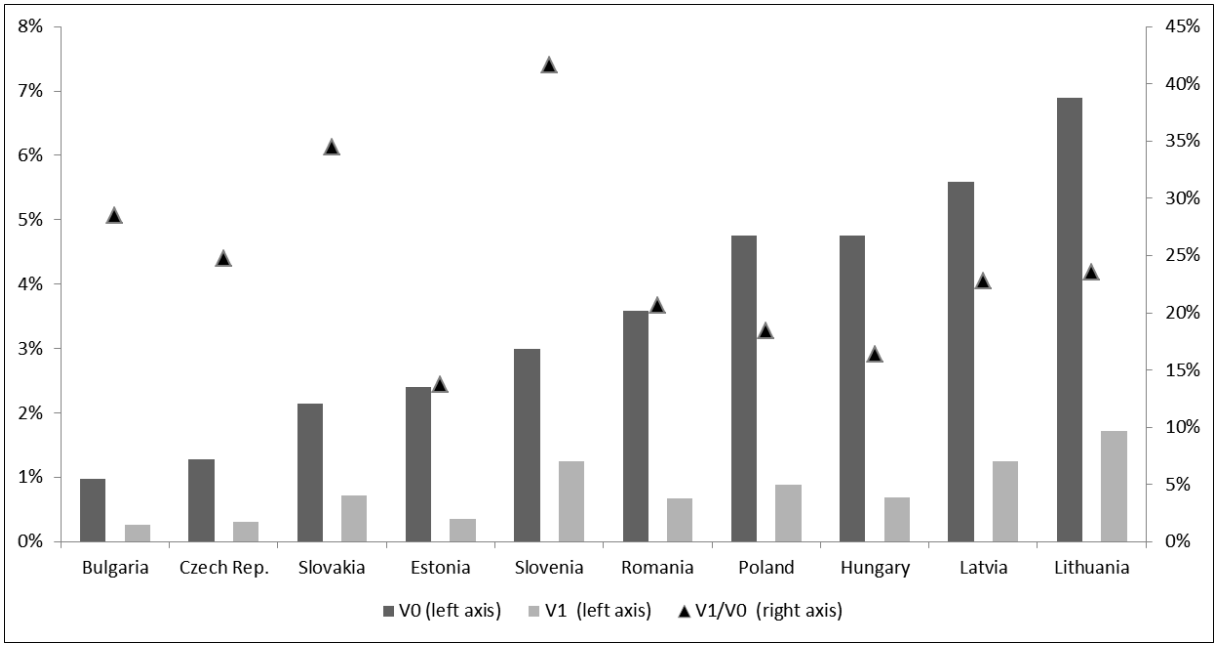
[12] Brazil, Costa Rica, India, Indonesia, Mali, Mexico, Peru, the Philippines, South Africa, Turkey, and Vietnam.

[13] Garnero et al. (2015) cover five of the 10 CEE countries that we analyse, and several EU15 countries. Although they distinguished between non-compliance and non-coverage, in the CEE economies the coverage is *de jure* universal. Thus, Garnero et al. (2015) the results for CEE can be interpreted as representing the incidence of non-compliance.

[14] In 2013, 75.9 million workers over age 15 in the United States were paid at hourly rates, representing 58.8% of all wage and salary workers.

The average depth of violation per worker (V_1^m) ranged (on the average in 2002-2013) from 0.3% (of the country-year specific minimum wage) in Bulgaria, the Czech Republic, and Estonia to 1.3% in Latvia and Slovenia and 1.7% in Lithuania. Such low values are not surprising considering the moderate incidence of violations. We thus find that the average shortfall per underpaid worker is a more informative measure. Figure 3 shows that, with the exception of Estonia, countries with a below-average incidence of violations exhibited above-average shortfalls that ranged from from 24.7% of the country-year specific minimum wage in Czech Republic to 41.7% in Slovenia (an average of 32.3% on the average across these countries in 2003-2012). On the other hand, countries with above-average incidences of violations (and Estonia) recorded below-average shortfalls that ranged from 13.7% of the country-year specific minimum wage in Estonia to 23.5% in Lithuania (an average of 19.3% across these countries in 2003-2012).

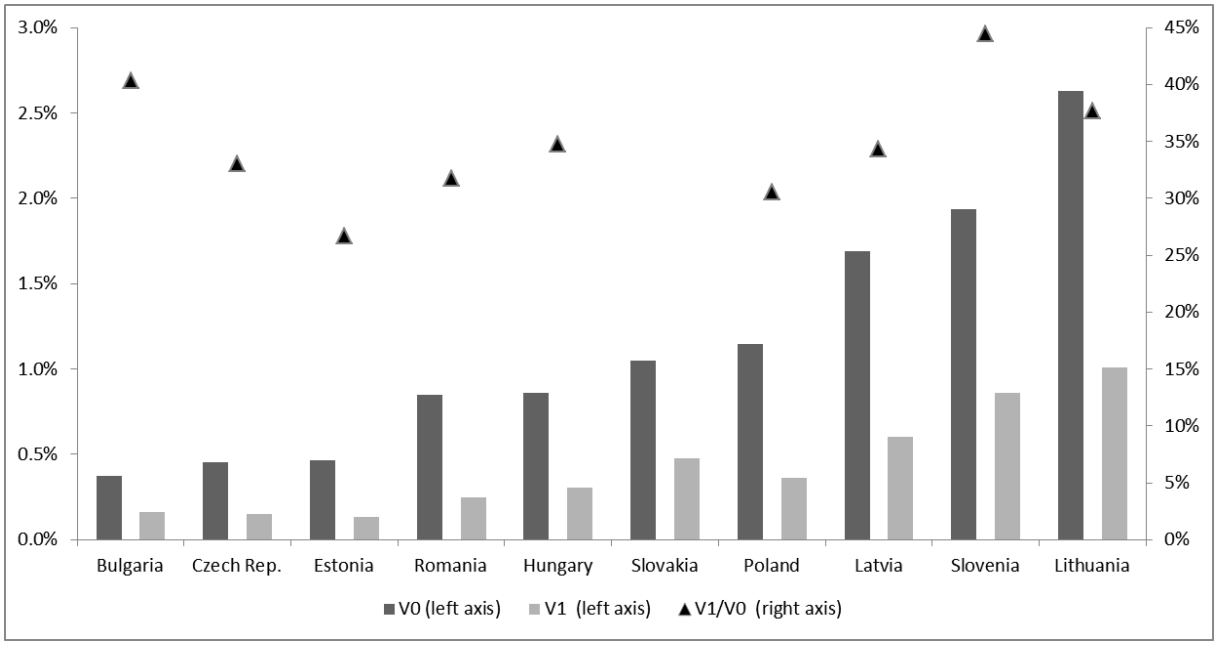
Figure 3: Monthly minimum wage violation measures in the CEE10: 2003-2012 averages.



Note: V_0 - incidence of violations, V_1 - depth of violations, V_1/V_0 - average shortfall per underpaid worker. Source: own calculations on the EU-SILC data.

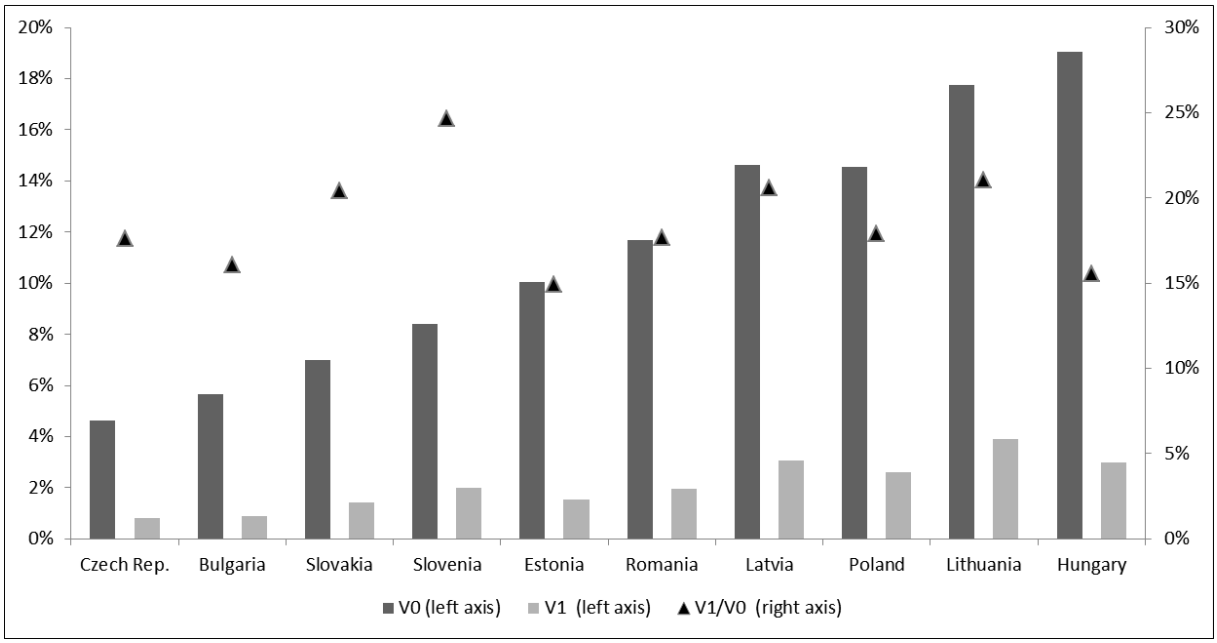
Figures 4-5 present the monthly minimum wage violation measures, V_α^m, calculated for the 75% of the minimum wage threshold and the 125% of the minimum wage threshold, respectively. The incidence of violations, (V_0^m) is obviously much lower for the 75% threshold (between 0.4% in Bulgaria and 2.6% in Latvia), and is much higher for the 125% threshold (between 4.6% in the Czech Republic and 19.0% in Hungary), but the ranking of the countries is generally preserved. The same applies to the patterns identified above with regard to average shortfalls and the depth of violations. Table 8 in the appendix shows that the cross-country correlations between all of the basic measures calculated for the 100% of the minimum wage threshold and the alternative thresholds are high; above 75% for the incidence of violations and above 90% for both depth measures. The findings from our basic estimates are thus quite robust to changes in the threshold, and in the remaining part of the paper we will present our results for the 100% of the minimum wage threshold, while selected results for the other two thresholds can be found in the appendix.

