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Industrial relations and social dialogue

Annex 1: Methodological discussion paper – Approaches to estimating the magnitude of compliance with minimum wages

Annex to Part 1

Minimum wages: Non-compliance and enforcement across EU Member States – Comparative report

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Abstract

Wage levels and their distributions vary substantially across European countries. Similarly, also the minimum wage legislation is highly heterogeneous, with statutory minima and implementation mechanisms that differ depending on the characteristics of the system of industrial relations, the political environment and the performance of the domestic economy.

The paper's aim is to focus on rates of non-compliance with minimum wages (statutory or collectively agreed) for all EU Member States (EU27), tackling the limited number of studies providing comparative evidence on wage floors in the EU. The document also reports a review of the scientific literature on non-compliance with minimum wages and a review of the harmonised EU datasets that are currently available to carry out the quantification of non-compliance.

To quantify non-compliance with statutory or negotiated minimum wages, two harmonised datasets on earnings are used: namely European Union Statistics on Income and Living Conditions (EU-SILC) and the Structure of Earnings Survey (SES). Results for 2018 show that non-compliance in the EU27 ranges between 0.01% in Belgium using SES and 14.5% in Italy using EU-SILC. The cross-country average is around 5.7% in EU-SILC and 1.3% in SES (the population−weighted EU average being 8.1% and 1.4%, respectively). The estimates obtained using SES are generally lower because employers are highly unlikely to willingly report wages that do not comply with legal minima, but they are not negligible. Underpaid employment seems to be mostly concentrated among young workers and those with fixed-term and part-time contracts. It is also concentrated in smaller firms. The services sector seems to be more affected by non-compliance than the manufacturing sector. Finally, no clear trend in terms of non-compliance emerges over time, when the analysis is restricted to the period between 2014 and 2018.

Executive summary

Background and objectives

- Non-compliance with minimum wage legislation is an important phenomenon to study from a policy perspective. It can inform policymakers about the quality of the enforcement and monitoring system, and more generally about the efficacy of the minimum wage policy in reducing in-work poverty. It can also help to harmonise and integrate different economies within an EU-wide perspective to ensure that business in some countries are not unfairly advantaged by excessively lower costs.
- This paper aims to quantify non-compliance among EU Member States, illustrating the main challenges related to its measurement and following the best practices currently available. It also aims to illustrate potential shortcomings of the current sources of information and to discuss potential improvements in the EU's data framework that would improve our understanding of the phenomenon.

Main challenges

- Measuring non-compliance requires the use of precise information on income, which is often difficult to obtain. Currently available harmonised datasets at EU level differ regarding the availability of information on income, the sample size and its coverage.
- A second challenge concerns information on minimum wage levels across Member States. This information is currently available in countries with a government-legislated nationwide minimum wage; however, in countries where pay floors are set through sector-wide collective bargaining, information on their level is seldom available and is difficult to obtain.
- Given these challenges, estimates of non-compliance across EU countries should be interpreted as approximations, rather than very precise numbers.

Methodological approach

- A comprehensive literature review on the main approaches that have been adopted in quantifying non-compliance with minimum wage legislation is provided.
- Two main sources of information on earnings are used to quantify non-compliance. The two main databases on which our analysis is based are those of the Structure of Earnings Survey (SES) and European Union Statistics on Income and Living Conditions (EU-SILC). Each of these databases has advantages and limitations, which are thoroughly discussed in the paper.
- Information on nationwide minimum wage levels is derived from Eurostat. Subminimum wage levels implemented for selected group of workers were also considered, when possible. Pay floors set by collective bargaining are derived from information provided by Eurofound and from national statistical agencies, when available.
- In quantifying non-compliance, a conservative approach has been adopted, with the aim of providing a lower-bound estimate derived from the available EU-level data. This approach is

adopted to ensure that measurement error in any of the relevant variables does not affect our quantification exercise.

- Following our conservative approach, the sample is restricted to employees, excluding other groups potentially affected by non-compliance such as the self-employed. Workers were considered to be paid less than the minimum wage only if their reported pay level was below 95% of the wage floor. In countries without a statutory minimum wage, but where wage setting is characterised by collective bargaining, only minimum pay floors set by this means within sectors or nationwide have been considered, thus potentially underestimating non-compliance with respect to wage floors set higher up in the wage distribution.
- A rich set of sensitivity tests on each estimate of non-compliance has been provided, considering the influence on the results of adopting alternative income definitions, minimum wage definitions that consider subminimum levels whenever possible and sample selection choices. We have also provided a rich set of descriptive statistics to characterise workers paid below the minimum wage.

Key findings

- The estimated level of non-compliance with the minimum wage legislation depends crucially on the source of data that is considered. When using SES, which generally covers only larger firms and uses income information reported by employers, non-compliance levels tend to be generally quite low. When using EU-SILC, which covers the entire working-age population, and where income information is self-reported, non-compliance levels tend to be higher.
- Non-compliance estimates using EU-SILC are positively correlated with estimates obtained from SES. Non-compliance is also positively correlated with the Kaitz index, suggesting that it is higher when the minimum wage is set higher with respect to a country's wage distribution. According to the main EU-SILC estimates, the cross-country (unweighted) average non-compliance rate has grown slightly from 5.1% to 5.7% between 2014 and 2018. Countries where non-compliance was higher than the median level according to both EU-SILC and SES data are Cyprus, Denmark, Estonia, France, Germany, Hungary and Spain. Countries with non-compliance levels consistently lower than the median were Belgium, Bulgaria, Croatia, Finland, Latvia, Malta, Romania and Slovakia.
- Workers paid less than the minimum wage are generally younger, less educated, more likely to be female, on a fixed-term or part-time contract and employed by smaller firms. Regarding the sectoral composition of non-compliance, the services sectors are generally more affected by this phenomenon than the manufacturing sector.
- Non-compliance is much more common among employees working shorter working hours, which could reflect a low attachment to the labour market. Non-compliance is also higher when estimated using hourly instead of monthly wages, which mean that employers may comply with monthly minimum wages, but make employees work more hours than stated in their contract, so that they do not comply with hourly minimum wages, as reflected by the data.

Policy pointers

- Quantifying non-compliance is a challenging task, which crucially depends on the quality and characteristics of the data used. In order to improve our knowledge on this phenomenon, more harmonised, comprehensive and precise data sources on income at EU level should be made available.
- Data collection efforts should be made in order to obtain better information on minimum wage levels in contexts characterised by collective bargaining, where pay floors are typically set at industry-wide level by trade unions and employers' associations.

Introduction

Minimum wage-setting mechanisms represent a powerful labour market tool, they are binding, and their implementation is widespread across European countries: in 2021, 21 of the 27 Member States of the European Union had statutory minimum wages established at national level, and the others had minimum wages negotiated at sectoral level (Austria, Cyprus,[1] Denmark, Finland, Italy and Sweden).

Minimum wages establish the legal right of workers to receive a minimum amount of remuneration for work performed during a given period, giving workers 'the right to recover amounts by which they may have been underpaid' (ILO, 1970), thus protecting workers against unduly low pay. However, a difference between de jure and de facto regulation often exists in both advanced and developing countries. The effective functioning of the minimum wage institution crucially relies on its enforcement and compliance with its rates. Enhancing compliance with minimum wages is also a matter of social policy, since non-compliance disadvantages underpaid workers as well as compliant firms. Indeed, in many countries non-compliance may be the response of certain businesses to increases in the minimum wage level. Hence, instead of firing workers, they may get a cost advantage by paying lower minimum wages, undermining competition through the exploitation of different channels (Garnero, 2018).

The aim of this report is to provide a comprehensive quantification of non-compliance with minimum wage regulations, using the best available cross-country databases on EU Member States. The report not only focuses on the proportion of workers below the minimum wage but also provides a picture of the relative size of low-paid employment. This additional evidence improves the overall reliability of the results, given that an exact definition of non-compliance is subject to a sizeable uncertainty due to potential misreporting and measurement error.

Quantifying the size of the workforce that is currently paid below the minimum wage is not an easy task. Each estimate crucially depends on the quality of the available data, on the coverage of the sample and on the estimation approach that is adopted. Estimates of non-compliance are to be taken as approximations, not precise numbers. As has been documented in this paper, estimates of the extent of non-compliance can differ according to the data used, even when the same country is considered. Despite these difficulties, some tendencies emerge from the analysis. Underpaid employment seems to be mostly concentrated among young workers and those on a fixed-term contract or with a part-time job. It is also concentrated in smaller firms. The services sector seems to be more affected by non-compliance than the manufacturing sector.

The paper is structured as follows. First, it aims to review the available scientific literature that quantifies non-compliance with statutory and collective agreed minimum wages. Second, it reviews the available harmonised datasets for EU Member States, pointing out advantages and disadvantages of each. Last, and most importantly, it provides a quantitative analysis of the extent of

[1] In January 2023, Cyprus introduced a statutory minimum wage. However, it does not apply to the results included in this report. Cyprus is something of a hybrid case, since it had an occupation-specific statutory minimum wage underlying the collectively agreed levels.

non-compliance with minimum wages across the EU27 with available cross-country harmonised datasets, highlighting existing gaps in knowledge and limitations.

Literature review on non-compliance with minimum wages

Background

This section of the paper presents a systematic literature review of the evidence that provides a quantification of non-compliance with minimum wages. Compliance with minimum wages and, more generally, the issue of enforcement of minimum wages are still rarely analysed. Only a few studies focus on single European countries, and even less cross-country analysis about Europe is available (as extensively reviewed hereafter). Moreover, existing evidence primarily focuses on minimum wages set at national level and only very few papers look at minimum wage levels set in collective agreements, which in several European countries are the most important wage-setting institution, as outlined in the main report.

The first attempts to quantify non-compliance with minimum wages date back to the 1970s. Ashenfelter and Smith (1979) first investigated the issue of minimum wage compliance in the United States, remarking that, 'in the midst of numerous studies intended to establish the quantitative effects of the minimum wage law, it is remarkable that no one has bothered to establish that this law actually affects wage rates […] presumably reflecting the belief that employers fully comply with this law'. They found very high levels of compliance in the USA in the 1970s and pointed out the importance of research on minimum wages to comprehensively examine the issue of non-compliance.

While most of the policy debate and the economic literature on minimum wages focus on their employment effects, it should be kept in mind that enforcement of and compliance with minimum wages are crucial for their effective functioning and that non-compliance may have negative consequences not only for workers but also for compliant employers, as it gives non-compliant firms an illegitimate cost advantage and may promote unfair competition. Given the multidimensional nature of non-compliance, several channels of underpayment are available to firms to achieve such a cost advantage (Garnero, 2018). On the one hand, firms might replace some regularly paid employees with underpaid employees (not covered by minimum standards) or increase overtime hours without proper remuneration, or even assign workers to a lower occupational level than the correct one. On the other hand, in complex settings, where several collective agreements (and minimum wage rates) are available, firms might save on labour costs by selecting the most convenient collective agreement. Indeed, Rani et al (2013) did find evidence that in developing countries the rate of compliance is negatively related to the number of applicable minimum wages. Moreover, in countries where wages are set by industry-wide agreements and there are no clear and certified rules governing who is entitled to bargain, firms can opt out from the national collective bargaining system and sign their own contracts (i.e. 'pirate' agreements), setting minimum wages below the existing ones (Lucifora and Vigani, 2021). In this context, enhancing compliance with the statutory minimum is not just a legal necessity but also important for social policy.

Thus, to sum up, the existing evidence seems to suggest that firms can use various channels to pay wages below the minimum.

- They can reduce the number of formal employees and increase the number of informal ones.

- They can increase the number of non-standard employees who are not, or poorly, covered by the minimum wage legislation (at either national or sectoral level). This may create bogus self-employed workers, casual or project workers, or posted workers.
- They can hire regular and fully formal employees paid at the minimum wage but ask them to work unpaid extra hours (known as off-the-clock work).
- They can assign workers to a lower level to underpay them.
- They can referring to the wrong agreement and 'inadvertently' pay less than the reference minimum wage, or apply the most convenient collective agreement.
- In those systems where wage floors are set at sectoral level by social partners and where there are no (or limited) rules to establish the representativeness of social partners that can sign legally binding agreements, employers can even set their own wage floors below the existing ones by signing a pirate agreement.
- Non-compliance is likely to be more pronounced where wage floors are more binding.

Estimates of non-compliance rates

A recent extensive study by the ILO (2021) finds that 266 million wage earners are paid less than the minimum wage, either because they are not legally covered or because of non-compliance.[2] Although the effectiveness of minimum wages crucially depends on enforcement and compliance, empirical evidence is still scarce and mainly focused on developing countries (Ronconi, 2010; Kanbur et al, 2013; Rani et al, 2013; Ye et al, 2015; Bhorat et al, 2019; Mansoor and O'Neill, 2020). Most of the countries analysed have non-compliance rates above 20%, but estimates vary widely from country to country, with figures as high as 80% for Mali (Bhorat et al, 2015) and lower than 5% for Argentina (Ronconi, 2010).

Evidence for high-income countries finds rates of non-compliance that are typically lower. Figures from Ireland, based on a direct question from the Irish Labour Force Survey (LFS), reveal that the proportion of workers paid below the minimum wage ranged between 1.2% and 1.4% of total employment in 2016–2018 and that 5.6% of workers below the minimum wage are being paid subminimum rates for reasons other than those permitted under legislation (McGuinness et al, 2020). Interestingly, the use of this direct question allows the authors to distinguish workers paid below the minimum wage because they are legally exempt from those who are entitled to the minimum wage but do not receive it. This leads to a sort of self-assessed measure of non-compliance.

The German Mindestlohn Kommission reports that in 2015 2.7% of German workers were paid less than the newly introduced statutory minimum wage (Mindestlohn Kommission, 2022). A recent study on the effects of the minimum wage suggests that compliance (either calculated using survey data or obtained from monitoring and enforcement activities) seems to be a major issue (Bruttel, 2019). The causal short-term distributional effects of the reform introduced in Germany in 2015, which set the new minimum wage at €8.50 per hour (exceeding the hourly wages of more than 10% of all eligible employees in 2014), have also been assessed in a study by Caliendo et al (2017). Using

[2] The ILO report also shows that non-compliance is very much linked to the much broader issue of informality, which however cannot be measured with the data used in this report.

panel data from the German Socio-Economic Panel for 2012–2015, and a difference-in-differences approach, the authors find a sizeable positive effect on the bottom quintile of the region-specific hourly wage distributions but did not find an improvement in monthly earnings for low-paid employees, as most of them also experienced an equivalent reduction in working hours. In this respect, the reform has proven more effective at increasing contractual hourly wages than actual wages, suggesting an increase in unpaid overtime.[3] Moreover, in the first months of 2015 around 7% of eligible employees were still paid below the new wage floor, suggesting moderately high rates of non-compliance in the short run.

The United Kingdom (UK) Low Pay Commission, using the Annual Survey of Hours and Earnings and the LFS, provides annual estimates of non-compliance with minimum wages, showing that the trend in recent years has been upward. The most recent estimates, from 2021, show that around 1% of jobs are paid below the relevant minimum wage. They also show that rates of underpayment vary between sectors. Most underpaid workers are concentrated in the largest low-paying occupations: retail, hospitality, and cleaning and maintenance. But the relative rates of underpayment measured in some other occupations – childcare in particular – are substantially higher and have been rising in recent years.