Figure 4: Monthly minimum wage violation measures in the CEE10 for the 75% of the minimum wage threshold: 2003-2012 averages.



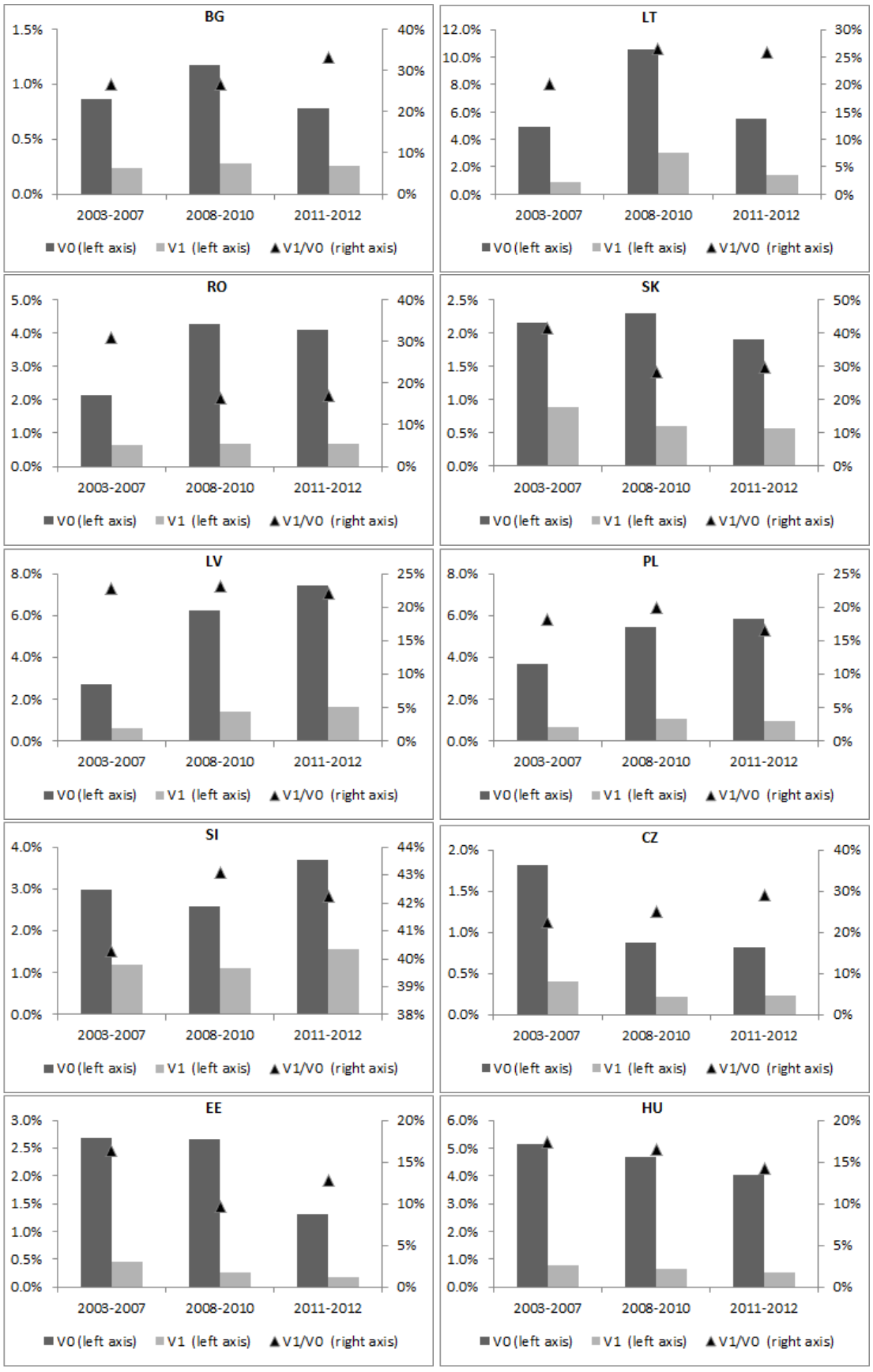
Note: V_0 *- incidence of violation,* V_1 *- depth of violation,* V_1/V_0 *- average shortfall per underpaid worker.*
Source: own calculations on the EU-SILC data.

Figure 5: Monthly minimum wage violation measures in the CEE10 for the 125% of the minimum wage threshold: 2003-2012 averages.



Note: V_0 *- incidence of violation,* V_1 *- depth of violation,* V_1/V_0 *- average shortfall per underpaid worker.*
Source: Own calculations on the EU-SILC data.

Figure 6: Monthly minimum wage violation measures in the CEE10: evolution over time.



Note: V_0 *- incidence of violations,* V_1 *- depth of violations,* V_1/V_0 *- average shortfall per underpaid worker.*
Source: Own calculations on the EU-SILC data.

We identify three patterns of changes in the incidence of minimum wage violations over time (Figure 6).

In Bulgaria, Lithuania, Romania, and Slovakia the incidence of violations increased temporarily during the crisis of 2008-2010. In 2011-2012, non-compliance declined to pre-crisis levels in Bulgaria, Lithuania, and Slovakia, but it decreased only slightly in Romania. The average shortfall was rising in Bulgaria and Lithuania, while the average depth of violation per worker followed an inverted-U pattern. In Romania and Slovakia both the average shortfall and the average depth of violation per worker were gradually decreasing.

In Latvia, Poland, and Slovenia the incidence of violations rose over the analysed period. In Latvia and Poland the increase was gradual, and the sharpest rise occurred in 2008-2010.[15] In Slovenia the incidence of violations declined in 2008-2010, but rose sharply in 2011-2012. In all three countries the average shortfall increased slightly in 2008-2010 and declined thereafter; thus, the average depth of violation in 2008-2010 and in 2011-2012 was higher than in 2003-2007.

In the Czech Republic, Estonia, and Hungary the incidence of violations was decreasing over the analysed period, especially in the last two countries. The trends in the average shortfall were diverse: in the Czech Republic it was increasing, in Estonia it was U-shaped, and in Hungary it was decreasing. Nevertheless, in all three countries the average depth of violation per worker was declining.

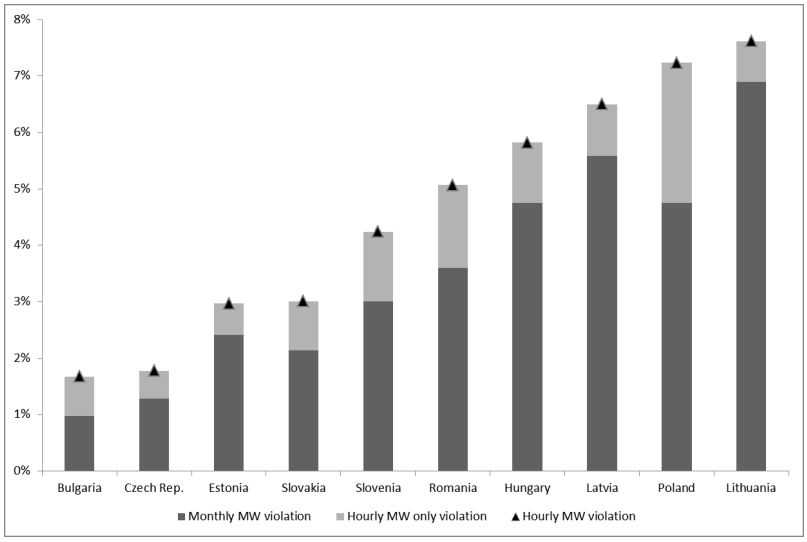
Accounting for violations by hours, we find that the overall incidence of minimum wage violations rose by about $\frac{1}{3}$, as shown in Figure 7, which decomposes the average hourly minimum wage incidence of violations, V_0^{h}, into the monthly minimum wage incidence of violations, V_0^{m} (see Figure 3), and the incidence of violations in hourly wage terms only, V_0^{h}-V_0^{m}. On average in 2003-2012, the incidence of violations in hourly wage terms only was most pronounced in Poland (affecting 2.5% of full-time workers), Romania (1.5%), and Hungary (1.3%); and was least pronounced in the Czech Republic (0.5%), Estonia (0.6%), and Lithuania (0.7%). The incidence of violations of hourly minimum wage rules among workers earning at least the monthly minimum wage, V_0^{h}-V_0^{m}, was moderately correlated with the incidence of monthly wage violations, V_0^{m}, (a cross-country correlation coefficient of 32.6%), but if Lithuania (which had the highest monthly incidence of violations) is omitted, the correlation turns solid (60.7%). Thus, the only substantial difference we find when ranking the CEE10 countries in terms of incidence of monthly violations and incidence of hourly violations is that Poland emerges as the country with the second-highest incidence of hourly violations.

In the countries in which the shortfall in monthly wage terms, $V_1^{\mathrm{m}}/V_0^{\mathrm{m}}$, was above average (Bulgaria, the Czech Republic, Slovakia, Slovenia), the average shortfall in hourly wage terms, $V_1^{\mathrm{h}}/V_0^{\mathrm{h}}$, was lower. This implies that the shortfall among workers who were earning at least the monthly minimum wage, but who were working so many hours that their hourly wages were below the hourly equivalent of the relevant minimum wage, was lower than the shortfall among workers who were not earning the monthly minimum wage. The opposite was the case in the countries with a below-average shortfall in monthly terms (except for Lithuania). As a result, the cross-country dispersion of the average shortfall was lower for hourly wage violations than for monthly violations (Figure 8). In the CEE10 countries the number of hours worked per week was higher than in the EU15 countries,[16] and our evidence suggests that extra hours are used to ensure compliance with monthly minimum wage laws while paying sub-minimum hourly wages.