Evidence from a case study on small firms in UK low-paying sectors and businesses owned by new migrant communities (Ram et al, 2017) reveals that several firms, both new and long established, do not comply with the statutory minimum wage, namely the National Living Wage, and that the boundary between compliance and non-compliance is fluid, with firms complying in respect of some workers and not others. Intense competition, a structure of employment where the category of 'helpers' (workers doing specific tasks for a limited time) is widely used, a low perceived risk of being penalised and workers' acceptance of the situation appear to be the main drivers of non-compliance with the National Living Wage.

Cross-country evidence is still rare. Garnero et al (2015) focus on 17 EU countries in 2007–2009 and uncover significant heterogeneity in non-compliance rates across countries (from 13% in Italy to less than 1% in Bulgaria), with an average around 3.5%. Goraus-Tańska and Lewandowski (2019), using EU-SILC for 10 central and eastern European countries with a statutory national minimum wage, show that over 2003–2012 the share of underpaid workers was similar to that estimated for the United States or China and was highest in Lithuania (6.9%), Latvia (5.6%) and Hungary (4.7%), while it was much lower in Bulgaria (1.0%) and Czechia (1.3%).[4] The results also show that non-compliance is not limited to a violation of current minimum wages but reflects systematic underpayment – the majority of workers were also paid below the minimum wage a year before – with a significant depth

[3] Others show increases of monthly wages as well (Mindestlohn Kommission, 2022).

[4] These results have some similarities to, but also some differences from, the estimates provided in this report. In particular, Hungary and Lithuania have consistently higher non-compliance than Bulgaria and Czechia according to the estimates in this report when using the 2018 EU-SILC edition, but non-compliance in Latvia is lower. Moreover, non-compliance levels reported by Goraus-Tańska and Lewandowski (2019) are generally lower than those presented in this report. As explained in Box 2 below, the approach of Goraus-Tańska and Lewandowski (2019) is extremely conservative and leads to a quite large loss of observations, which could explain such differences in the results with respect to the report. A further potential source of differences in the results is the coverage of the data, which refer to 2003–2012 in the case of Goraus-Tańska and Lewandowski (2019).

of violation: the average monetary shortfall ranges from 13.7% of the country- and year-specific minimum wage in Estonia to 41.7% in Slovenia.

Recent empirical evidence on the effects of increases in minimum wages on the magnitude and determinants of non-compliance is also available for the United States. Clemens and Strain (2020), using data from the Current Population Survey for 2011–2013 and 2016–2017, matched with external data sources on minimum wages, find strong evidence that higher minimum wages increase the prevalence of workers paid below the state minimum wage, with increases in measured underpayment between 10% and 25% of realised wage gains following minimum wage hikes.

Sources of heterogeneity in non-compliance estimates

The existing literature shows that compliance is affected by the level at which minimum wages are set relative to average wages, as well as by institutional factors (Rani et al, 2013; Bhorat et al, 2015; Garnero et al, 2015; Goraus-Tańska and Lewandowski, 2019). Systems with bargained sectoral-level minima and complex legal provisions are associated with a higher bite of the minimum wage (the ratio of the minimum wage to the median wage, as shown by Kaitz indices) than systems with statutory floors. That higher bite could lead to a larger share of underpaid workers. Garnero (2018), using three alternative data sources on wages for Italy (the LFS, SES and administrative data from Italian social security) matched to a dataset on negotiated wages, investigates the degree of non-compliance with sectoral minimum wages set by collective agreements. Although all employees in Italy should earn at least the minimum fixed by sectoral agreements, the study shows that on average around 10% of workers are paid an average of 20% less than the sectoral minimum, and that non-compliance rates are higher in the South, in small firms, and among women and temporary workers. In addition, a recent study by Garnero and Lucifora (2020) investigates the relationship between non-compliance with minimum wages and employment in Italy and uncovers a trade-off between higher (lower) compliance with minimum wages and lower (higher) employment levels, even though it is small and only when the rate of non-compliance is low.

Recent literature addresses the growing concerns about the increase in unregulated and unpaid overtime. Part-time employment saw considerable growth across the EU after the Great Recession, possibly increasing the prevalence of fake part-timers, working shorter hours mainly de jure but not so much de facto. Firms may hire regular employees, pay them the minimum wage and ask them to work unpaid extra hours as well. These unrecorded unpaid overtime hours make the firm compliant with the minimum monthly rate, but not with the hourly rate (Garnero, 2018). The measurement of working hours is important for the effective enforcement of wage violations, since it presents a considerable margin of adjustment through which many violations might take place (Green, 2017).

The Organisation for Economic Co-operation and Development (OECD, 2021) reports a non-negligible incidence of unpaid overtime: around 5% of full-time workers in OECD countries in 2019, ranging from 0.02% in Latvia to 25.4% in the Netherlands. For the workers concerned, overtime amounted to 7.7 hours per week (compared with 8.3 hours observed on average for workers with paid overtime), ranging from 5.9 hours in Lithuania to 11.3 hours in Switzerland.

Overtime hours are often not accurately recorded (Green, 2017), and this leads to problems of severe data limitations inherent in any survey that is intended to be used to measure non-compliance rates. Paid overtime is more likely than unpaid overtime to be directly related to working time regulation, and is more measurable. In contrast, the measurement of unpaid overtime is likely

to be particularly unreliable. Green (2017) focused on the relationship between hours worked and hours paid, with a unique dataset containing information at individual level. It shows that unrecorded and unpaid overtime hours, off-the-clock work, in the United States are mainly done by low-skilled workers.

Low-paid workers are also more likely to work a second job, rather than working paid overtime, and these second jobs would not be counted as overtime. Green also shows that workers employed by small firms and in industries with a high rate of wage and hour violations are associated with larger differences between hours worked and paid. Off-the-clock work is mostly concentrated in small firms, and in industries that largely employ low-wage workers. These results are in line with other recent research, which uses survey and administrative data to document non-compliance with minimum wage and overtime regulations.

Bernhardt et al (2013) and Milkman et al (2012), both using the 2008 Unregulated Worker Survey (a representative survey of workers in Chicago, Los Angeles and New York City), find that job and employer characteristics are important drivers of the industry variation in non-compliance with minimum wages. In particular, Bernhardt et al (2013) find that job and employer characteristics play a greater role in industry differences in compliance than workers' characteristics do, of the order of 2.5 times as much as workforce composition. Milkman et al (2012) identify garment manufacturing, construction and private domestic service as key violation-prone industries, all of which account for a greater share of the low-wage workforce in Los Angeles than in New York City and Chicago. Ji and Weil (2015), using a unique dataset of franchisor- and franchisee-owned establishments matched to information on wage and hour administration investigations from the Wage and Hour Investigation Support and Reporting Database, find that, in the United States, franchised outlets are more likely to commit wage and hour violations. They underline the importance of understanding the way in which compliance incentives vary across types of business organisations.

In Table A1 in the appendix, we summarise the results of the literature review included in this chapter, reporting for each paper reviewed the title, data and observation period, geographical coverage, methodological approach and main findings.

Measurement issues and methodological aspects

While the rates of non-compliance in developing countries are so high as to make accurate measurement a refinement rather than an essential issue, the relatively low figures found among high-income countries point to the importance of accurate measurement for the correct definition of policy responses. However, measuring the extent of non-compliance with minimum wage rates is not a straightforward exercise, for several reasons. National data on enforcement and compliance are scarce and, for countries without statutory minimum wages, where wage floors are set by collective agreements (in Europe those are Austria, Denmark, Finland, Italy, Norway and Sweden), even less is known about their level, coverage and compliance, given the lack of an electronic register or database storing the contents of collective agreements (Eurofound, 2019). In addition, the particularly high rates of non-compliance with sectoral minimum wages found in these countries (Kampelmann et al, 2013) may reflect the fact that information on minimum rates might be more easily available for national than for sectoral minima (firms may refer to the wrong agreement and pay less than the reference minimum wage). Moreover, in countries with a statutory minimum, the presence of subminima (which are typically linked to age, tenure and occupation) could make it

difficult to identify the actual pay floors of all workers. The scarcity of reliable and comparable cross-country datasets on wages undermines comparisons of non-compliance rates across the EU27. Furthermore, one of the major problems with the measurement of non-compliance is the informal undeclared economy, in which workers are either not covered or poorly covered by collective agreements and non-compliance is thought to be more common. Such non-compliance is typically identified through qualitative research methods (Ram et al, 2017).

A necessary note concerns legally grounded situations in which underpayment is permitted by governments. Statutory minimum wages are not always constructed to cover the totality of workers. In many countries, wage floors present exceptions defining different rates of minimum wages for certain specific groups, such as young workers, apprentices, labour market entrants, long-term unemployed people, workers with disabilities or unskilled workers. In most cases, it consists of downward deviations from the statutory minimum wage. These are defined as subminima, and they aim to improve the labour market prospects of younger or less experienced people by allowing employers to pay such workers less than the statutory minimum wage. These schemes increase the employment prospects of individuals belonging to the above-mentioned groups, whose productive capacity is generally lower than that of the average minimum-wage worker. In general, subminima tend to be specified as a proportion of the basic statutory minimum wage, and thus changes to the latter also lead to adjustment of the subminima. Hence, these deviations need to be considered, to correctly assess the true extent of non-compliance with wage floors in force. In the next section we provide insights into the methodology employed to consider them in the quantification analysis, while more technical details on the calculation of non-compliance are shown in Box 1.

Box 1: Measurement of non-compliance

Non-compliance can be estimated in three ways:

- based on statistical data, as the percentage of workers earning less than the legal minimum wage in various jobs and sectors
- based on violations of minimum wage regulations detected during workplace inspections
- based on direct complaints made by workers to supervising bodies and courts

While an analysis of non-compliance based on the second or third method can only be partial, as it refers to detected cases or filed complaints, the first statistical methodology still provides only rough estimates, and it is subject to some measurement error.

When non-compliance measures rely on survey data, sampling and weighting procedures might be a source of error (Ritchie et al, 2017), and individuals declaring below-minimum wages might simply represent misreported values. One way to mitigate the effect of measurement error on non-compliance estimates in Europe has been proposed by Kampelmann et al (2013), who reduce the true minimum wage by 25% to produce 'lower bound' estimates, and by Garnero et al (2015), who allow for a 15% margin of error. Moreover, measuring non-compliance as the share of workers paid below the minimum wage might fail to quantify the extent of underpayment. That approach cannot distinguish workers earning just slightly less than the legal minimum wage from workers who are paid well below the minimum.

In order to address the above problems, Bhorat et al (2013) proposed using the Foster–Greer–Thorbecke poverty measurement technique to create a family of indices of minimum wage

violation (the simple share of underpaid workers, the depth of the underpayment and the average shortfall per underpaid worker). This index has been used by Rani et al (2013), Bhorat et al (2015), Garnero (2018), Goraus-Tańska and Lewandowski (2019) and Mansoor and O'Neill (2020) to assess the extent and depth of violation of minimum wages.

Formally, the non-compliance index NC_c, for a given country indexed by c, is defined as follows:

$$NC_c(\alpha) = E_c[v_i]$$

$$v_i = \left(\frac{w_m - w_i}{w_m}\right)^{\alpha} \text{ if } w_m - w_i > 0$$

$$v_i = 0 \text{ if } w_m - w_i \leq 0$$

The non-compliance index defined above is the average level of the variable v_i in country c, where v_i is the depth of violation. If a worker indexed as i earns less than the relevant minimum wage w_m, the variable v_i is strictly positive. If a worker earns at least the minimum wage, the variable v_i takes a value equal to 0.

The parameter α defines the aversion to underpayment. If the coefficient α is set equal to 0, v_i becomes an indicator function, taking on the value 1 when w is strictly less than w_m, and the value 0 when w is greater than or equal to w_m, and NC_c then becomes equal to the share of workers paid below the minimum wage in the country. If α is set equal to 1, then NC_c becomes an average of positive differences between the minimum wage and actual wages, expressed as a percentage of the minimum wage, with equal weights for all workers. For values of α greater than 1, workers who are more underpaid have higher weight. An average shortfall per worker can be then computed from the depth of violation over the headcount indicator of violation.

Data sources and methodology for quantifying non-compliance

Wage levels and their distributions vary substantially across European countries. Similarly, minimum wage legislation is also highly heterogeneous, with statutory minima and implementation mechanisms that differ depending on the characteristics of the system of industrial relations, the political environment and the performance of the domestic economy.

In this section, we present the steps implemented to provide a quantification of non-compliance across EU27 countries, focusing on non-compliance originating from work within the same country (not including, for example, posted workers) and covering only employees (not self-employed people). In order to measure non-compliance, two sources of data have to be linked – one that makes it possible to measure the income distribution within each country, and one that provides minimum wage levels that apply to each Member State – to identify underpaid workers depending on how their wages are related to national wage floors.

The section is organised as follows: first, an overview of existing harmonised EU-level databases that can be useful to estimate non-compliance with minimum wages from a cross-country perspective and identify the variables that are relevant to the calculation of non-compliance; second, the available information on national minimum wage legislation for the EU27.

Choice of cross-country data sources

To measure minimum wage underpayment, data from two harmonised databases containing data on employees' earnings in EU Member States are used: the EU-SILC and SES databases.[5] Ultimately the European Working Conditions Survey (EWCS) could in principle be used, but given the small sample size it will be used only to analyse the characteristics of low-paid workers in terms of job quality. Estimating non-compliance requires a precise measurement of the entire distribution of earnings, and this procedure is potentially subject to a large measurement error due to small-sample bias. For these reasons we resort to the EU-SILC and SES databases, which are substantially larger and in principle allow more precise estimation of the earnings distribution. Moreover, checking the consistency of findings using different data sources is fundamental for studies on compliance with minimum wages (see Ritchie et al, 2017). Each dataset has advantages and drawbacks, extensively described in Table 1 below (more details can be found in Box A1 in the appendix).

Table 1: Characteristics of the datasets used to estimate non-compliance in the EU27

Characteristic	SES	EU-SILC	EWCS
Frequency	Every 4 years	Annual	Every 5 years

[5] The European Union Labour Force Survey would be the ideal source of information to carry out the quantification exercise. It is a high-frequency (quarterly) and up-to-date survey, representative of the working-age population (not only on the formal sector), and it would be sufficiently large to provide reliable estimates of the left tail of the earnings distribution in each EU country. Unfortunately, data on wages are not available in the harmonised EU-level version of the survey; they are provided only in the national versions of the LFS.

Sample	Repeated cross-section of firms (employer–employee type) generally with more than 10 employees in the areas of economic activity defined by sections B to S (excluding O) of Nomenclature of Economic Activities Rev. 2[a]	Repeated cross-section and longitudinal survey on sample of households, representative of the population of each country	Repeated cross-section of workers (country sample size around 1,000–3,000 per year)
Information on wages	Reported by the employer	Self-reported	Wages net of taxes
Information on working hours	Hours paid in the month to which wages relate	The reported working time pattern refers to the time of the survey, while reported labour income can refer either to the previous year or to the current period	Hours usually worked per week
Main pros	• Matched employer–employee data • Reliable and harmonised data on earnings • Large sample size	• All sectors and informal economy covered • Precise information on earnings from all sources of income • Rich information on workers' background • High-frequency data	• Harmonised data at EU level with complete coverage of EU27 • Rich information on job characteristics
Main cons	• Low-frequency data • Unavailability of data on (i) firms with < 10 employees, (ii) informal sector, (iii) agriculture and public administration and (iv) possible reporting errors made by the respondent	• Limited information on employers' characteristics • Potential measurement error and non-response issues for earnings • Difficulty in constructing a wage estimate based on the available information on yearly labour earnings • Identification of hourly wages for the given (last) calendar year based on the assumption that hourly wages are equally distributed over time	• Low-frequency data • Small sample size • Earnings data reported only net of taxes

Note: *[a] The inclusion of section O and of the information on enterprises with fewer than 10 employees remains optional.*

SES is a large matched employer–employee survey providing accurate information on a large sample of enterprises about employees' gross wage levels, hours of work and individual characteristics, as well as plant attributes such as the size of the firm, its main economic activity and the geographical location of the local unit. The population of employees included in the survey is those with an employment contract in the observation unit in the reference month. However, the survey is conducted only once every four years, and it is based on a sampling strategy that includes only employers with more than 10 employees in the formal sector, for most countries. This last characteristic appears to create difficulties for the analysis of compliance with minimum wage regulations, which could be underestimated, since underpaid workers tend to be concentrated in small firms and in the informal sector; see Weil (2005) and Garnero (2018), among others. Nevertheless, being able to assess the amount of non-compliance among larger employers in the formal sector using reliable earnings data harmonised at cross-country level still provides relevant information from a policy perspective. The business activities included in SES microdata belong to Nomenclature of Economic Activities (NACE) Rev. 2 sections B to S excluding O, hence without public administration and defence, or agriculture, forestry and fishing. However, some countries also provide information on public administration voluntarily. Moreover, SES uses various means of data collection: tailor-made questionnaires, already existing surveys, administrative data or a combination of such sources. In many cases the respondent inside the single unit firm is the reference human resources manager, who may consciously or unconsciously give erroneous information. For these reasons the survey is likely to underestimate the proportion of workers being paid below minimum wages directly, but it is a reliable source for understanding how many workers are earning around the minimum wage.

EU-SILC could in principle be considered an ideal dataset for the analysis of non-compliance. The survey is household based, so that all types of workers are covered independently from the sector of activity and characteristics of the employer. In particular, workers in the informal sector are potentially covered. This information is very important when trying to quantify non-compliance with minimum wage regulations, given that it is likely to prevail in the informal sector. Moreover, background household characteristics are well documented. Another advantage of this survey is that it is conducted on a yearly basis. However, this survey also has several drawbacks. First, the sample size tends to be smaller, and the income variable is self-reported by employees and thus potentially subject to misreporting. Second, information on earnings is not well harmonised across countries. In some instances, earnings information refers to the year before the survey, while information on hours worked and employers' characteristics refers to the current period of the interview.

The EWCS is a very good source of information on the quality of jobs, but the wages it records are only net of taxes. For this reason, we will use this dataset to provide a cross-country (all countries) and cross-sector (all sectors) job quality analysis using a set of indicators that measure several dimensions of the quality of jobs (i.e. working time quality also in terms of working hours, prospects and work intensity; see Eurofound 2012, Green et al, 2013). In particular, various dimensions of job quality for those who are paid at or below the legislated minimum will be explored with these data.

Identification of relevant variables and of the sample of interest

From EU-SILC, the 2014 and 2018 editions were considered, but wage variables typically refer to the previous years, 2013 and 2017. Therefore, minimum wages applicable in 2013 and 2017 have been used when using earnings from the previous year to define actual wage levels. 27 countries are

included in the analysis of EU-SILC. For SES, two editions were analysed, 2014 and 2018, covering 25 countries in total: all Member States of the European Union except Austria and Ireland (Slovakia and Slovenia only for 2018).

A robust analysis was performed to compare the magnitude of compliance obtained with different selections from the sample, and different selections of earnings measures. In the analysis, information on firms' and individuals' background characteristics has also been used, mainly focusing on information harmonised across the SES and EU-SILC databases, in order to improve the comparability of the results.

In each country and in each of the available editions of the EU-SILC and SES databases, several comparable measures of earnings were defined. Given that minimum wage levels typically apply to gross wages, the main measure used is gross earnings. Besides wages, hours worked are another important variable to consider in the analysis of non-compliance. On one hand, they make it possible to measure earnings at a more precise level, for example by adjusting part-time monthly pay levels to full-time equivalents. On the other hand, they make it possible to investigate whether they constitute a margin of adjustment for firms that are not willing to comply with minimum wage regulations, since they are difficult to monitor and can result in underpaid employment due to excess working hours.

In general, the main definition of earnings is based on monthly wages, thus using monthly minimum wage rates to compute non-compliance. As a robustness test on our main results, gross hourly wages as an alternative definition of earnings have also been used, and non-compliance levels estimated through hourly and monthly minimum wages have been compared. When computing non-compliance with hourly wage levels, the minimum wage is translated into an hourly gross equivalent level, dividing the monthly minimum by the standard duration of full-time labour contracts implied by a 40-hour working week. Since most countries have a working week that is equal to or less than 40 hours, this approach makes it possible to derive a conservative estimate of non-compliance when using hourly wages.

All the analyses are carried out applying sampling weights in order to report only estimates that are representative of the actual population of interest. In general, the sample consists of full-time salaried employees and part-time workers reporting the amount of time spent at work, so that all earnings can be expressed at full-time equivalent levels. In the main estimates of non-compliance based on EU-SILC, workers who changed job during the previous year were excluded, in order to ensure the comparability of information on earnings (typically measured in the previous year) with information on job characteristics (typically measured in the current period). The procedures adopted entail significant loss of observations, particularly in EU-SILC. The coverage rate of the sample is reported in Table A2 of the appendix.

The preferred sample for analysis covers employees aged 20–65 and excludes workers with apprenticeship contracts. This choice is rationalised by the fact that exemptions to minimum wages apply in several countries for young workers and apprentices, and these exemptions are often difficult to adjust for owing to limitations in the available information (for example, age is reported only in discrete intervals in SES). Thus, the sample restriction allows us to provide conservative estimates of non-compliance that is better harmonised for potential differences in legislation at cross-country level. To check the consistency of the results, the estimation of non-compliance is repeated for the sample of workers aged 14–65 and including apprentices. These latter results are

also compared with estimates that take into consideration the presence of subminima whenever possible. This adjustment in the minimum wage variable is discussed in more detail in the following subsection.

Box 2: Definitions of employees' monthly earnings adopted

The main variable used to measure individuals' earnings is gross monthly wage, translated into full-time equivalent. This information is available in both the SES and EU-SILC databases but with different definitions.

SES

Gross monthly wages in the reference month

SES collects data on earnings actually received in cash by employees in the reference month. The information collected relates to the earnings paid to each job holder and does not cover earnings by the same employee elsewhere in a second or third job. Overtime earnings and premiums related to shift work are excluded from the preferred measure of gross monthly earnings. Instead, a monthly measure of bonuses obtained, dividing annual bonuses and allowances not paid at each pay period by the number of months worked, is included in earnings. For workers on part-time contracts, the monthly wage is transformed into a full-time equivalent level. This transformation can be performed using a variable indicating the percentage of work performed in comparison with full-time workers.

Gross hourly wages in the reference month

Hourly wages are derived by dividing the gross monthly wage defined above by the numbers of hours paid during the reference month (without considering overtime hours). Minimum wages were adjusted at hourly level by dividing the official monthly minimum by 40 multiplied by 52/12, which is the number of hours worked per month implied by a 40-hour working week. Since most countries have a working week that is equal to or less than 40 hours, this approach allows us to derive a conservative estimate of non-compliance when using hourly wages.

EU-SILC

The EU-SILC database contains two variables that can be used to estimate monthly earnings of employees. One variable (PY010G) refers to employees' gross earnings received during the year before the time of the interview. One drawback of this variable is that job-related information refers to the current interview period, so that some adjustment needs to be made to take into account this difference in the timing of measurement. The second variable (PY200G) refers to gross monthly earnings received in the period of the interview and is the preferred choice only in Bulgaria and Croatia. Based on these two variables, three estimates of employees' full-time equivalent monthly earnings have been computed, which we define below.

Notice that each definition of income adopted is characterised by a different availability rate with respect to the population of employees included in the sample. Availability rates differ for two main reasons: the number of missing values in the variables recording income; the sample restriction choices implied by each income definition adopted. Table A2 in the appendix summarises, for each of the income definitions described below, the percentage of observations (out of the employees' population) for which non-compliance can be estimated.

Baseline definition

This definition is based on the variable PY010G (except in Bulgaria and Croatia). To account for differences in the timing of measurement between income information and job-related information, the sample includes only workers who (i) did not change job in the last year (PL160) and (ii) worked either always full time (PL070) or always part time (PL071) during the last year.

To express the annual value (PY010G) as monthly full-time equivalent earnings, the procedure adopted is (i) divide it by months worked either part time or full time (PL070 and PL071); (ii) scale up this value to a working schedule of 40 hours per week whenever weekly hours worked (PL060) are less than 40, assuming that the reported level of hours worked in the current period is a close approximation to the actual working schedule during the last year.

Following a Eurofound practice, the income variable defined above is scaled down by the ratio of hours worked in the main job to total hours worked whenever individuals were holding more than one job.

There are two countries, Bulgaria and Croatia, where current period earnings are used for the baseline definition, because the variable PY200G (employees' gross monthly earnings received in the period of the interview) offer good quality data in these two countries. Since this variable refers to the same period as other job-related information, no adjustment is needed to account for potential differences between the current and past jobs. In order to express this measure of income as full-time equivalent earnings, its value is scaled up whenever weekly hours worked (PL060) were less than 40. To ensure comparability across countries, the sample is restricted to workers who had at least one year of tenure and did not change between a part-time and a full-time contract in the previous year. Although this correction would not be strictly necessary when using current-period earnings, it was applied to ensure that differences across countries are not driven by different sample selection procedures.

Hourly wages were estimated by dividing the monthly wage by the number of hours worked implied by the working schedule reported for the current week, restricting the sample to workers with more than one year of tenure for comparability purposes. Minimum wages were adjusted at hourly level by dividing the official monthly minimum by 40 multiplied by 52/12, which is the number of monthly hours worked implied by a 40-hour working week. Since most countries have a working week that is equal to or less than 40 hours, this approach allows us to derive a conservative estimate of non-compliance when using hourly wages.

Brandolini et al (2011) earnings definition

This definition is based on the variable PY010G. Following Brandolini et al (2011), full-time equivalent monthly earnings were calculated by dividing the annual value (PY010G) by the number of months worked in full-time jobs (PL070) plus the number of months worked in part-time jobs (PL071), scaled down by a country- and sex-specific factor equal to the ratio of median hours of work in part-time jobs to median hours of work in full-time jobs. This results in a larger sample of employees, since information on hours worked is not necessarily needed at individual level to construct this measure, although the cost is less precision in the adjustment of wages to full-time equivalent levels.

Following a Eurofound practice, the income variable defined above is scaled down by the ratio of hours worked in the main job to total hours worked whenever individuals were holding more than one job.

Goraus-Tańska and Lewandowski (2019) earnings definition

We have also considered a more restrictive and conservative definition of full-time equivalent monthly earnings, which is still based on the variable PY010G and is constructed as follows.

Following Goraus-Tańska and Lewandowski (2019), only the workers who at the time of the survey (i) were employed full time and actually worked at least 40 hours per week, (ii) had only one job and (iii) were employed full time in all months of the previous calendar year are considered.

Following a Eurofound practice, the income variable defined above is scaled down by the ratio of hours worked in the main job to total hours worked whenever individuals were holding more than one job.

Data on national minimum wage legislation among EU Member States

The analysis of compliance with pay regulations requires the gathering of information on the level of minimum wages in each EU Member State. Minimum wages are widespread: of the 27 Member States of the EU in 2021, 21 have statutory minimum wages established at national level, and the others have minimum wages negotiated at sectoral level (Austria, Cyprus, Denmark, Finland, Italy and Sweden).

For this purpose, the information provided by Eurofound and Eurostat on the level of minimum wages across EU Member States is used. For statutory minimum wages, statistics published biannually by Eurostat referring to monthly national minimum wages applicable at the beginning of the year are used.[6] The national minimum wage usually applies to all employees, or at least to a large majority of employees in a country. It is fixed at an hourly, weekly or monthly rate, and it is enforced by law, often after consultation with social partners, or directly by a national intersectoral agreement. Minimum wages are generally presented as monthly wage rates for gross earnings, that is, before the deduction of income tax and social security contributions payable by the employee; these deductions vary from country to country. For those countries where the national minimum wage is not fixed at a monthly rate (for example, where minimum wages are specified on an hourly or weekly basis) the level of the minimum wage is converted into a monthly rate according to conversion factors supplied by the countries.[7]

A country specificity to consider when building a reliable methodological approach is the existence of collective bargaining in the country. This institution may impose higher wage floors for selected groups of employers in covered sectors. In some particularly important instances, collective

[6] We use the statutory minimum wage in force during the first half of the reference year, except for SES, for which we employ second-half levels, since its wage information is related to October.

[7] France: (hourly rate × 35 hours × 52 weeks) / 12 months. The national minimum wage was €9.61/hour in 2014 and €9.88/hour in 2018. Germany: (hourly rate × 40 hours × 52 weeks) / 12 months. The national minimum wage was €8.50/hour in 2015 and €8.84/hour in 2018. Ireland: (hourly rate × 39 hours × 52 weeks) / 12 months. The national minimum wage was €8.65/hour in 2014 and €9.55/hour in 2018. Malta: (weekly rate × 52 weeks) / 12 months. The national minimum wage was €166.26/week in 2014 and €172.51/hour in 2018.

bargaining imposes statutory wage floors differentiated by sector for all employees whenever a national statutory minimum wage does not exist. In such institutional settings, defining measures of non-compliance tends to be more challenging and it requires the use of refined algorithms to match workers to their relevant minimum wages. However, that approach could not be followed in this paper for lack of sufficient information.

In Table 2 are reported the minimum wage levels that will be used in the analysis. The national minimum wages, as reported in Table 2, usually apply to all employees, or at least to a large majority of employees in a country. However, several Member States define different rates of minimum wage for specific groups; these are defined as subminima and their presence is highlighted in columns 4 and 5 of Table 2. Note also that some countries may not have subminima, but they could still have age-related or other exemptions from the application of the minimum wage. The list of subminima and exemptions for each country is reported in Table A3 in the appendix.