[15] In both countries the minimum wage hikes were largest in 2008-2010. In Latvia, 50% of the total real minimum wage growth between 2003 and 2012 occurred in 2008-2010 (46% in nominal terms). The respective figures for Poland were 56% in real terms and 48% in nominal terms. Kamińska and Lewandowski (2015) showed that in Poland 1.35 million more workers (out of a total of 13.55 million workers) were directly affected by the increase in the minimum wage between 2007 and 2008 than by the increase in the minimum wage between 2006 and 2007.

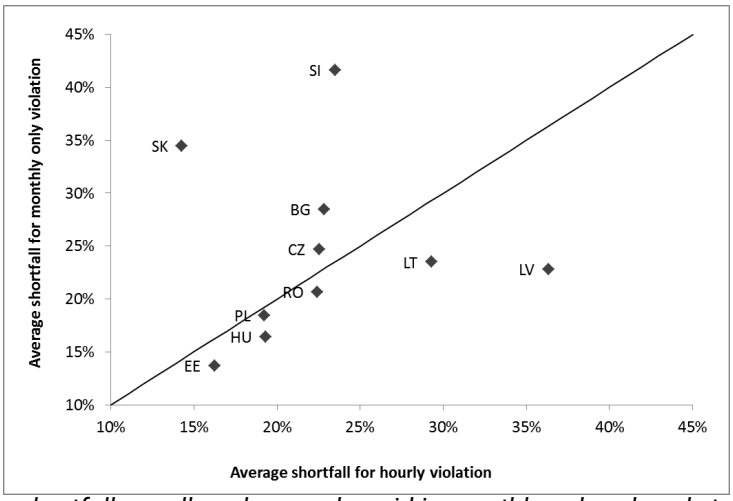
[16] According to the EU-LFS 2012 data, all of the CEE10 countries are among the 12 countries with the highest usual weekly hours worked (the other two are Portugal and Greece, ranked 8 and 9).

Figure 7: Hourly minimum wage incidence of violations in the CEE10: 2003-2012 averages



Source: own calculations on the EU-SILC data.

Figure 8: Average shortfall of monthly vs. hourly underpaid workers in the CEE10: 2003-2012 averages.



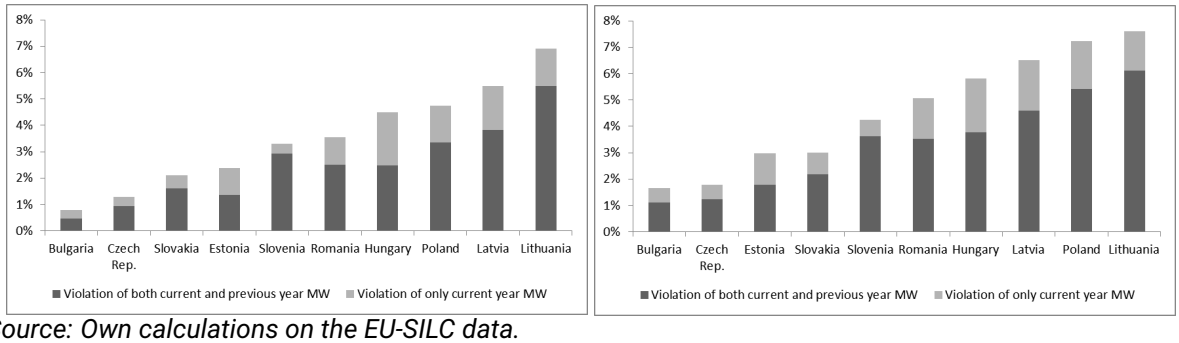
Note: X-axis - average shortfall per all workers underpaid in monthly or hourly only terms; Y-axis - average shortfall per workers underpaid in monthly terms.
Source: Own calculations on the EU-SILC data.

We also find that minimum wage violations in the CEE10 did not result only from the failure to comply with a minimum wage hike introduced in a given year. Figure 9 shows that in all of the CEE10 countries a majority of the underpaid workers were earning less than both the current minimum wage and the minimum wage in a previous year. The patterns were very similar for monthly and hourly violations. On average in 2004-2012, the share of such workers among all workers who were underpaid in monthly terms ranged from 55% (64% in hourly terms) in Hungary, to 57% (60%) in Estonia, 80% (80%) in Latvia, and 89% (85%) in Slovenia; while the cross-country average was 70% (68%). There were no systematic differences in the shares of these workers between countries with high and low levels of violations. The data don't allow us to verify whether the workers whose rights were violated under the current and the previous minimum wage rules were also underpaid in the previous year, or were, for example, jobless before moving to low-paid employment. While the shares of workers who were earning less than both the current and the previous year's minimum wage among all workers affected by non-compliance were generally high, in all of the countries we find that the

density of wages close to the increased minimum wage was slightly greater than at other points of the wage distribution. The sensitivity analysis calculations with 75% and 125% of the minimum wage threshold (Figures 14 and 15 in the appendix) show that the shares of workers who earned less than both the current and the previous year's (proportionally adjusted) minimum wage were higher than in the benchmark case: on average, the shares were 85% (78%) and 73% (76%), respectively.

Figure 9: Decomposition of the average (over 2004-2012) incidence of violations into violations of both the current and the previous year's minimum wage, and the current minimum wage only

Monthly violation (V_0^m) Hourly violation (V_0^h)



Source: Own calculations on the EU-SILC data.

4.2 Individual and workplace characteristics of workers affected by non-compliance

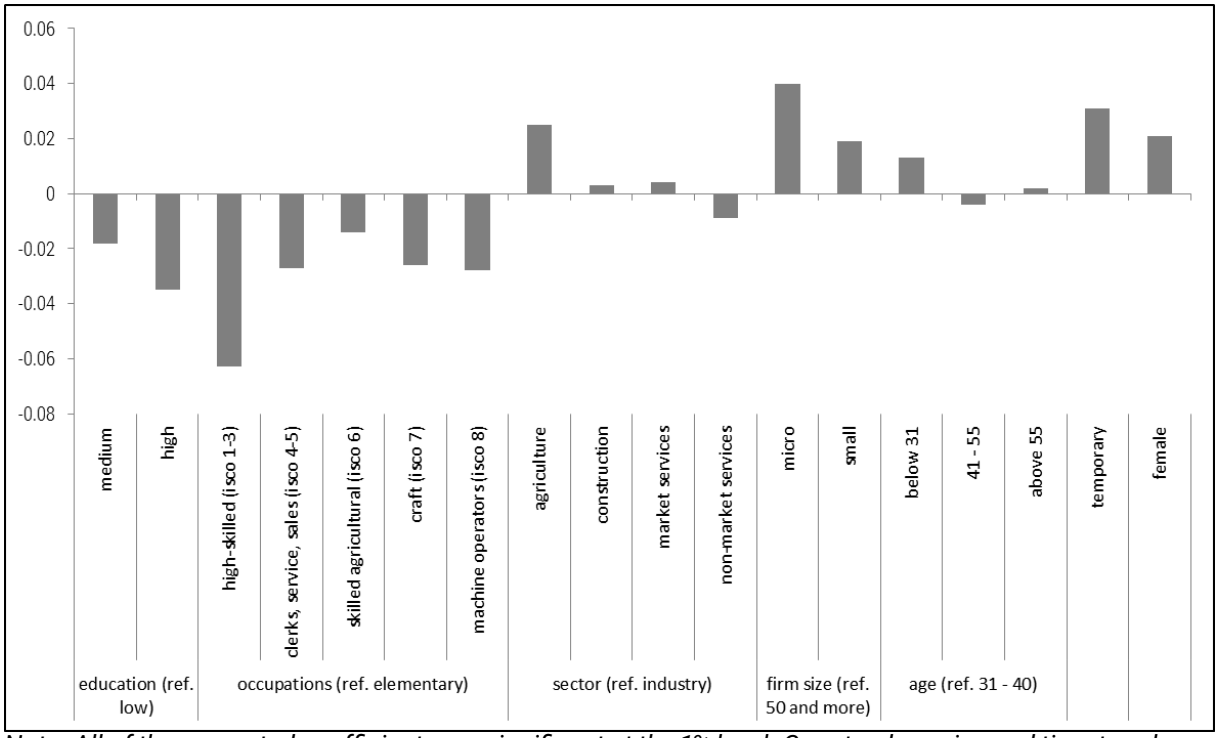
In this subsection we seek to identify the individual and the workplace features related to minimum wage violations. To this end we estimate a probit regression for the probability of non-compliance in hourly wage terms, v_0^h, on a pooled dataset with country and time controls. We also estimate separate models for each country. The results are presented in Table 10 in the appendix, and in most cases the relative importance of various regressors is preserved.

The set of significant categorical independent variables is similar to those found in the Mincerian wage regressions, which are broadly used in the literature to study determinants of wages. The marginal effects obtained from the pooled regression (see Figure 10) show that the youngest workers (aged 25-30) faced the highest, and workers aged 41-50 faced the lowest probability of being affected by non-compliance (respectively 1.3 pp. higher and 0.4 pp. lower than for workers aged 31-40). However, the relationship between the probability of being affected by non-compliance and age is not monotonic: i.e., workers aged 55 and above were by 0.2 pp. more likely to have experienced it than workers aged 31-40. Importantly, women were significantly more likely to been affected by non-compliance than men: the marginal effect for women was 2.1 pp., which we think is relatively strong. Our results also point to the importance of education and skills. Across the CEE10, workers with medium education had a 1.8 pp. lower probability of being affected by non-compliance than workers with low education, while the effect for workers with tertiary education was twice as high (3.5 pp.).[17] Moreover, workers in high-skilled occupations (ISCO 1-3) were much less likely (by 6.3 pp.) than workers in elementary occupations to be affected by non-compliance (the strongest marginal effect in the model). Negative and noticeable marginal effects are also found for machine operators (2.7 pp.); clerks, sales, and service workers (2.7 pp.); and craft workers (2.6 pp.).