In the analysis, to provide harmonised comparisons across countries with different minimum wage structures, for our main estimates only the national wage levels as defined in columns 2 and 3 will be considered. Nevertheless, as a robustness test, non-compliance rates that also consider age- and tenure-based subminimum levels whenever the data made it possible are shown. Many of these subminima apply depending on workers' ages, and SES provides age only in broad ranges, undermining the possibility of applying different rates to targeted subgroups of the analysed sample. For some of these instances, a weighted average of subminima rates applied within age groups has been computed to see how non-compliance estimates react to different specifications. Similarly, information about whether work is under an apprenticeship contract is not available, but several subminima apply to this group of workers. More details on the levels of subminima among the EU27, and on the strategies adopted to deal with them in the data, are reported in Tables A3, A4 and A5 in the appendix. The section 'Sensitivity analysis on the quantification of non-compliance: The role of young workers and of subminimum rates' presents the main estimates of non-compliance when subminima are applied.

Table 2: Minimum wages in Member States

Country code	Minimum wage rates (€)		Presence of subminima		Type
	2014	2018	2014	2018	
BE	1,502	1,563	Yes	No	S
BG	174	261	No	No	S
CZ	310	478	No	No	S
DE	n.a.	1,498	No	No	S
EE	355	500	No	No	S
ES	753	859	No	No	S
FR	1,445	1,498	Yes	Yes	S
EL	684	684	Yes	Yes	S
HR	396	462	No	No	S
HU	342	445	No	No	S
IE	1,462	1,614	Yes	Yes	S

LT	290	400	No	No	S
LU	1,921	1,999	Yes	Yes	S
LV	320	430	No	No	S
MT	718	748	Yes	Yes	S
NL	1,486	1,578	Yes	Yes	S
PL	404	503	No	No	S
PT	566	677	No	No	S
RO	190	408	Yes	No	S
SI	789	843	No	No	S
SK	352	480	No	No	S
AT	1,496	1,586	n.a.	n.a.	C
CY	854	840	n.a.	n.a.	C
DK	2,363	2,427	n.a.	n.a.	C
FI	1,440	1,469	n.a.	n.a.	C
IT	863	883	n.a.	n.a.	C
SE	1,808	1,894	n.a.	n.a.	C

Notes: *C, collective agreements (estimated minimum wages are a statistical artefact, which is not comparable to the other countries); S, statutory minimum wage. For those countries where the national minimum wage is not fixed at a monthly rate (for example, where minimum wages are specified on an hourly or weekly basis), the level of the minimum wage is converted into a monthly rate according to conversion factors supplied by the countries. "n.a" refers to not applicable.*

Sources: *Eurostat database on minimum wages for statutory minimum wages and Eurofound (2021), Table 1 (p. 12), for countries without statutory minimum wages, identified as the average of the three lowest collectively agreed minimum wages identified by the Network of Eurofound Correspondents*

For countries without statutory minimum wages – Austria, Cyprus, Denmark, Finland, Italy and Sweden – wages are implemented through collective agreements. In most countries, however, no electronic register of these agreements exists, and no precise numbers on coverage are available. Indeed, gathering these data represents a major challenge. For comparative purposes, estimates provided by Eurofound (2021) are used. These are obtained by calculating an average of the three lowest collectively agreed minimum wages identified by the Network of Eurofound Correspondents for 2018. These measures (lower part of Table 2) are a statistical construction, since no single minimum wage levels exist in these countries. Nevertheless, they allow analysis with caveats for Austria, Cyprus, Denmark, Finland and Sweden. To extend the analysis to 2014 as well, given that collective contracts tend to follow inflation trends, the levels in 2014 were imputed using the OECD inflation rate statistics to express them as constant in real terms across periods.

Italy has a register of collective agreements. The approach used in this case builds on that of Garnero et al (2020) and uses 18 collectively agreed sectoral minimum wages, identified for each sector by the Italian National Statistical Office (ISTAT). ISTAT monitors collective contracts on a regular basis, and in 2015 it created a dataset on the estimated industry *minima minimorum* (the minimum pay levels among those defined by each collective contract). For the following years, the level of these

minima were imputed using the planned inflation levels of the Italian government, given that collective contracts tend to closely follow these rates. The values used in the estimations are reported in Table 3. Given that collective agreements are negotiated at industry level, sector-specific minima represent a more granular and precise measure of the true minimum pay level applying to each worker. Following this approach, the analysis of non-compliance can be performed separately for each sector, each of which is characterised by a different statutory minimum pay level. However, minima that are negotiated for selected occupations within industries above the sector-specific pay floor cannot be considered, since information to link workers in the SES or EU-SILC data to the occupational job titles that are characterised by higher minimum wages is not available.

Table 3: Collectively agreed minima for Italy by NACE sectors (monthly minimum wage) (€)

Sector	2014	2018
A	1,056	1,084
B	1,385	1,421
C	1,154	1,184
D	1,356	1,392
E	1,407	1,444
F	1,203	1,235
G	1,242	1,275
H	1,078	1,107
I	1,249	1,282
J	995	1,021
K	1,777	1,824
L	1,802	1,849
M	1,166	1,197
N	1,097	1,126
O	1,400	1,436
P	1,126	1,155
Q	1,103	1,132
R	1,249	1,282
S	1,284	1,317

Note: *A, agriculture, forestry and fishing; B, mining and quarrying; C, manufacturing; D, electricity, gas, steam and air conditioning supply; E, water supply; sewerage, waste management and remediation activities; F, construction; G, wholesale and retail trade; repair of motor vehicles and motorcycles; H, transportation and storage; I, accommodation and food service activities; J, information and communication; K, financial and insurance activities; L, real estate activities; M, professional, scientific and technical activities; N, administrative and support service activities; O, public administration and defence; compulsory social security; P, education; Q, human health and social work activities; R, arts, entertainment and recreation; S, other service activities.*

Source: *ISTAT negotiated wages database (year 2014), updated for subsequent years using the planned Italian inflation rate (from the Italian Treasury Department). Negotiated wages account for the presence in the agreement of a 13th and a 14th month and include tax and social security contributions paid by employees*

Methodology for quantitative cross-country analysis of the extent of non-compliance among EU Member States

After the discussion of cross-country data on individual earnings matched with the relevant minimum wage applying to each worker, this section presents the methodology used in the quantitative assessment of non-compliance.

In order to quantify non-compliance, the main indicator used is the proportion of workers below the minimum wage, out of the total number of employees. All estimates included in this paper consider sampling weights to provide evidence representative of the population of interest. Since sampling weights suffer from measurement error problems, cross-validation of the results using both the EU-SILC and SES databases provides further evidence of the reliability of our results.

A correction is applied to the proportion of workers paid below the minimum wage to avoid overestimating the amount of non-compliance. This consists of considering workers compliant with the minimum wage even when there are small differences between the pay floor and the actual wage, specifically if the differences are below 5% of the minimum wage (thus, cases of non-compliance were identified only if earnings were below 95% of the minimum wage). This methodology is called a doughnut correction and is often implemented in empirical studies on non-compliance (Garnero, 2018).

The analysis does not only focus on the proportion of workers below the minimum wage, but also provides a picture of the relative size of low-paid employment. For this purpose, three categories of workers are defined as follows:

- below minimum wage workers: those earning less than 95% of the relevant minimum wage
- minimum wage workers: those earning between 95% and 105% of the relevant minimum wage
- above 1.5 minimum wage workers: those earning between 105% and 150% of the relevant minimum wage

This classification of workers allows us to provide a more comprehensive overview of the size of low-paid employment. This additional evidence improves the overall reliability of the results, given that an exact definition of non-compliance is subject to sizeable uncertainty due to potential misreporting and measurement error. Defining non-compliance as a wage level below 95% of the minimum is a conservative approach that ensures that small measurement errors do not contribute to its quantification.

A measure of the bite of the minimum wage, a potentially important factor to explain non-compliance, is the Kaitz index, which is the ratio of the minimum wage to the median wage in the country. This index is contrasted with the measures of non-compliance defined above. In particular, the relationship between the percentage of workers paid below the minimum in each country and the Kaitz index can be represented by scatterplots.

Another method that has been adopted to quantify the size of the workforce earning around the minimum wage is the histogram of earnings. These graphs are based on estimates of the wage distribution obtained by dividing the earnings variable into equally spaced intervals, which are called bins. The histogram provides the share of the population whose earnings are comprised in the interval defined by each bin. Histograms make it possible to represent the density function of wages, and the minimum wage level is highlighted to visualise how many workers lie to the left or to the

right of this threshold. To provide a cross-country visualisation of the distribution of wages around the pay floor, earnings are expressed as a percentage of the national minimum wage, or of the relevant sectoral pay floor set by collective bargaining.

Descriptive statistics for workers who earn less than 95% of the national minimum wage are shown and contrasted with the rest of the population. In computing these statistics, the focus is on the most recent year (2018), and the data are pooled across countries to identify European-level characteristics of workers paid below the minimum wage. These results are reported in the section 'Individual characteristics of underpaid employees'.

To check whether hours worked are a margin of adjustment for firms that are not willing to comply with minimum wage regulations, statistics on hours worked below and above the minimum wage in each country are reported. The consistency of the estimates employing hourly wages instead of monthly earnings is also investigated. See 'The relationship between working hours and non-compliance' for both.

Based on the results on the calculation of non-compliance, a set of scoreboard tables is built, which help to identify the combinations of occupations/sectors more at risk of underpayment in each country. Each table highlights, by the use of different colours, which combinations of occupations and sectors in each country are at higher risk of non-compliance. Moreover, this approach is very useful to compare countries and map the degree of non-compliance in a simple and visually direct way. This analysis is presented in the section 'Incidence of non-compliance across industries and occupations'.

Results of quantification of non-compliance

In this section, the main results of the quantification of non-compliance among the EU27 are presented. Results mainly focus on 2018, which is the most recent edition available for both EU-SILC and SES. First, the main estimates of non-compliance across the EU27 are shown, obtained using a combination of approaches that best ensures comparability of the results across databases and countries. Then, how the results are affected by following alternative approaches is investigated, as described in the previous sections. All the results shown in this section are also summarily reported in Tables A6 and A7 in the appendix. Table A6 shows all the point estimates derived from EU-SILC on which the tables and figures of this section are based. Table A7 reports the corresponding point estimates based on SES.

As mentioned, since the precision of estimates of non-compliance is usually hampered by measurement error, each estimate is subject to some uncertainty. To limit this uncertainty, checking for consistency in the results using a variety of approaches is the most viable strategy, which has been adopted in this paper.

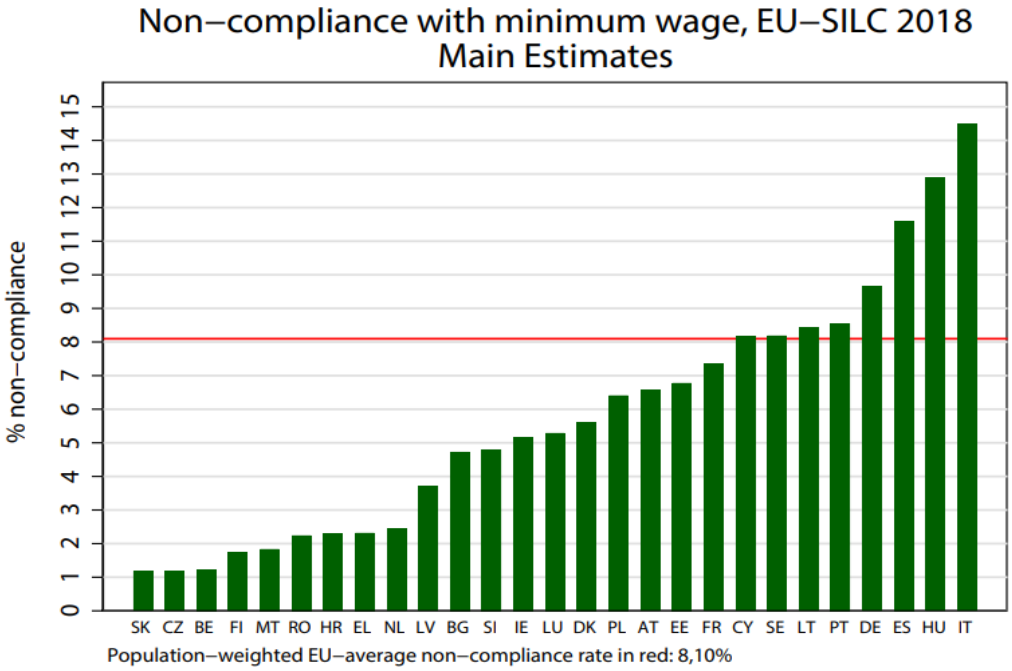
Quantification of non-compliance

Figure 1 provides the estimates of non-compliance across the EU27 derived from EU-SILC, and Figure 2 reports the corresponding estimates derived from SES.[8] As can be seen, non-compliance is generally lower in the SES database than in the EU-SILC database. In the former database, the EU-level average weighted by population size is only 1.43%, and it ranges between 5.94% in Cyprus and 0.01% in Belgium. In EU-SILC, the EU-level average is 8.1%, and estimates range from 0.21% in Belgium to 14.5% in Italy. Overall, results are in a range that is consistent with previous estimates of non-compliance for European countries, which are concisely reported in Table A1 in the appendix, although there are also some differences from previous estimates. In general, differences in estimates of non-compliance can be attributed to differences in data sources, time, sample coverage and approaches used to define employees' wages.

There are several reasons that can explain why non-compliance tends to be higher when estimated using EU-SILC than using SES. First, SES is based on a sampling design that includes only private-sector firms with more than 10 employees, while non-compliance is generally larger in smaller firms and in the informal sector. Second, earnings information is derived from payroll data in SES, while it is self-reported in EU-SILC. For this reason, it may be less likely in SES that employers declare a wage level that is below the statutory one. However, non-compliance is higher when estimated using SES in Greece, which could in part be linked to the fact that, to properly impute a monthly wage level, workers with less than one year of tenure are excluded from the EU-SILC sample in our main estimates. Thus, a significant proportion of underpaid employees could also be underrepresented in this sample.

[8] Estimates of non-compliance should be used with care when drawing conclusions, given discrepancies between different datasets and estimates.

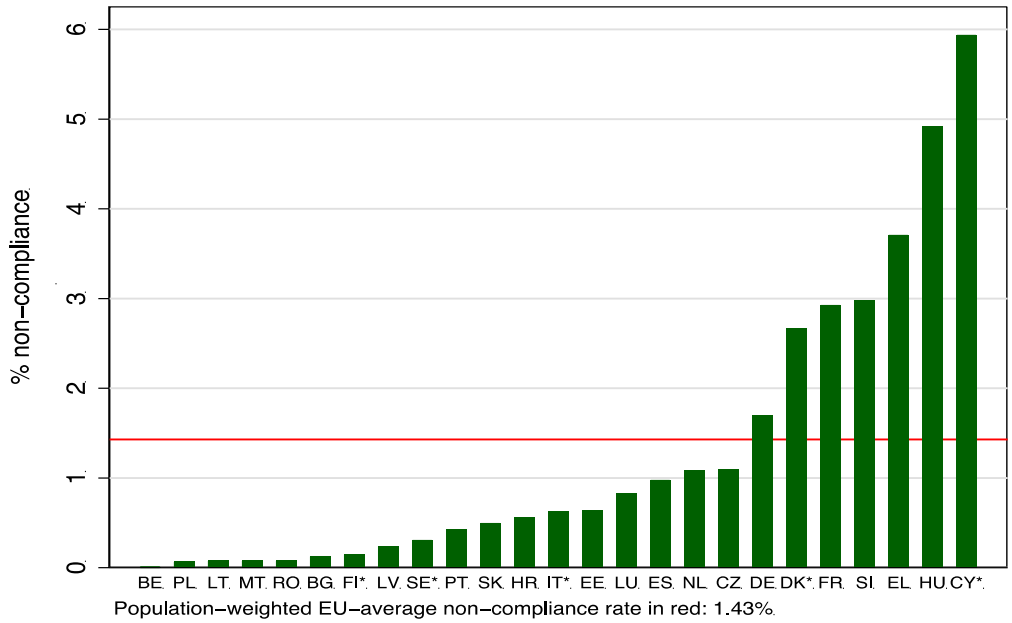
Figure 1: Non-compliance rates estimated using EU-SILC 2018



Notes: *The percentage of workers earning below 95% of the minimum wage is reported. The sample includes workers aged 20–65. It excludes workers with less than one year of tenure and those changing between part-time and full-time contracts in the previous year. All statistics, including the EU-level average, are computed using sampling weights. The estimated population-weighted EU average non-compliance rate is 8.1%. *Minimum wage estimated from sectoral minimum wages set through collective bargaining.*

Source: *EU-SILC 2018 edition*

Figure 2: Non-compliance rates estimated using SES 2018



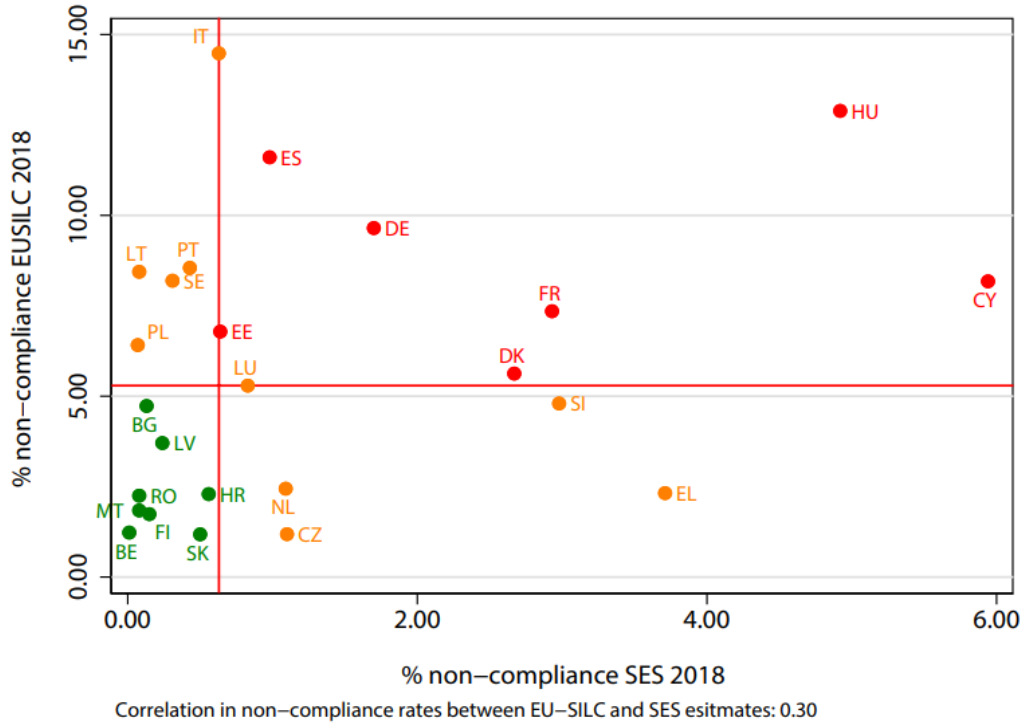
Notes: *The percentage of workers earning below 95% of the minimum wage is reported. The sample includes workers aged 20–65 and excludes apprentices. All statistics, including the EU-level average, are computed*

*using sampling weights. The estimated EU-level average non-compliance rate is 1.43%. * Minimum wage estimated from sectoral minimum wages set through collective bargaining.*

Source: *SES 2018 edition*

There are, however, also similarities across databases in estimates of non-compliance. To better identify them, a classification of EU Member States is constructed based on how strong their non-compliance level is in each database. Figure 3 provides a scatterplot where the vertical axis reports the non-compliance level estimated from EU-SILC, while the horizontal axis reports the level estimated from SES. The median level of non-compliance at EU level in EU-SILC is represented by the horizontal red line, and in SES by the vertical red line.

Figure 3: Relationship between non-compliance rates using SES and EU-SILC



Note: *The percentage of workers earning below 95% of the minimum wage is reported. The sample includes workers aged 20–65 and excludes apprentices (in SES). Countries in green have a non-compliance level below the EU27 median level in both SES and EU-SILC. Those in orange have a non-compliance level above the median in only one of the two databases. Those in red have a non-compliance level above the median according to both datasets. The correlation in non-compliance rates between EU-SILC and SES estimates is of 0.3.*

Source: *SES and EU-SILC 2018 editions*

Each dot on the graph represents a country. Countries where non-compliance is below the median level of both EU-SILC and SES are in green. Countries for which non-compliance is above the EU-level median in only one of the two databases are in orange. Finally, countries where non-compliance is above the EU median according to both databases are highlighted in red. According to this classification, there are eight Member States highlighted in green (Belgium, Bulgaria, Croatia, Finland, Latvia, Malta, Romania and Slovakia), ten Member States in orange (Czechia, Greece, Italy, Lithuania, Luxembourg, Netherlands, Poland, Portugal, Slovenia and Sweden) and seven Member States in red (Cyprus, Denmark, Estonia, France, Germany, Hungary and Spain). These estimates

show that non-compliance tends to be high in several of the larger countries such as France, Germany and Spain. It is also high in some small and medium-sized eastern and southern European countries such as Cyprus (where non-compliance is estimated with respect to collectively bargained minimum wages), Estonia and Hungary.

From Figure 3, it emerges that the correlation between estimates of non-compliance obtained in the EU-SILC database and in the SES database is positive, with a correlation coefficient around 0.3. The majority of countries are labelled in either green or red, meaning that most of them can be conclusively classified as high- or low-non-compliance countries according to both databases. Nevertheless, there are also significant discrepancies in the results across datasets, which underlines the importance of considering carefully which source of information is used in measuring non-compliance, as estimates tend to be data-dependent.

An important element to consider concerning estimates obtained in EU-SILC is the definition of income adopted. Several alternative approaches have been suggested in the literature. Box 3 provides a sensitivity analysis using the main alternative approaches to estimate non-compliance that can be employed on EU-SILC data, and it shows that our main estimates are relatively conservative and closer to the non-compliance levels obtained using SES.

Box 3: Sensitivity analysis on the quantification of non-compliance: The role of income definition adopted in EU-SILC

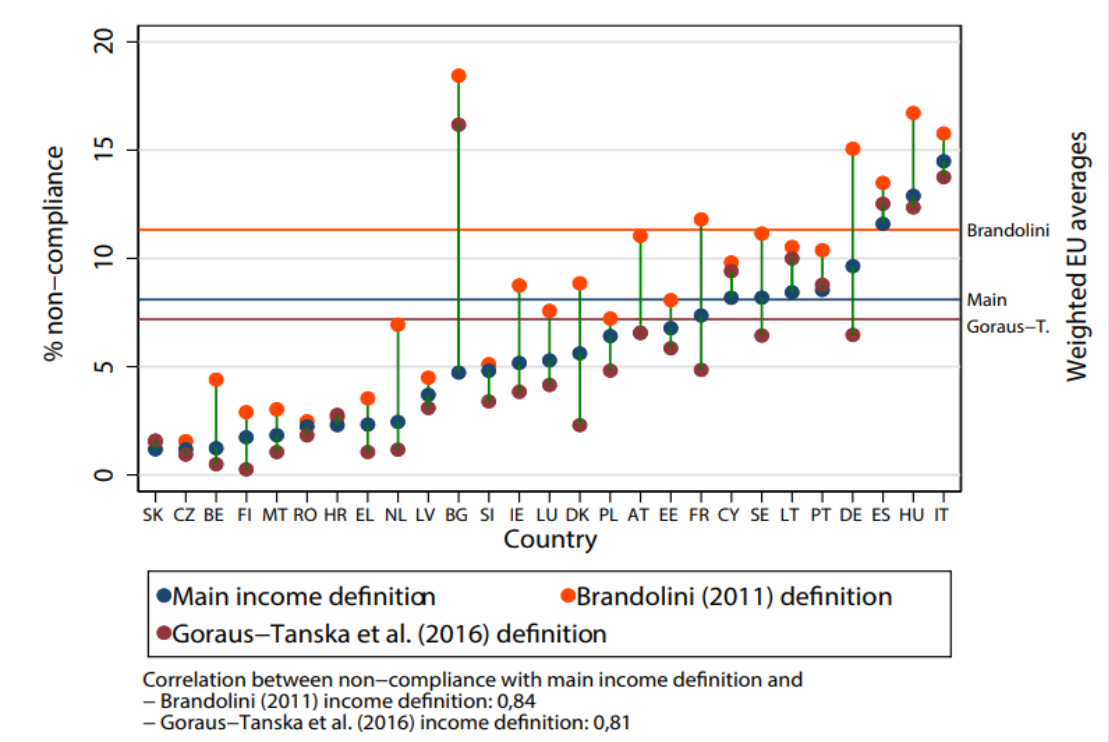
Estimating non-compliance can be influenced by the definition of income adopted. This is a particularly relevant point when using the EU-SILC dataset. As discussed in Box 2, in this survey there are two variables that describe individual income. One refers to the year prior to the interview; the other refers to the current period. The availability of the latter variable is quite limited. Since the main income variable refers to a period that is different from the one in which all job characteristics are measured, including the number of hours worked, some adjustments have to be made.

The main approach followed to deal with this problem is illustrated in Box 2. It involves a restriction of the sample to workers with one year of tenure and a career characterised by the same type of contract throughout the previous year. The estimates of non-compliance obtained using this definition of income are referred to as main estimates. In the literature, Brandolini et al (2011) and by Goraus-Tańska and Lewandowski (2019) have proposed two alternative approaches to deal with income measurement in EU-SILC data. Both are described in Box 2.

As a robustness test, non-compliance levels across Member States in EU-SILC using the two income definitions proposed in the literature mentioned above have been computed. Figure 4 summarises the results of this sensitivity analysis, reporting the non-compliance levels estimated using the three alternative income definitions.

Table A2 in the appendix provides the availability rate of each income definition by country. Availability rates are largest when using the Brandolini et al (2011) approach. They are only slightly lower when using our main approach, given the restriction of the sample to workers with at least one year of tenure. Availability rates are much lower when using the Goraus-Tańska and Lewandowski (2019) approach, mostly because the sample is restricted to full-time workers with a 40-hour weekly schedule. The main income definition adopted in our estimates leads to non-compliance estimates that are generally more conservative than the Brandolini et al (2011) income definition. The Goraus-Tańska and Lewandowski (2019) definition also leads to more conservative estimates of non-compliance than the Brandolini et al (2011) approach, but our main income definition entails a substantially less severe loss of observations. In the Goraus-Tańska and Lewandowski (2019) approach, only workers continuously employed full time during the previous year and working at least 40 hours in the current period are kept in the sample.

Figure 4: Comparison between non-compliance estimated using alternative definitions of income, EU-SILC 2018



Notes: *Non-compliance is computed as the percentage of workers earning less than 95% of the minimum wage. All statistics are weighted using sampling weights. Estimates in blue are obtained from the baseline income definition described in Box 2. Estimates in orange are obtained using the Brandolini et al (2011) definition described in Box 2. Estimates in purple are obtained using the Goraus-Tańska and Lewandowski (2019) definition of income. In this last case, estimates are reported only for countries where the sample coverage is above 50%. Averages on the right vertical axis are computed using sample weights on the full EU-level data. The correlation between the main non-compliance estimates and those estimated using the Goraus-Tańska and Lewandowski (2019) income definition is of 0.81. The correlation between the main non-compliance estimates and those estimated using the Brandolini (2011) income definition is of 0.84.*

Source: *EU-SILC 2018 edition*

The lower rate of non-compliance obtained using the main estimates than using the Brandolini et al (2011) approach can be ascribed in part to the fact that newly hired workers are excluded from the sample, unless they have one year of tenure. Given that this is a group of workers with potentially lower pay, this may lead to the exclusion of potentially underpaid employees. However, the variable on which all three definitions are based refers to earnings received throughout the previous year with respect to the interview date. For this reason, including in the sample workers with less than one year of tenure could be troublesome and lead to inconsistencies in the data.

A second reason why non-compliance could be overestimated with the Brandolini et al (2011) approach is that in this definition working schedules are imputed based on the country- and gender-specific median number of hours worked. Thus, a worker with a shorter schedule is more likely to be considered underpaid when using the Brandolini et al (2011) income definition, and this could lead to an increase in measurement error, leading to less precise estimates.

Notice on the other hand that the Goraus-Tańska and Lewandowski (2019) approach tends to be more conservative than the main approach of this report, although this is not always the case for all countries. As discussed above, the Goraus-Tańska and Lewandowski (2019) approach has the disadvantage of a substantial

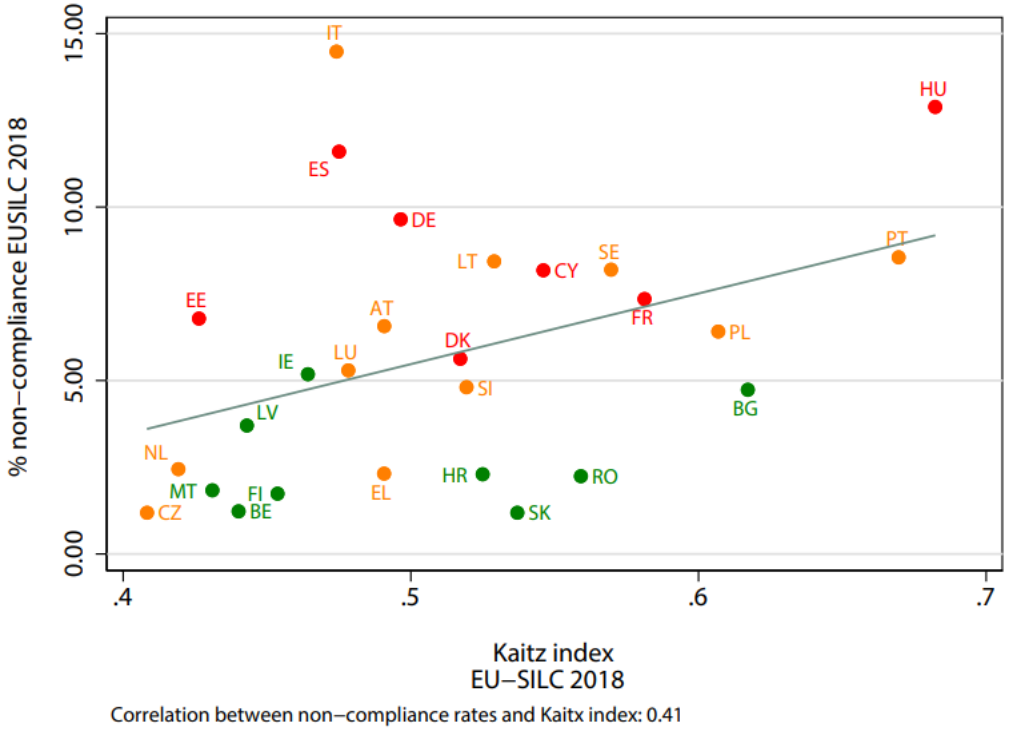
loss of observations, which could undermine the overall representativeness of the sample. The estimates reported in Figure 4 using the Goraus-Tańska and Lewandowski (2019) definition for Bulgaria, Czechia, Hungary and Latvia are different from those actually documented by Goraus-Tańska and Lewandowski (2019). This is mainly due to differences in the time coverage of the data, which referred to the first decade of the 2000s in the case of Goraus-Tańska and Lewandowski (2019).