[17] We define low education as levels 1-2, medium education as levels 3-4, and high education as levels 5-6 of the ISCED classification.

In terms of sectors, the only sector in which the probability of being affected by non-compliance was lower than in industry was in non-market services (-0.9 pp.). Agriculture had the highest marginal effect of all sectors: the probability of committing a violation was 2.5 pp. higher in agriculture than in industry. The effects for construction and market services were also positive, but small. We also find a negative relationship between firm size and the probability of committing a violation: compared to workers in firms with 50 or more employees, workers in micro firms (with fewer than 10 employees) were 4.0 pp. more likely and workers in small firms (10-49 employees) were 1.9 pp. more likely to be affected by non-compliance.

Figure 10: Marginal effects from probit regression on non-compliance dummy.



Note: All of the presented coefficients are significant at the 1% level. Country dummies and time trends are included.

Source: Own estimations on the EU-SILC data.

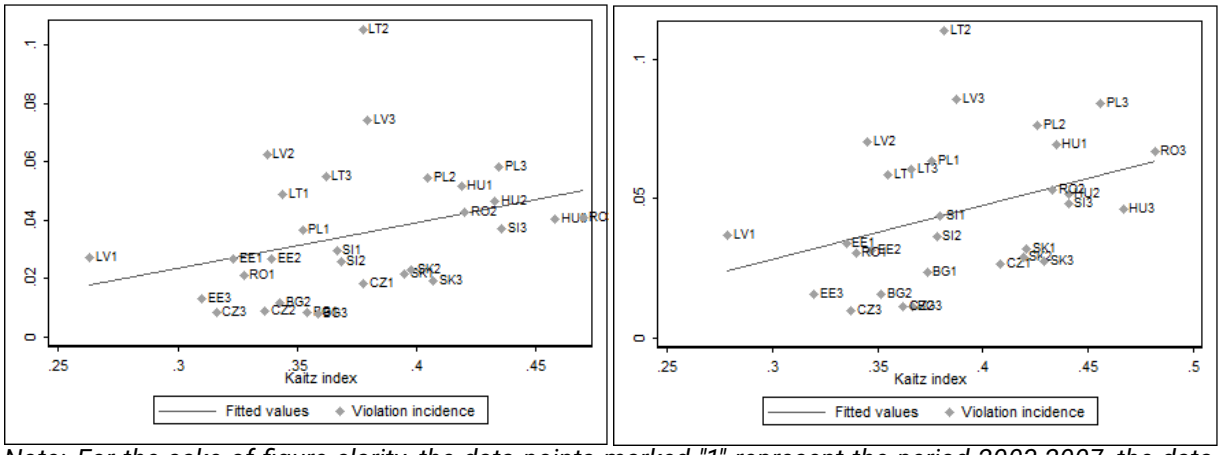
We identify a strong and positive marginal effect for temporary workers, who were by 3.1 pp. more likely to have been affected by non-compliance than workers with open-ended contracts. These findings may indicate that employers in the CEE used non-standard working arrangements to pay wages below the statutory minimum levels. Indeed, Table 9 in the appendix shows that in all of the CEE10 countries the incidence of violations was much higher among temporary workers. However, because the shares of workers who were in temporary employment were relatively low in most countries, the overall incidence of violations among temporary workers was basically the same as the incidence of violations among permanent workers. The only exception is Poland (the country with the highest share of workers who were in temporary employment in the EU in 2012), where the overall incidence of violations was 1 pp. higher than the incidence of violations among permanent workers only, as the incidence of violations among temporary workers was 10 pp. higher than among permanent workers. In general, the countries with the highest incidence of violations in monthly terms (V_0^m) - namely, Latvia, Poland, and Hungary-also had a relatively high incidence of violations in hourly wage terms only ($V_0^h - V_0^m$), and large differences in the incidence of violations among temporary and permanent workers.

The above findings are replicated by sensitivity analysis estimations with non-compliance dummies calculated with 75% or 125% of the minimum wage threshold. While there are some differences in the magnitude of the marginal effects between these alternative estimations and the benchmark estimations, the relative sizes of the marginal effects (related to the highest marginal effect, estimated for high-skilled occupations) are virtually identical in each estimation (see Figure 16 in the appendix).[18] The relative importance of particular characteristics is thus robust to the selection of the non-compliance threshold.

4.3 Macro-level determinants of minimum wage violation

The patterns of the incidence and other measures of violations may be related to various patterns in the development of the Kaitz index and of other macroeconomic or institutional variables in particular countries. The Kaitz index did not change in Romania and Slovakia over the 2003-2012 period (see Figure 1), and in these countries the incidence of violations increased only temporarily during the crisis (see Figure 6).[19] Poland and Latvia experienced strong increases in both the Kaitz index and in the incidence of violations. The Czech Republic was the only CEE10 country with a decreasing (if only slightly) Kaitz index and a declining incidence of non-compliance. Figure 11 confirms that the Kaitz index was positively correlated with the incidence of violations in the CEE10, in line with literature showing that a higher Kaitz index is accompanied by a higher incidence of violations.[20]

Figure 11: Minimum wage incidence of violations vs. Kaitz index in the CEE10, 2003-2013.
Monthly violation (V_0^m) Hourly violation (V_0^h)



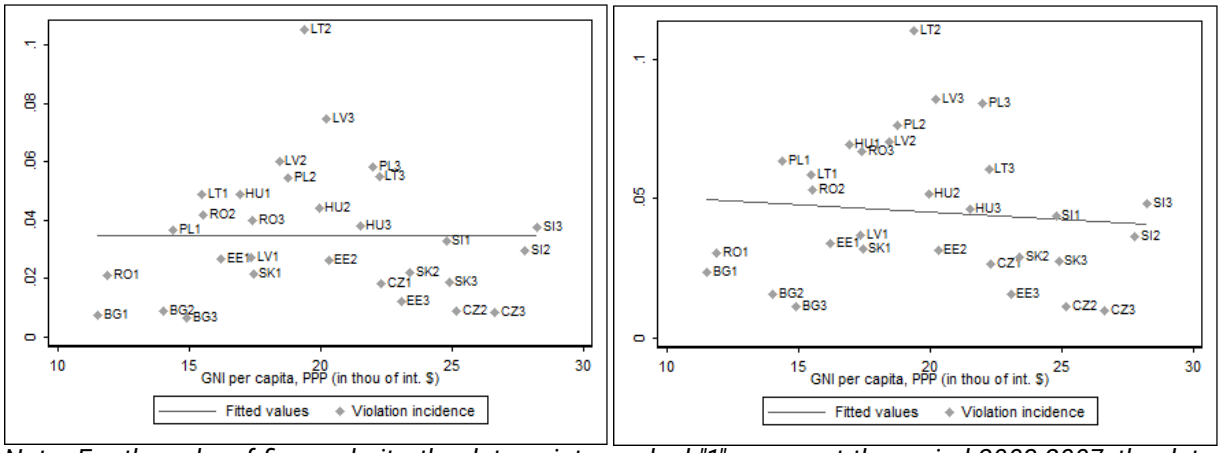
Note: For the sake of figure clarity, the data points marked "1" represent the period 2003-2007, the data points marked "2" represent the period 2008-2010, and the data points marked "3" represent the period 2011-2012.
Source: Own calculations on the EU-SILC data.

[18] Detailed estimation results for 75% and 125% of the minimum wage thresholds are available upon request.
[19] Romania is the only country in which there was a discrepancy between our estimate of the Kaitz index and the Eurostat and the OECD estimates. In the appendix we report the results of macro-level analyses excluding Romania.
[20] Andalón and Pagés (2008) showed that sectors and occupations with a higher Kaitz index in Kenya also had higher levels of non-compliance. Bhorat et al. (2012) found a positive relationship between the Kaitz index and the likelihood of violations for sector-occupation-location categories in South Africa. Bhorat et al. (2015a) showed that higher Kaitz indices were associated with higher levels of non-compliance in a sample of sub-Saharan African countries. Rani et al. (2013) found a positive correlation between the incidence of violation and the Kaitz index across 11 developing economies. Garnero et al. (2015) discerned a link between higher Kaitz index values and the incidence of workers who were paid less than the minimum wage at a sectoral level in a sample of EU countries.

Previous studies have also indicated that more advanced countries usually have higher levels of compliance (see subsection 4.1). However, Figure 12 shows that the incidence of violations was not correlated with the output (GNI) per capita in the CEE10 in 2003-2012.

Figure 12: Incidence of minimum wage violations vs. GNI per capita (in PPP) in the CEE10.

Monthly violations (V_0^{m}) Hourly violations (V_0^{h})



Note: For the sake of figure clarity, the data points marked "1" represent the period 2003-2007, the data points marked "2" represent the period 2008-2010, and the data points marked "3" represent the period 2011-2012. The GNI per capita is reported in thousands of current international dollars.
Source: Own calculations on the EU-SILC and World Development Indicators data.

We analyse the relationship between the incidence of violations, the Kaitz index, and the output per capita using a country-level panel regression. We focus on monthly minimum wage violations, V_0^{m}, but also estimate models for hourly violations, V_0^{h}, as a robustness check. The estimation results suggest that within countries an increase in the Kaitz index translated into a higher incidence of violations (see Table 2). Within each country, a 1 pp. increase in the Kaitz index was, on average, associated with a 0.31 pp. increase in the incidence of monthly minimum wage violations. However, no significant relationship was found when the between-country variation was analysed. Moreover, within countries the GNI per capita was significantly and negatively related to the incidence of monthly minimum wage violations (an increase in the GNI per capita of one thousand current international dollars was associated with a 0.1 pp. decrease in the incidence of violations), but there was no significant between-country relationship. Table 2 shows that for hourly minimum wage violations the findings were the same, and the effects were, in absolute terms, even stronger. This suggests that different developments in the Kaitz index (and in the GNI per capita) can explain different developments in the incidence of violations in the CEE10 countries, but that differences in the Kaitz index (and in the GNI per capita) between countries did not explain the differences in the average incidence of violation levels between the CEE10 countries.[21]

[21] The insignificant estimates of the between-country parameters could be related to the small sample size, but we also ran separate regressions using the Kaitz index and the GNI per capita as explanatory variables only, and the results were essentially the same. They are available upon request.

Table 2: Relationship between the incidence of minimum wage violations, (V_0), the Kaitz index, and the GNI: panel regression

variables	(1) monthly violation (V_0^m) between-effects	(2) monthly violation (V_0^m) fixed-effects	(3) hourly violation (V_0^h) between-effects	(4) hourly violation (V_0^h) fixed-effects
GNI pc (PPP)	-0.0005	-0.0012*	-0.0009	-0.0021***
	(0.0019)	(0.0006)	(0.0020)	(0.0006)
Kaitz index	0.0629	0.3140***	0.1478	0.3808***
	(0.2063)	(0.0498)	(0.2263)	(0.0479)
Constant	0.0205	-0.0591***	0.0092	-0.0540***
	(0.0852)	(0.0193)	(0.0934)	(0.0186)
Observations	85	85	85	85
R-squared	0.022	0.354	0.085	0.475
No. of countries	10	10	10	10

Standard errors in parentheses: *** p<0.01, ** p<0.05, * p<0.1

Source: Own estimations on EU-SILC, Eurostat and World Bank data.

Rani et al. (2013) argued that high minimum wage levels and complex legal provisions (resulting from, for instance, multiple wage floors for different types of workers) are key explanatory factors for non-compliance. Garnero et al. (2015) found for European countries that the link between higher Kaitz index values and the incidence of workers who are paid less than the minimum wage is significantly weaker in systems with a national wage floor. As all of the CEE10 countries have national wage systems with statutory minimum wages, the differences between them in the incidence of violations cannot be related to a multiplicity of wage floors or to sectoral differences in coverage. Nevertheless, to test whether differences in non-compliance levels in the CEE10 could be related to institutional characteristics, we ran a range of panel regressions with the Kaitz index and standard variables that measured both the labour market institutions and the broader economic and regulatory environment. These explanatory variables include the strictness of employment protection measures, trade union density, the bargaining coverage rate, the labour inspection rate, as well as the World Bank Doing Business index and its sub-indices that reflect the regulations pertaining to paying taxes and enforcing contracts (see the note under Table 3 for a more detailed description). We also estimated the model using the unemployment rate as an alternative (to the GNI) measure of the macroeconomic situation. Because our sample size was small (and for some institutional measures was even more limited than the benchmark sample), in each regression we used the Kaitz index and a selected institutional variable. The results of country fixed-effects panel regressions on the monthly incidence of minimum wage violations, V_0^m, are presented in Table 3.[22]

[22] To save space, we omit the results of the models on the hourly minimum wage violations, V_0^h, and the between-effects estimates. They are available upon request.

Table 3: Panel regressions with country fixed effects of the incidence of monthly minimum wage violations, (V_0^m)

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
Kaitz index	0.2481***	0.1603**	0.2117***	0.3375***	0.1996**	0.1816***	0.5881***	0.3112***	0.2901***
	(0.0527)	(0.0608)	(0.0641)	(0.0775)	(0.0956)	(0.0596)	(0.1558)	(0.0528)	(0.0487)
Unemployment rate	0.0012*								
	(0.0006)								
EPL index		0.0062							
		(0.0087)							
Trade unions density			0.0014**						
			(0.0007)						
Bargaining coverage rate				0.0005*					
				(0.0002)					
Labour inspections rate					0.0007				
					(0.0082)				
Tax wedge						-0.0001			
						(0.0010)			
Doing business, DTF							-0.0012		
							(0.0021)		
Paying taxes, DTF								-0.0001	
								(0.0004)	
Enforcing contracts, DTF									0.0000
									(0.0011)
Constant	-0.0672***	-0.0451	-0.0712**	-0.1145***	-0.0407	-0.0355	-0.1113	-0.0771**	-0.0746
	(0.0182)	(0.0286)	(0.0283)	(0.0354)	(0.0386)	(0.0480)	(0.1452)	(0.0312)	(0.0775)
Observations	85	47	49	57	34	55	30	70	84
R-squared	0.355	0.180	0.239	0.292	0.166	0.171	0.442	0.383	0.330
No.of countries	10	7	6	9	10	6	10	10	10

Standard errors in parentheses: *** p<0.01, ** p<0.05, * p<0.1

Note: Data sources as follows. Unemployment rates - Eurostat. EPL - OECD, Strictness of Employment Protection for individual and collective dismissals for regular contracts. Trade unions density - OECD, ratio of wage and salary earners who are trade union members, to total number of wage and salary earners. Bargaining coverage rate - AIAS, employees covered by collective (wage) bargaining agreements of all wage and salary earners in employment with the right to bargaining. Labor inspections rate - ILO, average number of labour inspectors per 10,000 employed persons. Tax wedge - OECD, single person at 67% of average earnings with no children. Doing Business, Paying taxes, Enforcing contracts - World Bank Doing Business database, distance to frontier measures.

Source: Own estimations on EU-SILC data and other data enlisted above.

The Kaitz index turned significant (at a 1% level) in all of the specifications. The magnitudes of estimated parameters varied between specifications, but in the models with a nearly full sample size they were virtually the same as in the benchmark model (see Table 2). The unemployment rate was positively and significantly related to the incidence in non-compliance (a 1 pp. increase in the unemployment rate was associated with an increase in the incidence of minimum wage violations of 0.1 pp.). These results confirm that higher minimum to median wage ratios were associated with higher levels of non-compliance in the CEE, while better macroeconomic conditions were associated with lower levels of non-compliance. Regarding the institutional and regulatory variables, the only two that are shown to be significant were related to trade unions. We find that both trade union density and collective bargaining coverage rate were significantly (at a 5% and a 1% level, respectively) and positively related to the incidence of minimum wage violations. Union density and collective bargaining coverage have been declining in the CEE, and reached rather low levels (Kahancova, 2012). However, recent institutional reforms have increased the ability of unions to bargain and enforce wage agreements (Magda et al., 2015). This may suggest that the higher the share of workers receiving higher wages and stronger protection as a result of unions activity in the CEE, the higher probability that those left behind are earning below the minimum wage. On the other hand, Ivlevs and Veliziotis (2016) showed that union members in CEE were less likely than similar non-members to lose their jobs during the Great Recession, but were more likely to experience a wage reduction, so higher density and coverage could have alleviated overall wage pressures. Interestingly, we find no significant relationship between the incidence of violations and the rate of labour inspections, the enforcing contracts index, or the EPL index.

We also apply country-level panel regressions to shed light on the relationship between the depth of non-compliance, the Kaitz index, and the output per capita. We find that (as in the case of the incidence of violations) the higher the Kaitz index, the higher the depth of violation, (V_1). According to our estimates (Table 4), a 1 pp. increase in the Kaitz index was associated with a 0.07 pp. increase in the depth of monthly violations. A higher GNI per capita was associated with a significantly lower depth of violation, but the effect was small. The between-country effects were insignificant for both the Kaitz index and the GNI per capita. This suggests that in the case of the depth of violations as well both these variables were related to the within-country developments. The results for hourly violations were consistent with those for monthly violations, and were larger in absolute terms. Table 5 shows that in the CEE10 there was no significant relationship between the average shortfall, (V_1/V_0), the Kaitz index, and the GNI either between or within countries. Thus, a positive within-country relationship between the average depth of violations and the Kaitz index resulted from a positive relationship between the Kaitz index and the incidence of violations: a higher Kaitz index is related to a higher incidence of violations, (V_0), and as there was no systematic pattern in terms of the gap per underpaid worker, (V_1), the average depth of violation, (V_1/V_0), also turned out to be higher. Thus, we don't estimate the models with institutional variables on depth nor shortfall.

Tables 11-13 in the appendix present the results of robustness tests: estimates of panel regressions applied to violation measures calculated with 75% and 125% of the minimum wage thresholds, and to benchmark violation measures in the sample without Romania. The significance of the Kaitz index and the sign of the estimated parameter was preserved in all of the alternative specifications, although the GNI per capita turned out to be not significant in the regressions on V_0^m and V_1^h calculated with 75% of the minimum wage threshold, and excluding Romania.

Table 4: Relationship between the average depth of minimum wage violations, (V_1), the Kaitz index, and the GNI: panel regression

variables	(1) monthly violation (V_1^m) between-effects	(2) monthly violation (V_1^m) fixed-effects	(3) hourly violation (V_1^h) between-effects	(4) hourly violation (V_1^h) fixed-effects
GNI pc (PPP)	0.0003	-0.0003	0.0002	-0.0005**
	(0.0005)	(0.0002)	(0.0005)	(0.0002)
Kaitz index	0.0019	0.0700***	0.0187	0.0821***
	(0.0520)	(0.0160)	(0.0559)	(0.0157)
Constant	0.0008	-0.0126**	-0.0013	-0.0108*
	(0.0215)	(0.0062)	(0.0231)	(0.0061)
Observations	85	85	85	85
R-squared	0.070	0.209	0.044	0.284
No. of countries	10	10	10	10

Standard errors in parentheses: *** p<0.01, ** p<0.05, * p<0.1

Source: Own estimations on EU-SILC, Eurostat and World Bank data.