Reassuringly, the relative ranking of countries is fairly stable across estimation methods. Estimates of non-compliance obtained using alternative income definition methods are highly correlated. Overall, this analysis shows that we have adopted a conservative approach when estimating non-compliance using EU-SILC, and that relative differences across countries are quite similar using other estimation methods adopted in the literature. Given that SES estimates are generally conducive to lower estimates of non-compliance, the main estimation approach adopted with EU-SILC is also the one that leads to the most similar estimates of non-compliance across databases, which provides indirect support for its reliability.

Level of minimum wages with respect to the pay distribution and quantification of workers around its level

When evaluating the level of non-compliance in a country, it is important to consider the level of the minimum wage with respect to the country's wage distribution. One useful measure of whether the minimum wage is set high or low with respect to prevailing wage levels in a given country is the Kaitz index, which is the ratio of the minimum wage to the median wage. Directive (EU) 2020/2041 on adequate minimum wages in the European Union suggests several indicators as measures of an adequate minimum wage level, among them the well-known ratio of 60% of the national gross median wage, corresponding to a Kaitz index of 0.6. The Kaitz index is also considered a good predictor of non-compliance, given that complying with the minimum wage legislation could be more difficult the higher the statutory pay level is set relative to prevailing wage levels.

Figure 5: Relationship between non-compliance rates and the Kaitz index in EU-SILC



Correlation between non−compliance rates and Kaitx index: 0.41

Notes: *The percentage of workers earning below 95% of the minimum wage is reported on the vertical axis, and the Kaitz index (the ratio between the minimum wage and the median wage) is reported on the horizontal axis. For Italy, characterised by multiple minimum wages set by collective bargaining at the sector level, the lowest pay floor is selected in defining the Kaitz index. For the other countries characterised by collective bargaining, the average of the minima set by collective contracts has been used (see section 'Data on national minimum wage legislation among EU Member States'). The sample includes workers aged 20–65. Countries in green have a non-compliance level below the EU27 median level in both SES and EU-SILC. Those in orange have a non-compliance level above the median in only one of the two databases. Those in red have a non-compliance level above the median according to both datasets. The correlation between non-compliance rates and the Kaitz index is of 0.41.*

Source: *EU-SILC 2018 edition*

Figure 5 shows the relationship between the Kaitz index and non-compliance rates estimated using the 2018 edition of EU-SILC. In the graph, countries are highlighted with the same colours as Figure 3, which were used to highlight the consistency of their non-compliance levels across estimates. Figure A1 in the appendix shows a graph analogous to Figure 5 derived from SES estimates, which provide findings that are generally consistent with those obtained from EU-SILC.

Considering the distribution of countries along the horizontal axis of Figure 5, most of them have a Kaitz index estimated between 0.4 and 0.6. It can be seen that there is a generally positive correlation between non-compliance and the Kaitz index. In particular, the correlation coefficient between the percentage of workers earning less than 95% of the minimum wage and the Kaitz index is 0.41. Moreover, countries in red, which are those with generally higher non-compliance levels considering both SES and EU-SILC estimates, tend to lie above the linear prediction of non-compliance provided by the Kaitz index. This implies that these countries have rates of non-compliance that are higher than expected even taking into account the level at which the minimum wage is set.

When studying non-compliance, it is also important to consider how many workers are paid a wage that is fairly close to the minimum wage. This exercise makes it possible to determine the size of the workforce around or just above the minimum wage. Table 4 reports the percentages of workers earning less than 95%, between 95% and 105%, and between 105% and 150% of the minimum wage. The first group represents workers whose wages do not comply with the minimum wage legislation. The second group represents workers who earn just the minimum wage. The last group represents employees with earnings above, but relatively close to, the minimum wage. These estimates are based on the 2018 edition of EU-SILC.

Table 4: Non-compliance rates and proportions of employees close to the minimum wage, EU-SILC 2018, main estimates (%)

Country code	Non-compliance	Minimum wage workers	Workers between minimum wage and 1.5 × minimum wage
AT	6.57%	2.15%	16.37%
BE	1.23%	0.51%	8.77%
BG	4.73%	3.41%	34.27%
CY	8.18%	4.07%	23.47%
CZ	1.18%	1.09%	10.12%
DE	9.65%	2.82%	16.21%

DK	**5.62%**	**1.25%**	**12.97%**
EE	**6.78%**	**2.16%**	**14.98%**
EL	**2.32%**	**1.41%**	**18.69%**
ES	**11.60%**	**2.32%**	**13.45%**
FI	**1.73%**	**0.92%**	**8.01%**
FR	**7.35%**	**1.89%**	**25.93%**
HR	**2.29%**	**3.49%**	**27.30%**
HU	**12.88%**	**5.78%**	**33.00%**
IE	**5.18%**	**3.35%**	**18.13%**
IT	**14.48%**	**2.80%**	**17.96%**
LT	**8.44%**	**4.57%**	**22.63%**
LU	**5.29%**	**4.67%**	**21.38%**
LV	**3.70%**	**2.75%**	**17.75%**
MT	**1.84%**	**1.84%**	**14.29%**
NL	**2.45%**	**0.92%**	**9.97%**
PL	**6.41%**	**7.57%**	**29.90%**
PT	**8.55%**	**9.13%**	**32.41%**
RO	**2.24%**	**1.87%**	**30.19%**
SE	**8.19%**	**2.17%**	**21.29%**
SI	**4.80%**	**1.34%**	**23.24%**
SK	**1.18%**	**2.19%**	**22.32%**

Note: *The percentages of employees earning below 95%, between 95% and 105%, and between 105% and 150% of the minimum wage are reported. The sample includes workers aged 20–65 and excludes workers with less than one year of tenure.*

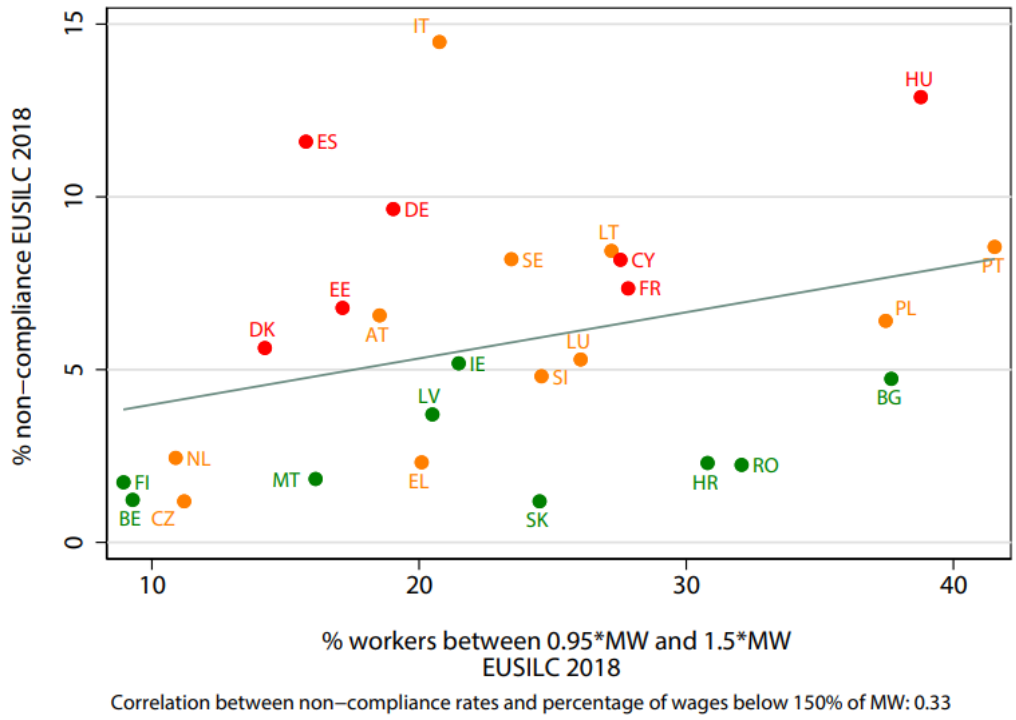
Source: *EU-SILC 2018 edition*

In Table 4, countries are highlighted in greener colours if the size of each group below or above the minimum wage is relatively small, and in redder colours if the size of each of the three groups of workers is relatively large compared with other countries. As can be seen, the percentage of workers earning between 95% and 105% of the minimum wage is generally quite low. Minimum wage workers range from almost 10% of employees in Portugal to levels below 1% in several countries. The incidence of workers paid between 105% and 150% of the minimum wage is generally larger, as it ranges between 34.3% in Bulgaria to 8% in Finland.

It is interesting to note that countries where non-compliance is relatively large (highlighted by red colours in the second column of Table 4), generally have higher percentages of workers with earnings at or just above the minimum wage level. The colours in the third and fourth columns of Table 4 are typically similar to the colours in the second column. Thus, the size of the workforce with earnings that are below a threshold close to the minimum wage is a good predictor of the incidence of non-compliance. This is because the proportion of workers below that threshold is generally larger when the minimum wage is set at a relatively high level. Moreover, the share of workers with

earnings close or below the minimum tends to be somewhat correlated with indicators such as the Kaitz index, which as mentioned is generally considered a good predictor of non-compliance.

Figure 6: Relationship between non-compliance rates and share of workers paid between 0.95 and 1.5 of minimum wage in EU-SILC



Note: *The percentage of workers earning below 95% of the minimum wage is reported on the vertical axis, and the percentage of workers earning between 95% and 150% of the minimum wage is reported on the horizontal axis. The sample includes workers aged 20–65. Countries in green have a non-compliance level below the EU27 median level in both SES and EU-SILC. Those in orange have a non-compliance level above the median in only one of the two databases. Those in red have a non-compliance level above the median according to both datasets. The correlation between non-compliance rates and the percentage of workers below 150% of the minimum wage is of 0.33.*

Source: *EU-SILC 2018 edition*

Figure 6 shows the relationship between non-compliance and the share of workers earning between 95% and 150% of the minimum wage according to EU-SILC.[9] The share of the workforce earning between 95% and 150% of the minimum wage according to EU-SILC ranges from around 9% in Finland and Belgium to 39% in Hungary. As can be seen, there is generally a positive relationship between the share of workers with earnings close to the minimum wage and non-compliance. The correlation coefficient between these rates is 0.33. Countries highlighted in red, which have a generally higher non-compliance level in both SES and EU-SILC, tend to lie above the linear prediction of non-compliance provided by the share of employees earning between 95% and 150% of the minimum wage. This implies that their non-compliance level is higher than could be inferred from the share of the workforce with earnings close to the minimum wage.

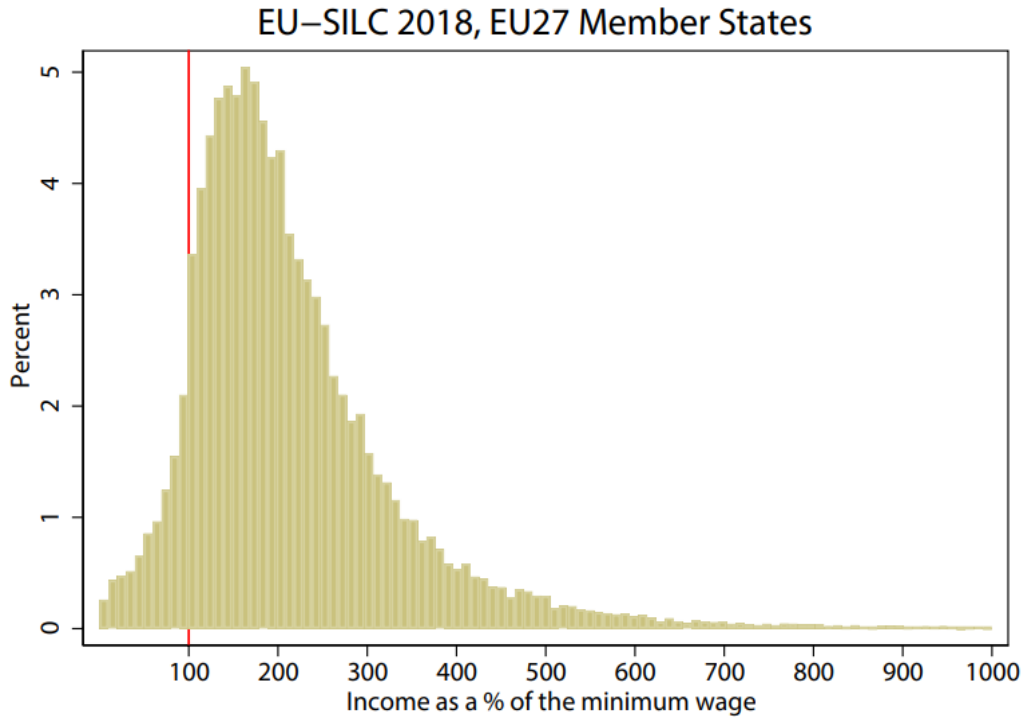
[9] Figure A2 provides the corresponding graph constructed using the 2018 edition of SES, which shows very similar results.

To show the workforce paid around the minimum wage, Figure 7 illustrates the wage distribution, expressed as a percentage of the national minimum wage. Figure A3 (in the appendix) provides the corresponding figure using SES. In countries with pay floors set by collective bargaining, wages are expressed as a percentage of the relevant sectoral minimum level. In each graph, a worker who is paid exactly the minimum wage level is labelled as earning 100% of the minimum wage. The vertical axis of the graphs shows the percentage of the population that earns the wage level corresponding to each bar of the histogram.

As can be seen, the size of the workforce to the right of the minimum wage (which is highlighted by the red line) is generally quite high, while it declines substantially to the left of the pay floor. This trend is particularly relevant in the case of SES, while the percentage of underpaid workers is larger in EU-SILC, as it amounts to around 8.1%. In both databases, the percentage of the workforce earning more than five times the minimum wage tends to be quite small.

Figure A4 in the appendix illustrates the wage distribution as a percentage of the minimum wage for each country and each database considered in this analysis. By comparing country-specific estimates across the two datasets, it emerges that the mass of observations to the left of the minimum wage is generally larger in EU-SILC in all countries considered in the analysis.