Table 5: Relationship between the average shortfall, (V_1/V_0), Kaitz index, and the GNI: panel regression

variables	(1) monthly violation (V_1^m/V_0^m) between-effects	(2) monthly violation (V_1^m/V_0^m) fixed-effects	(3) hourly violation (V_1^h/V_0^h) between-effects	(4) hourly violation (V_1^h/V_0^h) fixed-effects
GNI pc (PPP)	0.0120	-0.0017	0.0099*	-0.0009
	(0.0071)	(0.0028)	(0.0049)	(0.0019)
Kaitz index	0.1461	-0.2582	0.1154	-0.2043
	(0.7845)	(0.2307)	(0.5463)	(0.1597)
Constant	-0.0428	0.3709***	-0.0080	0.3196***
	(0.3239)	(0.0896)	(0.2255)	(0.0620)
Observations	85	85	85	85
R-squared	0.296	0.028	0.370	0.031
No. of countries	10	10	10	10

Standard errors in parentheses: *** p<0.01, ** p<0.05, * p<0.1

Source: Own estimations on EU-SILC, Eurostat and World Bank data.

5 Conclusions

In this paper we study non-compliance with minimum wages in 10 Central and Eastern European countries which joined the European Union since 2004, and have statutory national minimum wages. Enforcement and compliance are key elements for any minimum wage policy to be able to achieve its goals. However, they're rarely analysed. We think that data challenges are a part of the answer why. None of the EU-wide surveys provides monthly wages directly reported by workers that would allow analysing for all workers whether they are paid below the minima they're entitled to. To quantify the minimum wage violation in the

CEE10, we use the EU-SILC data and need to restrict our sample to full-time workers who had only one job and were employed full-time in every month of a calendar year previous to the survey. As a consequence, our results can be perceived as the lower-bound estimates of minimum wage violation incidence. Better data is needed to understand channels of violation of minimum wage policies and design evidence-based policies to improve compliance.

Using the methodology proposed by Bhorat et al. (2013), we analyse the incidence of violation and its monetary depth. We find that on the average in 2003-2012, the estimated monthly minimum wage violation incidence ranged from 1.0% in Bulgaria and 1.3% Czech Republic, to approx. 3% in Romania and Slovenia, to 4.7% in Poland and Hungary, to 5.6% in Latvia and 6.9% in Lithuania. These are values much lower than those found in developing countries, but similar to those estimated for the US, the EU countries or China. Violation only in hourly wage terms, i.e. that affecting workers at least earning monthly minimum wage but below its hourly equivalent due to extra unpaid hours, was especially noticeable in Poland, Latvia and Hungary. In all countries non-compliance was not only an issue of violation current minimum wage, but a more systematic underpayment - a majority of workers affected by non-compliance was earning also below the minimum wage valid a year before. This translated into noticeable depth of violation. The average monetary shortfall ranged from 13.7% of the country-year specific minimum wage in Estonia, to 41.7% in Slovenia. In all CEE10 countries violated workers earned not only less then the current minimum wage, but also less then the minimum wage before the most recent hike. Using probit regression we find that women, low-educated individuals, workers in services or agriculture, in micro firms and with temporary contracts were more likely to be affected by non-compliance in all CEE countries.

We also run a series of country-level panel regressions to understand relationship between violation patterns, the Kaitz index, output (GNI) per capita and institutional variables. We find that higher minimum to average wage ratios were associated with higher non-compliance. This effect was present within countries over time, not between them. On the other hand, higher GNI level was related to lower violation incidence, also within countries. On the other hand, the average shortfall per violated worker was not related to Kaitz index nor GNI in the CEE. Thus, the fact that the average depth of violation per worker was positively related to the Kaitz index and negatively to GNI per capita, resulted from higher incidence of violation related to higher Kaitz, or lower GNI. These findings are found to be robust to alternative wage thresholds and panel regression specifications. Also, bit surprisingly, we found a positive relation between incidence of non-compliance and trade union density as well as bargaining coverage in the CEE10.

Our findings show that workers who are supposed to be benefitting from minimum wage policies are most likely to be affected by non-compliance, and that higher minimum wages (relative to average wage) are related to higher incidence of non-compliance in the CEE10. Policy makers considering minimum wage hikes should take this property into account. Large hikes may increase non-compliance and workers likely to be affected are those with the lowest bargaining power. It is thus crucial to find a right balance between minimum wage increases, employers willingness / ability to pay the low-earners more, and enforcement costs. A minimum wage increase that would lead to rise in non-compliance and require a substantial enforcement effort is not meaningful. Nevertheless, enforcement can be enhanced with simplification of reporting of minimum wage violation, for instance via anonymous and simple telephone hotline that proved efficient in other countries (Gindling et al., 2014). Penalties and due wage top-ups can be levied without the labour court case, but perhaps for repeated infringements, especially with the simplified reporting. It is also possible that some firms and workers are actually not aware of currently binding minimum wage, so the policy, in particular hikes but also fines, should be broadly communicated, also involving social partners.

6 Appendix

Table 6: EU-SILC data availability by country

Available years	Countries
2003 - 2012	Estonia
2004 - 2012	Czech Republic, Hungary, Lithuania, Poland, Slovakia, Slovenia
2006 - 2012	Bulgaria, Latvia, Romania

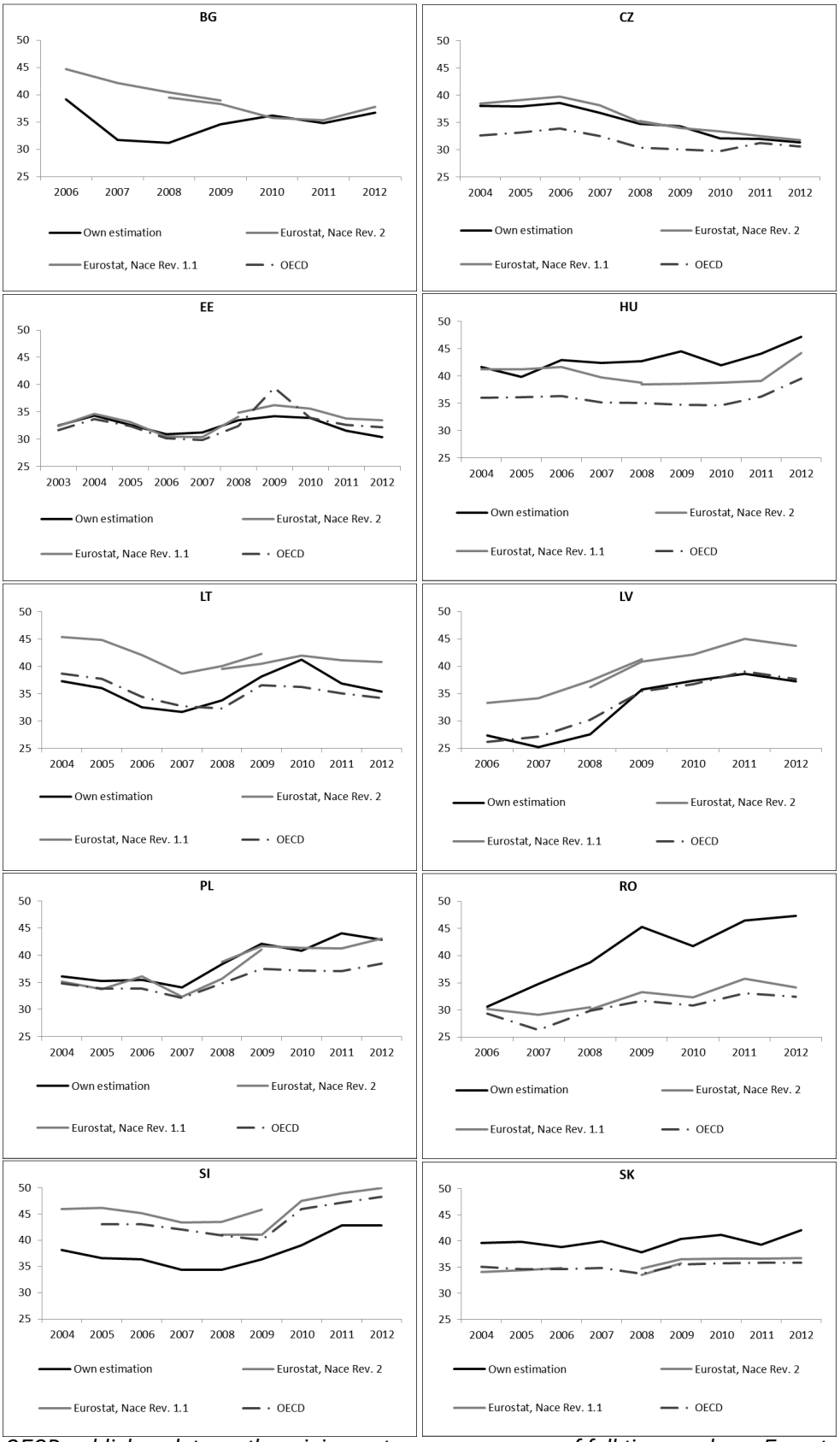
Note: The available years relate to the years for which income is reported. While most variables in the EU-SILC reflect the current situation of the surveyed individuals, the information on income relates to the previous calendar year. Thus, the EU-SILC data from 2004-2013 provide information on incomes from 2003-2012.
Source: Own elaboration based on OECD (2015), wageindicator.org and country-specific sources.

Table 7: Number of observations per country (total, and after applying consecutive restrictions)

	Total	Employees	Information on wages	Working full-time	Only one work place	Working 12m last year	Age above 25
Bulgaria	87,413	67,671	39,513	37,852	37,150	28,628	26,010
Czech Rep.	154,793	128,079	71,879	64,409	62,844	54,466	48,843
Estonia	112,529	88,816	56,950	50,858	48,960	38,674	34,466
Hungary	179,963	142,950	80,752	75,070	73,397	56,906	50,970
Latvia	101,279	85,281	42,045	38,598	37,145	27,464	24,192
Lithuania	97,091	79,468	44,276	38,469	36,080	29,298	26,835
Poland	296,766	192,064	105,918	93,028	85,913	69,161	60,490
Romania	113,704	68,672	36,130	35,635	33,938	32,651	29,460
Slovakia	120,434	93,565	59,425	47,366	46,777	39,845	34,495
Slovenia	223,265	145,669	104,656	100,026	97,566	83,237	75,927

Source: Own elaboration on the EU-SILC data.

Figure 13: Comparison of own estimates of the Kaitz indices with the OECD and Eurostat estimates.



Note: The OECD publishes data on the minimum to average wages of full-time workers. Eurostat provides information on the monthly minimum wage as a proportion of the average monthly earnings for industry, construction, and services (NACE Rev. 2, from 2008 onwards); and for industry and services (NACE Rev. 1.1, 1999-2009).

Source: Own calculations on the EU-SILC data, OECD Statistics, Eurostat.

Table 8: Correlations between the minimum wage violation measures calculated for the 75% of the minimum wage and 125% of the minimum wage thresholds, with benchmark measures calculated for the 100% of the minimum wage threshold (in %).

	Monthly wage violations			Hourly wage violations		
	V_0^m	V_1^m	V_1^m/V_0^m	V_0^h	V_1^h	V_1^h/V_0^h
75% threshold	76	95	90	79	92	90
125% threshold	92	84	78	93	88	81

Note: V_0 *- incidence of violations,* V_1 *- depth of violations,* V_1/V_0 *- average shortfall per violated worker.*
Source: Own calculations on the EU-SILC data.

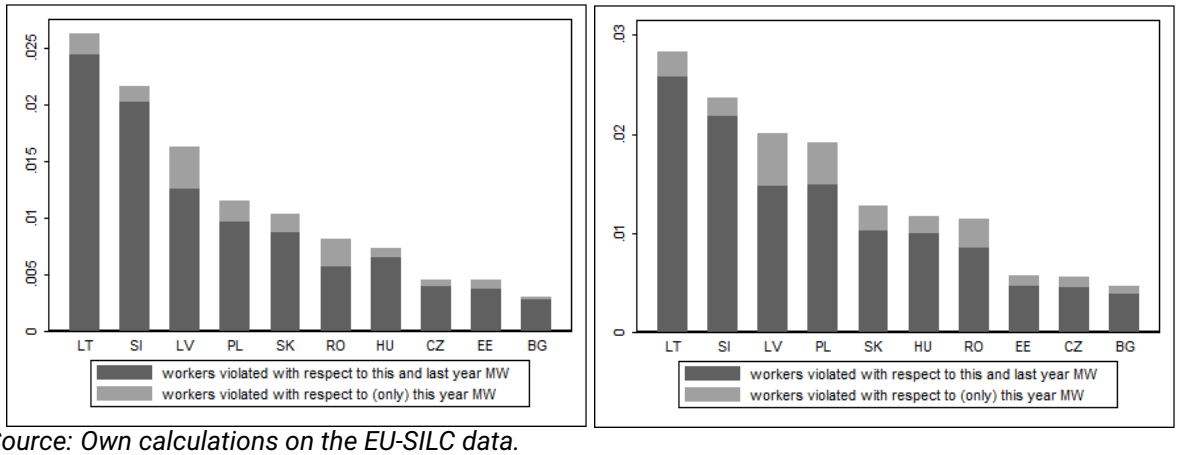
Table 9: Monthly minimum wage violation measures among permanent and temporary workers in the CEE10 (2003-2012 averages)

Country	Workers	Incidence of violations (V_0^m)	Depth of violations (V_1^m)
Bulgaria	total	2%	23%
	permanent	2%	23%
	temporary	6%	22%
Czech Rep.	total	2%	23%
	permanent	2%	23%
	temporary	4%	20%
Estonia	total	3%	14%
	permanent	3%	14%
	temporary	10%	28%
Hungary	total	6%	16%
	permanent	5%	16%
	temporary	15%	17%
Latvia	total	7%	22%
	permanent	6%	22%
	temporary	17%	39%
Lithuania	total	8%	24%
	permanent	7%	23%
	temporary	13%	32%
Poland	total	7%	19%
	permanent	6%	19%
	temporary	15%	19%
Romania	total	5%	19%
	permanent	5%	19%
	temporary	12%	24%
Slovakia	total	3%	29%
	permanent	3%	30%
	temporary	5%	25%
Slovenia	total	4%	36%
	permanent	4%	37%
	temporary	7%	34%

Source: Own calculations on the EU-SILC data.

Figure 14: Decomposition of the average (over 2004-2012) incidence of violations into violations of both the current and the previous year's minimum wage, and the current minimum wage only. 75% of the minimum wage threshold.

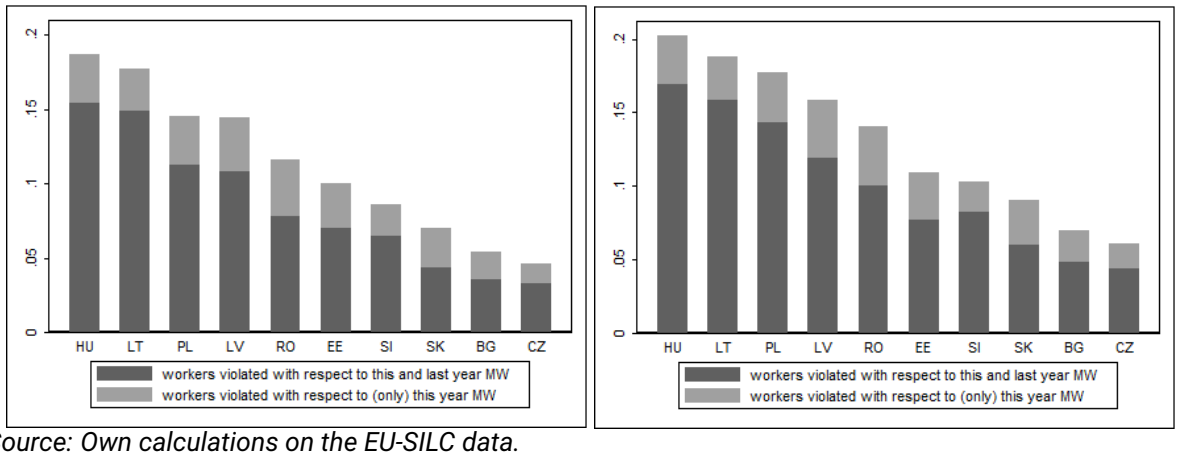
Monthly violations (V_0^m) Hourly violations (V_0^h)



Source: Own calculations on the EU-SILC data.

Figure 15: Decomposition of the average (over 2004-2012) incidence of violations into violations of both the current and the previous year's minimum wage, and of the current minimum wage only. 125% of the minimum wage threshold.

Monthly violations (V_0^m) Hourly violations (V_0^h)



Source: Own calculations on the EU-SILC data.

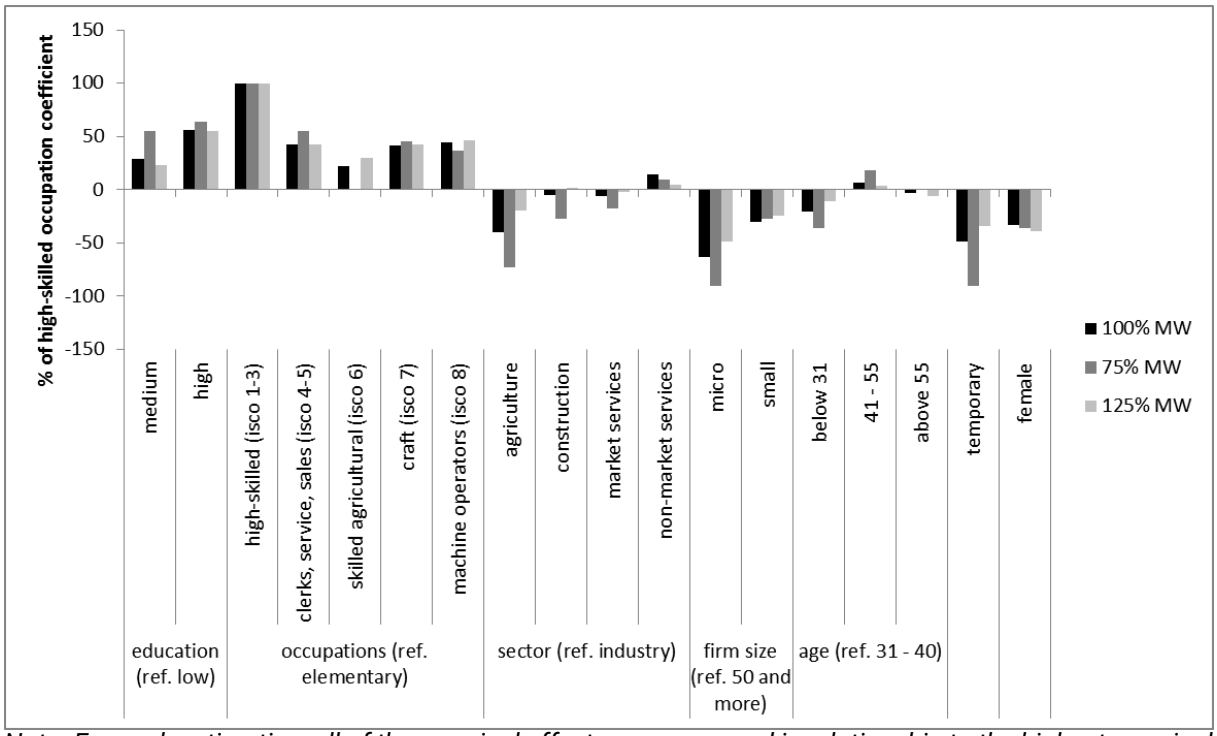
Table 10: Marginal effects from probit regression on non-compliance dummy