Figure 7: Wage distribution as a percentage of the minimum wage in the EU27, EU-SILC 2018



Note: *The graph shows the density function of wages expressed as a percentage of the national minimum wage in the EU27. For countries where minimum wages are set by collective contracts, sectoral minimum wages have been used. The vertical red line represents the minimum wage. The sample includes workers aged 20–65 years old. The proportion of workers earning less than 100% of the minimum wage is 8.1%. Sampling weights have been used in constructing the graph.*

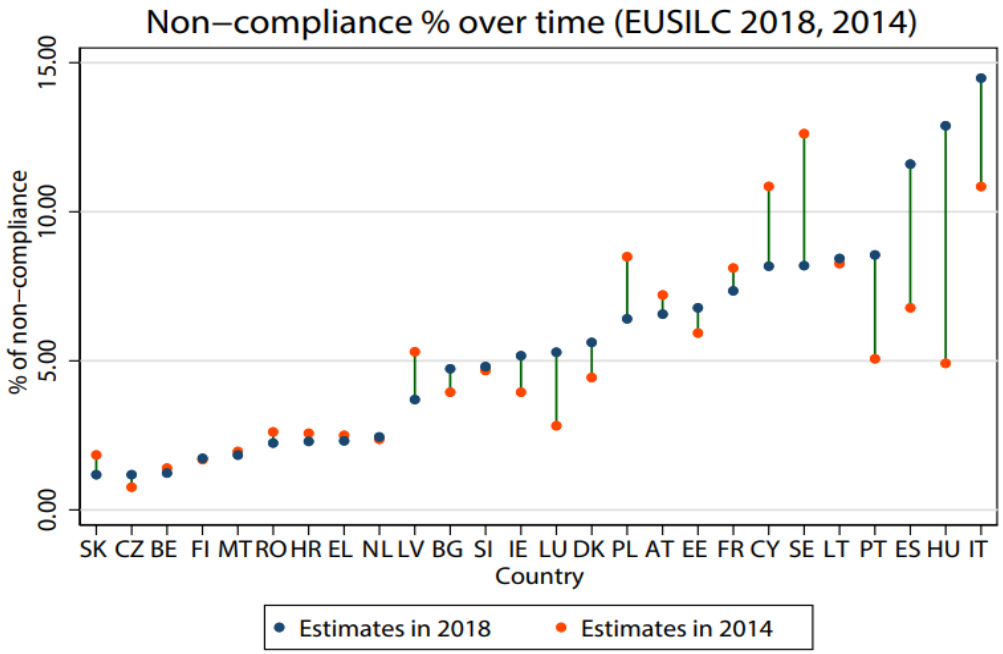
Source: *EU-SILC 2018 edition*

Trends in non-compliance over time

The longitudinal dimension of the data is used to explore the changes over time in non-compliance with wage regulations. Figure 8 compares the non-compliance estimates obtained for each country in the 2014 and 2018 editions of EU-SILC. The estimation approach adopted in this figure is the same as in Table 4. Figure 9 provides the corresponding evidence obtained by comparing non-compliance estimates in the 2014 and 2018 editions of SES.

The results show that non-compliance levels have been mostly stable over time when considered broadly across EU countries, since trends are mixed. Non-compliance rates have increased in around half of the countries, significantly so in Hungary, Spain, Italy, Portugal and Luxembourg. By contrast, they have declined over the period in around the other half of countries, significantly so in Sweden, Cyprus, Poland or Latvia. Overall, the population-weighted EU average increased from 6.6% in 2014 to 8.1% in 2018 according to EU-SILC estimates. Considering a fully balanced sample of countries, that is, only Member States in which non-compliance could be estimated in both 2014 and 2018, the population-weighted EU average increased at a slightly slower pace, from 6.6% to 7.7%.

Figure 8: Changes in non-compliance rates over time, EU-SILC 2014–2018

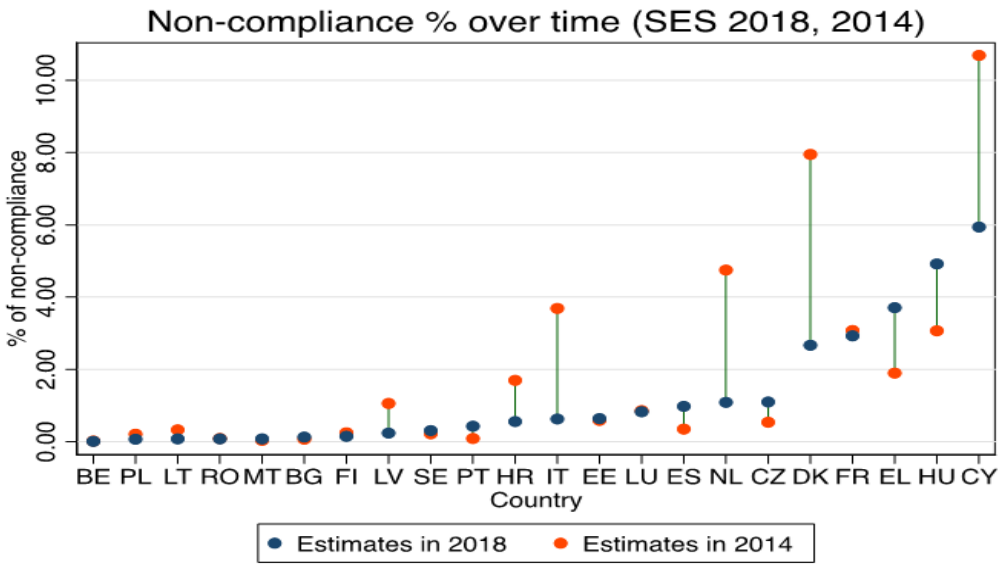


Note: *Below-minimum-wage workers are those earning less than 95% of the minimum wage. All statistics are weighted using sampling weights. The sample includes workers aged 20–65. The definition of income adopted is consistent across editions.*

Sources: *EU-SILC 2014 and 2018 editions*

As can be seen from Figure 9, when considering SES, the trend in non-compliance has been mostly flat and close to zero. Notable exceptions to this trend include Hungary, Greece, Czechia and Spain, which were characterised by an upward trend in non-compliance across time. In contrast, Cyprus, Denmark, the Netherlands, Italy, Croatia and Latvia were characterised by a reduction in non-compliance levels according to these estimates.

Figure 9: Changes in non-compliance rates over time, SES 2014–2018



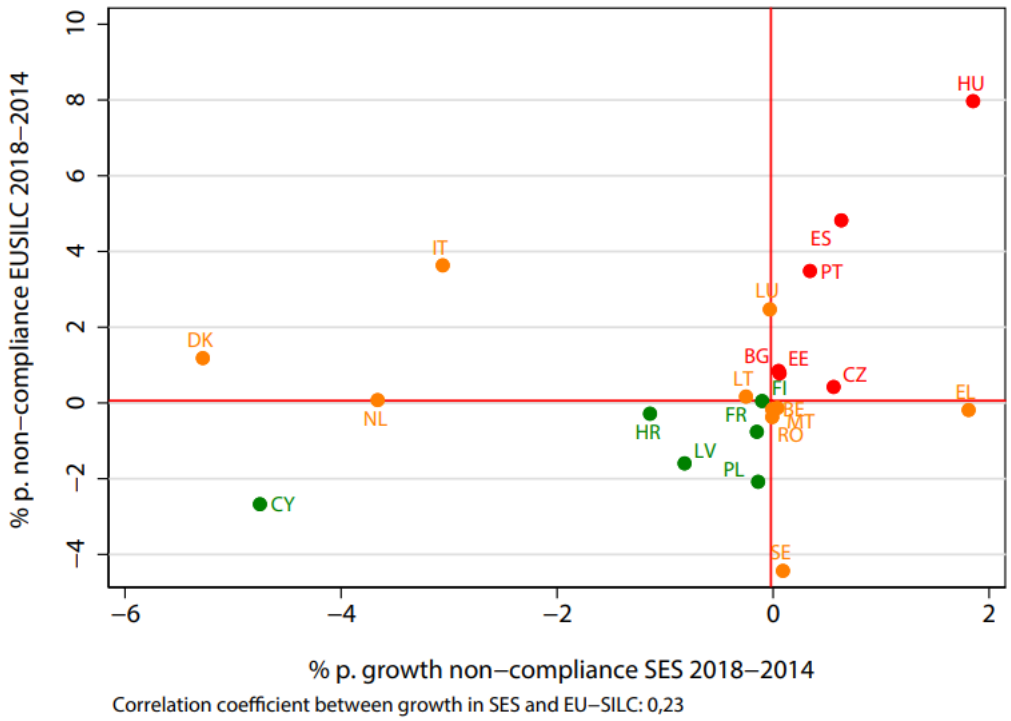
Note: *Below-minimum-wage workers are those earning less than 95% of the minimum wage. All statistics are weighted using sampling weights. The sample includes workers aged 20–65 and excludes apprentices. The definition of income adopted is consistent across editions.*

Sources: *SES 2014 and 2018 editions*

It is particularly interesting to compare the trends in non-compliance rates derived from the two alternative datasets used. Figure 10 compares the growth in percentage points of non-compliance rates estimated using EU-SILC, and the same growth obtained from the 2018 and 2014 editions of SES. In the graph, the horizontal red line represents the median growth in non-compliance across Member States estimated using EU-SILC. The vertical red line is the corresponding median estimated using SES. As can be observed, both medians are very close to zero, reflecting the overall stability in the estimates between 2018 and 2014. The correlation coefficient is positive and equal to 0.23, which shows that trends in non-compliance tend to be relatively similar across databases.

Figure 10 highlights, using different colours, which countries were characterised by the strongest growth in non-compliance according to both datasets (EU-SILC and SES), and also which were instead characterised by the strongest reduction. Countries are highlighted in green if the growth in non-compliance is below the EU-level median in both SES and EU-SILC. These are Cyprus, the Netherlands, Croatia, Poland, France and Finland. Countries in orange are characterised by growth in non-compliance above the EU-level median in only one of the two databases. These are Denmark, Italy, Lithuania, Luxembourg, Belgium, Malta, Sweden and Czechia. Countries in red are characterised by growth in non-compliance above the median in both SES and EU-SILC. These are Hungary, Greece, Spain, Portugal, Bulgaria and Estonia. Among these, Hungary's growth in non-compliance levels appears to be among the highest across all countries according to both EU-SILC and SES. In contrast, Cyprus has one of the consistently strongest reductions in non-compliance across time.

Figure 10: Comparison between the growth of non-compliance in SES 2014–2018 and in EU-SILC 2014–2018



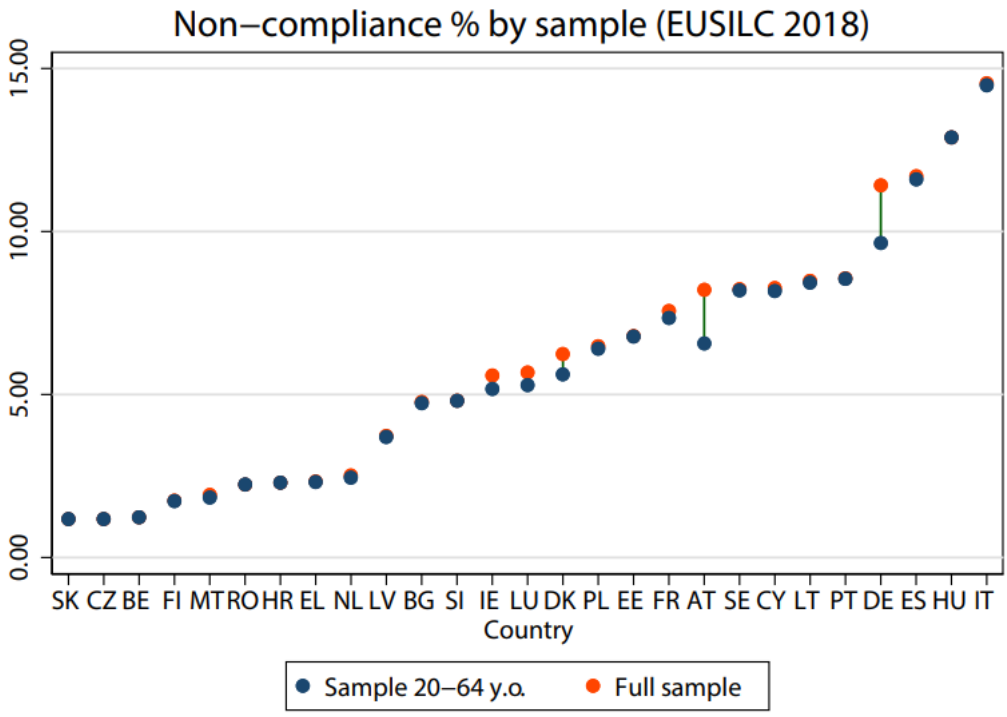
Note: *Below minimum wage workers are those earning less than 95% of the minimum wage. All statistics are weighted using sampling weights. The sample includes workers aged 20–65 and excludes apprentices (in SES). The definition of income adopted is consistent across editions. Countries in green experience growth in non-compliance below the median in both databases. Countries in orange experience growth in non-compliance above the median in only one of the two databases. Countries in red experience growth in non-compliance above the median in both databases. The correlation coefficient between the growth in SES and EU-SILC is of 0.23.*

Sources: *EU-SILC and SES 2014 and 2018 editions*

Sensitivity analysis of the quantification of non-compliance: The roles of young workers and of subminimum rates

When estimating non-compliance, it is important to acknowledge that its level may depend on the choices that have been made in constructing this parameter. In this section, several alternative definitions of non-compliance are shown, which are derived using different approaches along two dimensions: the sample selection choice, and the consideration of subminima for specific countries.[10] Overall, results appear to be qualitatively similar across estimation approaches, which suggests that the method adopted is quite robust.

Figure 11: Comparison between non-compliance rates in the restricted sample of workers aged 20–65, and in the full sample of workers aged 14–65, EU-SILC 2018



Note: *Below-minimum-wage workers are those earning less than 95% of the minimum wage. All statistics are weighted using sampling weights. The sample includes workers aged 20–65 for estimates highlighted in blue, and workers aged 14–65 for estimates highlighted in orange. The definition of income is consistent across sample selection choices.*

Source: *EU-SILC 2018 edition*

Figure 11 compares non-compliance estimates obtained from EU-SILC using the restricted sample of workers aged 20–65 and the corresponding estimates obtained by considering the full sample of employees aged 14–65. Figure A5 in the appendix provides the corresponding estimates by sample obtained from the SES database.