			BG	CZ	EE	HU	LT	LV	PL	RO	SI	SK
			Results from the regression on the pooled sample (country dummies coefficients)									
Results from the regression on the pooled sample			-0.052	-0.048	-0.030	-0.013	-0.002	-0.004	ref	-0.008	-0.016	-0.035
			Results from separate regressions by country									
education	medium	-0.018	-0.009	-0.009	n.s.	-0.024	n.s.	-0.021	-0.027	-0.034	-0.016	-0.012
(ref. low)	high	-0.035	-0.010	-0.020	-0.011	-0.052	-0.04	-0.057	-0.066	-0.065	-0.027	-0.015
occupations	high-skilled (isco 1-3)	-0.063	-0.023	-0.03	-0.067	-0.077	-0.078	-0.078	-0.087	-0.095	-0.026	-0.044
(ref. elementary)	clerks, service, sales (isco 4-5)	-0.027	-0.009	-0.018	-0.029	-0.035	-0.05	-0.039	-0.028	-0.024	-0.019	-0.019
	skilled agricultural (isco 6)	-0.014	n.s.	n.s.	-0.04	n.s.	n.s.	n.s.	-0.025	-0.022	n.s.	-0.043
	craft (isco 7)	-0.026	-0.013	-0.015	-0.039	-0.030	-0.033	-0.046	-0.03	-0.043	n.s.	-0.014
	machine operators (isco 8)	-0.028	-0.015	-0.017	-0.040	-0.025	-0.043	-0.044	-0.044	-0.030	n.s.	-0.014
sector	agriculture	0.025	0.010	n.s.	0.026	0.021	0.032	0.028	0.030	0.038	n.s.	0.019
(ref. industry)	construction	0.003	-0.020	n.s.	-0.008	0.021	n.s.	-0.030	0.011	n.s.	0.013	0.007
	market services	0.004	n.s.	0.004	n.s.	0.008	n.s.	n.s.	0.014	-0.009	n.s.	0.006
	non-market services	-0.009	-0.006	-0.006	0.006	-0.020	-0.009	-0.017	-0.030	0.009	0.007	n.s.
firm size	micro	0.04	0.011	0.018	0.035	0.051	0.083	0.069	0.058	0.038	0.034	0.014
(ref. 50 and more)	small	0.019	n.s.	0.007	0.010	0.025	0.040	0.032	0.040	0.010	0.008	n.s.
age	below 31	0.013	n.s.	n.s.	n.s.	0.015	0.018	n.s.	0.013	0.025	0.035	0.008
(ref. 31 - 40)	41 - 55	-0.004	n.s.	0.003	0.005	n.s.	-0.015	n.s.	-0.016	-0.008	-0.017	n.s.
	above 55	0.002	0.008	0.009	0.018	n.s.	-0.015	-0.011	-0.013	-0.014	n.s.	0.011
	temporary	0.031	0.021	0.010	0.031	0.047	0.030	0.065	0.046	0.022	0.009	0.013
	female	0.021	n.s.	0.016	0.021	0.012	0.035	0.022	0.021	0.027	0.032	0.020

Note: All coefficients significant at 10% level.

Source: own estimations on the EU-SILC data.

Figure 16: Comparison of marginal effects from probit regression on the non-compliance dummy calculated with 100% of the minimum wage threshold (benchmark estimation), 75% and 125% of the minimum wage threshold (sensitivity analysis estimation).



Note: For each estimation, all of the marginal effects are expressed in relationship to the highest marginal effect in a particular estimation, which was found for high-skilled occupations in every estimation.
Source: Own calculations on the EU-SILC data.

Table 11: Relationship between the incidence of minimum wage violations, (V_0), the Kaitz index, and the GNI: panel regression. Alternative specifications

variables	(1) monthly violation (V_0^m) between-effects	(2) monthly violation (V_0^m) fixed-effects	(3) hourly violation (V_0^h) between-effects	(4) hourly violation (V_0^h) fixed-effects
		75% of minimum wage threshold		
GNI pc (PPP)	0.0006	-0.0003	0.0005	-0.0007**
	(0.0007)	(0.0003)	(0.0008)	(0.0003)
Kaitz index	-0.0066	0.1114***	0.0274	0.1331***
	(0.1060)	(0.0362)	(0.1140)	(0.0359)
Constant	0.0009	-0.0134	-0.0030	-0.0091
	(0.0328)	(0.0105)	(0.0353)	(0.0105)
Observations	85	85	85	85
R-squared	0.103	0.115	0.064	0.174
No. of countries	10	10	10	10
		125% of minimum wage threshold		
GNI pc (PPP)	-0.0032	-0.0031***	-0.0035	-0.0047***
	(0.0045)	(0.0007)	(0.0043)	(0.0007)
Kaitz index	0.3440	0.7064***	0.4252	0.7497***
	(0.3974)	(0.0465)	(0.3862)	(0.0454)
Constant	0.0144	-0.1543***	-0.0005	-0.1275***
	(0.2051)	(0.0226)	(0.1993)	(0.0221)
Observations	85	85	85	85
R-squared	0.154	0.760	0.211	0.793
No. of countries	10	10	10	10
		Romania excluded		
GNI pc (PPP)	0.0006	-0.0002	0.0004	-0.0006*
	(0.0008)	(0.0003)	(0.0009)	(0.0003)
Kaitz index	-0.0048	0.1553***	0.0372	0.1675***
	(0.1242)	(0.0415)	(0.1331)	(0.0417)
Constant	0.0007	-0.0263**	-0.0041	-0.0190
	(0.0359)	(0.0123)	(0.0385)	(0.0124)
Observations	78	78	78	78
R-squared	0.085	0.173	0.055	0.210
No. of countries	9	9	9	9

Standard errors in parentheses: *** p<0.01, ** p<0.05, * p<0.1

Source: Own estimations on EU-SILC, Eurostat and World Bank data.

Table 12: Relationship between the average depth of minimum wage violations, (V_1), Kaitz index, and the GNI: panel regression. Alternative specifications

variables	(1) monthly violation (V_1^m) between-effects	(2) monthly violation (V_1^m) fixed-effects	(3) hourly violation (V_1^h) between-effects	(4) hourly violation (V_1^h) fixed-effects
		75% of minimum wage threshold		
GNI pc (PPP)	0.0003	-0.0001	0.0003	-0.0002
	(0.0003)	(0.0001)	(0.0003)	(0.0001)
Kaitz index	0.0005	0.0455***	0.0051	0.0481***
	(0.0429)	(0.0146)	(0.0439)	(0.0146)
Constant	-0.0025	-0.0059	-0.0030	-0.0046
	(0.0133)	(0.0043)	(0.0136)	(0.0042)
Observations	85	85	85	85
R-squared	0.172	0.117	0.154	0.135
No. of countries	10	10	10	10
		125% of minimum wage threshold		
GNI pc (PPP)	-0.0002	-0.0007***	-0.0003	-0.0011***
	(0.0010)	(0.0003)	(0.0010)	(0.0003)
Kaitz index	0.0354	0.1437***	0.0614	0.1611***
	(0.0859)	(0.0172)	(0.0900)	(0.0172)
Constant	0.0076	-0.0318***	0.0032	-0.0273***
	(0.0443)	(0.0083)	(0.0464)	(0.0084)
Observations	85	85	85	85
R-squared	0.027	0.491	0.075	0.557
No. of countries	10	10	10	10
		Romania excluded		
GNI pc (PPP)	0.0003	-0.0001	0.0003	-0.0002
	(0.0003)	(0.0001)	(0.0003)	(0.0001)
Kaitz index	0.0034	0.0668***	0.0094	0.0686***
	(0.0501)	(0.0166)	(0.0512)	(0.0166)
Constant	-0.0029	-0.0121**	-0.0035	-0.0105**
	(0.0145)	(0.0049)	(0.0148)	(0.0049)
Observations	78	78	78	78
R-squared	0.139	0.195	0.123	0.207
No. of countries	9	9	9	9

Standard errors in parentheses: *** p<0.01, ** p<0.05, * p<0.1

Source: Own estimations on EU-SILC, Eurostat and World Bank data.

Table 13: Relationship between the average shortfall, (V_1/V_0), the Kaitz index, and the GNI: panel regression. Alternative specifications

variables	(1) monthly violation (V_1^m/V_0^m) between-effects	(2) monthly violation (V_1^m/V_0^m) fixed-effects	(3) hourly violation (V_1^h/V_0^h) between-effects	(4) hourly violation (V_1^h/V_0^h) fixed-effects
		75% of minimum wage threshold		
GNI pc (PPP)	0.0049	-0.0004	0.0072	0.0015
	(0.0055)	(0.0034)	(0.0053)	(0.0033)
Kaitz index	0.5537	0.0424	-0.0009	-0.1160
	(0.8185)	(0.3774)	(0.7837)	(0.3674)
Constant	0.1137	0.3565***	0.1874	0.3306***
	(0.2534)	(0.1099)	(0.2427)	(0.1070)
Observations	85	85	85	85
R-squared	0.150	0.000	0.212	0.003
No. of countries	10	10	10	10
		125% of minimum wage threshold		
GNI pc (PPP)	0.0059*	-0.0018	0.0040	-0.0022**
	(0.0026)	(0.0013)	(0.0026)	(0.0010)
Kaitz index	0.0128	0.0090	0.0383	0.0470
	(0.2343)	(0.0869)	(0.2312)	(0.0688)
Constant	0.0675	0.2171***	0.0989	0.2141***
	(0.1209)	(0.0422)	(0.1193)	(0.0334)
Observations	85	85	85	85
R-squared	0.414	0.026	0.255	0.057
No. of countries	10	10	10	10
		Romania excluded		
GNI pc (PPP)	0.0033	-0.0002	0.0061	0.0019
	(0.0063)	(0.0028)	(0.0061)	(0.0027)
Kaitz index	0.7795	0.4849	0.1629	0.4548
	(0.9289)	(0.3523)	(0.9018)	(0.3450)
Constant	0.0871	0.2357**	0.1681	0.1689
	(0.2685)	(0.1045)	(0.2607)	(0.1023)
Observations	78	78	78	78
R-squared	0.158	0.028	0.154	0.037
No. of countries	9	9	9	9

Standard errors in parentheses: *** p<0.01, ** p<0.05, * p<0.1

Source: Own estimations on EU-SILC, Eurostat and World Bank data.

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