As can be seen, excluding younger workers is a conservative approach, since non-compliance levels are generally higher when the entire sample is used. However, differences between these estimates

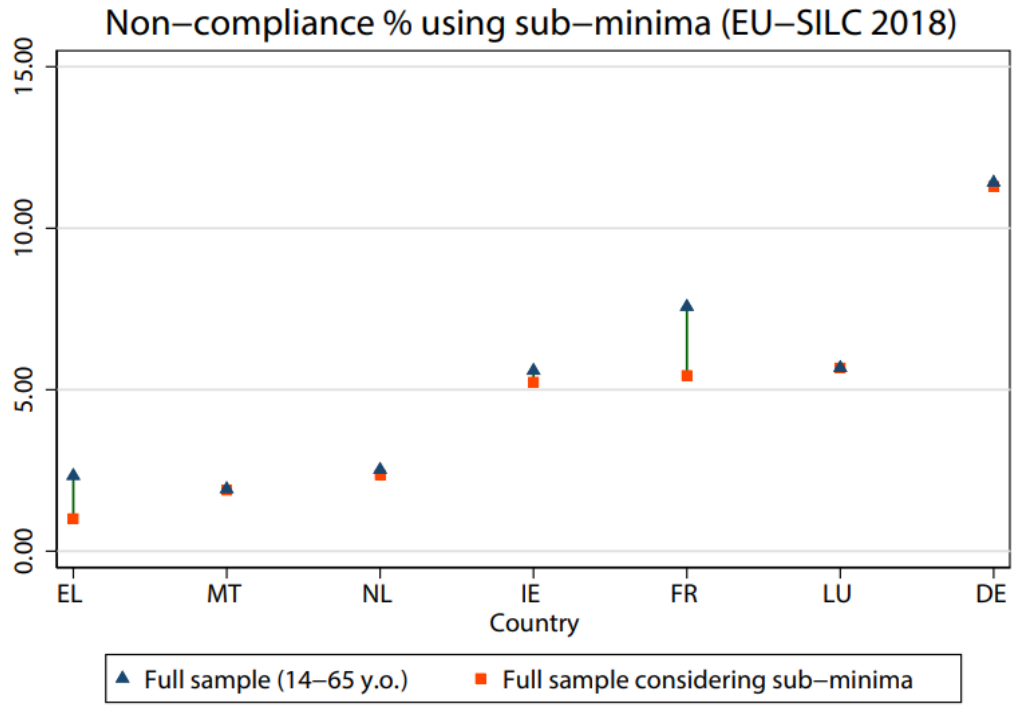
[10] For those cases in which they are used and available (see section 'Measurement issues and methodological aspects').

are relatively small. Younger workers are considered to be below the nationwide minimum wage even if their wage may comply with a subminimum level or with an exemption clause. The similarity across estimates of non-compliance obtained in the restricted and full samples suggests that such subminima play only a minor role in affecting our results. The largest discrepancies are observed in Germany, where workers below 18 years old are exempt from the nationwide minimum wage, and in Austria.

An alternative approach to deal with the influence of subminimum rates would be to consider them directly, applying the relevant rates to younger workers. This potentially reduces the meaningfulness of cross-country comparisons, since non-compliance is estimated with respect to a pay floor that is not always the nationwide statutory one for all countries. Nevertheless, we have followed this approach as a further robustness exercise. The list of subminima for each country is reported in Table A3 in the appendix, while Table A5 summarises the estimation approach adopted to considering these exemptions or reduced pay floors.

Figure 12 reports the comparison between non-compliance estimates computed in the full EU-SILC sample of workers ignoring subminima, and the corresponding estimates that impute to each worker potential subminimum rates. As can be observed, considering subminimum rates reduces the incidence of non-compliance. However, the discrepancy in the results from adopting these two alternative approaches is extremely small and barely noticeable (except in France and Greece, to a lower extent).

Figure 12: Comparison between non-compliance estimated using subminimum wage levels and using only the main nationwide level, EU-SILC 2018



Note: *Below-minimum-wage workers are those earning less than 95% of the minimum wage. All statistics are weighted using sampling weights. The sample includes workers aged 14–65. For estimates marked with blue triangles, only the main nationwide minimum wage level is considered. For estimates marked with red squares, the subminimum rates provided by Table A3 have been considered. The definition of income is consistent across estimates.*

Source: *EU-SILC 2018 edition*

Figure A6 compares non-compliance estimates computed in the full SES sample of workers ignoring subminima with the corresponding estimates that impute potential subminimum rates to workers. The number of countries for which this approach was possible was lower when using SES, mainly because the information on individuals' age is available only in ranges (see Table A5 for a summary of the estimation approach adopted when considering subminima). In this case too, considering subminimum rates reduces the incidence of non-compliance. The discrepancy between the results adopting these two alternative approaches is larger using SES than EU-SILC. The difference may reflect the more accurate information on pay levels available through SES.

Composition and characteristics of underpaid employment

This section discusses the demographic characteristics of employees paid less than the minimum wage; explores the relationship between working hours and the incidence of non-compliance with the minimum wage; and describes in detail the sectoral and occupational composition of underpaid employment.

Individual characteristics of underpaid employees

Table 5 provides a set of descriptive statistics derived from EU-SILC. For each variable considered, the second column reports the average computed on the sample of workers below the minimum wage, and the third column shows the average computed on the rest of the sample. The fourth column reports a test of the significance of the difference between the two means.

Starting from the upper part of table, it can be seen that workers below the minimum wage tend to be younger, and are more likely to be women, to be employed on a fixed-term contract, to work fewer hours and to work on a part-time contract. The result on hours worked suggests that workers below the minimum wage are more likely to be less intensively employed, as they are more likely to work part time. However, they also work shorter schedules on average. When computing hours worked per week separately for full-time and part-time workers below and above the minimum wage, those below the minimum wage still work fewer hours, particularly when employed part time. For full-time workers, however, the difference in working schedules is quite small between workers above and below the minimum wage. Workers below the minimum wage also have generally lower levels of education, and they are more likely to be employed by smaller firms. This last result may help explain why non-compliance is generally larger when estimated on the basis of EU-SILC, which also includes small firms.

Table 5: Descriptive statistics of workers paid less than the minimum wage and of the rest of the population, EU-SILC

Averages among workers above/below 95% of the minimum wage			
Characteristic	**Workers below 0.95 x minimum wage**	**Workers at or above 0.95 x minimum wage**	**Significance of difference**
Age	38.1	44.1	** (-)
% women	55.88%	46.70%	** (+)
% fixed-term contract	41.00%	9.22%	** (+)
Hours of work/week	35.1	38.2	** (-)
Hours of work if part-time	23.2	24.4	**(-)
Hours of work	40.3	40.7	*(-)
If full-time	30.8	15.8	** (+)
% part-time contract	30.80%	15.80%	** (+)
% 1-10 firm size	39.79%	19.09%	** (+)
% 11-49 firm size	31.75%	32.43%	(-)
% 50+ firm size	28.45%	48.48%	** (-)
% basic education	7.26%	2.92%	** (+)
% secondary education	57.49%	36.87%	** (+)

Notes: *Below-minimum-wage workers are those earning less than 95% of the minimum wage. All statistics are weighted using sampling weights. ** Significant at 1% level; * significant at 5% level. The significance of the difference in means between groups is calculated using the P-value of the two-sided t-test.*

Source: *EU-SILC 2018 edition*

Table A7 provides a similar set of descriptive statistics derived from SES. Also in SES, workers below the minimum wage are more likely to be women, on fixed-term contracts, younger and less educated. Similarly, they are more likely to work part time and work fewer hours, a result that is consistent with evidence on working time derived from EU-SILC. In comparing the results, note that hours worked are self-reported in EU-SILC, so they are more likely to include time spent on irregular jobs as well, while they are employer-reported in SES. The next section provides a more detailed analysis of the relationship between working hours and non-compliance with the minimum wage, while Box 4 provides an insight using information on the quality of jobs.

Box 4: The quality of jobs for underpaid workers

Exploiting data from the 2015 edition of the EWCS, which contains very detailed information about workers and jobs' characteristics, several dimensions of the jobs are analysed, and workers below and above the minimum wage are compared along these dimensions.[11] In particular, the focus is on four core dimensions of jobs: working hours, job security, work intensity and pace of work.

Workers below the minimum wage rarely report working (on average) more than 40 hours a week (only 9% versus 29% for those above the minimum wage), they are predominantly employed in part-time jobs (70% versus 13%) and also they are predominantly in involuntary part-time work (the hours they would desire to work being more than their reported weekly working hours). In particular, 35% of workers below the minimum wage report being involuntary part-timers, compared with only 4% of the rest of workers (see upper left panel of Figure 13).

In terms of job security, workers below the minimum wage report being more insecure about losing their current jobs in the next six months (25% versus 16%), but if they lose or quit their job they do not seem more worried about not finding one at a similar salary (see upper right panel). Increasing effort during work time has been widely recognised in recent decades as a potential cause for concern and major stressor (Green and McIntosh, 2001; Green, 2006).

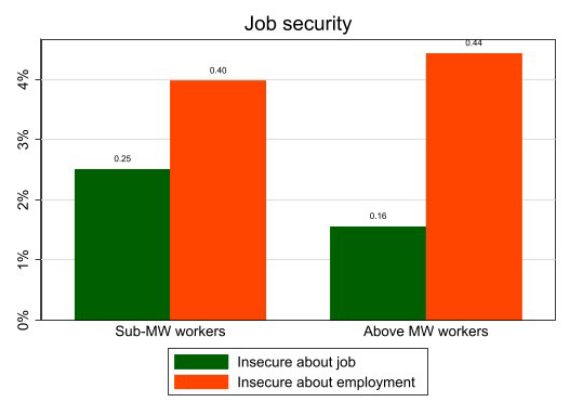
Work intensity means the intensity of work effort during work time, and it is generally expressed in terms of a range of demands placed upon workers, whether physical, cognitive or emotional. The jobs of below-minimum-wage workers appear less intense, in terms of (high) speed, (working to) tight deadlines and the need to work during free time to meet work demands (see lower left panel). This could be explained by the sectors in which they work (less manufacturing, more services) and by the fact that they work more on temporary and part-time contracts. For example, 49% of workers below the minimum wage report working to tight deadlines compared with 64% of workers above the minimum wage. Moreover, less control is exerted over the

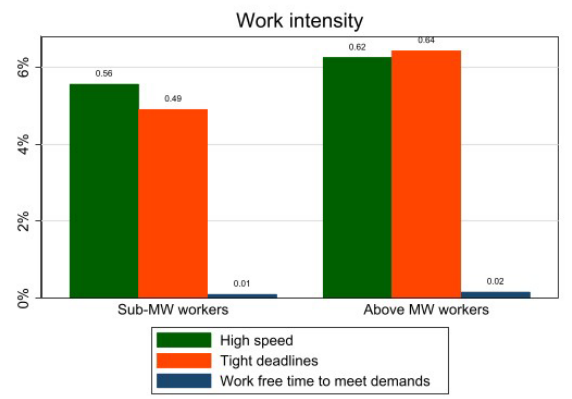
[11] Wages are reported net of taxes, as described in 'Choice of cross-country data sources'. We therefore follow the same procedure as used for EU-SILC for countries where gross wages were not available to identify workers below and above minimum wages. Owing to the small sample size at country level, more detailed analysis cannot be carried out using the EWCS.

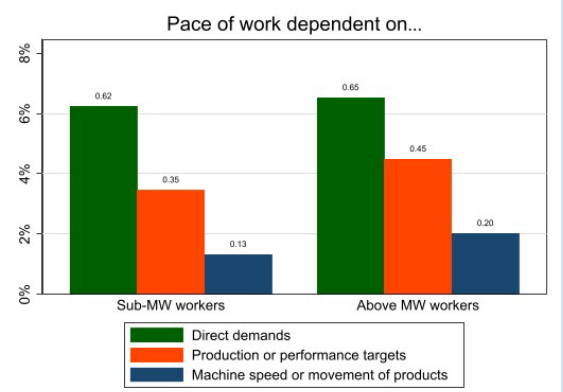
performance/productivity of below-minimum-wage workers, while the fact that their work is less dictated by the movement of machines and products (see lower right panel of Figure 13) may be explained by the fact that non-compliance with minimum wages is lower in manufacturing (different sectoral composition of the two groups of workers).

Overall, jobs paid below the minimum wage tend to be characterised by involuntary part-time work and low job security, but low work intensity. The EWCS is very informative about working conditions experienced by workers. However, the results must be interpreted with caution because of several caveats; for example, sample sizes are small, data are self-reported and earnings are available only as net of taxes.

Figure 13: Working conditions for workers below and above minimum wages







Source: *EWCS 2015*

Relationship between working hours and non-compliance

In analysing non-compliance, it is important to note that working hours could be a significant margin of adjustment employed by firms. Employers could be paying the right monthly wage rate in compliance with the legislation, while employing workers on longer schedules. On the other hand, low-paid workers could be concentrated among employees with discontinuous work records, often characterised by shorter working schedules.

Table 6: Average working hours above and below the minimum wage by country and dataset, EU-SILC 2018 edition

Country code	Hours worked		Hours worked if full-time workers		Hours worked if part-time workers	
	Below minimum wage	Above minimum wage	Below minimum wage	Above minimum wage	Below minimum wage	Above minimum wage
AT	34.4	37.8	41.4	42.2	22.3	24.0
BE	31.5	36.4	39.4	40.3	23.7	26.2
BG	39.4	40.5	42.5	40.9	24.5	22.0
CY	38.3	39.0	41.0	40.0	22.6	20.7
CZ	36.0	40.7	39.8	41.2	23.1	22.2
DE	31.5	38.0	40.3	42.6	19.9	24.2
DK	31.3	37.3	36.4	38.4	17.0	25.5
EE	37.8	39.7	41.1	40.8	24.7	22.8
EL	33.1	39.0	40.8	40.7	19.5	20.2
ES	37.3	38.3	40.9	40.1	21.6	21.4
FI	31.4	38.0	38.3	39.4	21.4	21.7
FR	35.2	37.7	40.2	39.7	26.6	25.9
HR	40.2	40.3	42.0	40.8	22.9	20.0
HU	38.8	40.0	40.0	40.3	25.6	25.3
IE	31.6	34.9	38.7	39.5	20.7	18.9
IT	35.5	37.1	39.6	39.0	26.5	25.1
LT	37.9	39.3	39.9	40.1	22.5	19.7
LU	36.7	41.0	41.1	44.0	28.6	25.7
LV	37.6	39.4	40.4	40.2	19.2	21.0
MT	30.4	39.4	40.4	40.4	17.3	20.4
NL	26.7	33.0	39.0	39.1	20.6	24.8
PL	39.6	40.4	41.4	41.2	24.8	23.8
PT	39.1	40.6	41.4	41.4	21.4	19.9
RO	40.0	40.7	40.2	40.8	32.4	25.6
SE	36.1	39.0	40.2	40.9	27.9	28.5
SI	39.3	40.9	40.7	41.7	23.2	22.0
SK	37.1	40.5	40.6	41.0	20.1	22.6
TOTAL	35.0	38.3	40.3	40.7	23.1	24.5

Note: *Below-minimum-wage workers are those earning less than 95% of the minimum wage. All statistics are weighted using sampling weights. The sample includes workers aged 20–65. Data for Romania and Slovenia is missing, as it was not possible to consistently compute non-compliance for this country using EU-SILC.*

Source: *EU-SILC 2018 edition*

Table 6 shows, for each EU Member State, the average number of hours worked per week in the EU-SILC database, reported separately for workers below and above the minimum wage. The same statistic has been computed on SES and is reported in Table A9. As can be observed, in general a similar tendency emerges from each dataset. Underpaid workers have shorter schedules, as they work on average 35 hours per week (compared with more than 38 in the rest of the population) according to EU-SILC, and 26 hours per week (instead of 35) according to SES estimates. This holds true in virtually all countries considered; the only exceptions are the SES estimates for Hungary, Poland and Romania, three eastern European countries where working schedules are generally longer than the EU average.

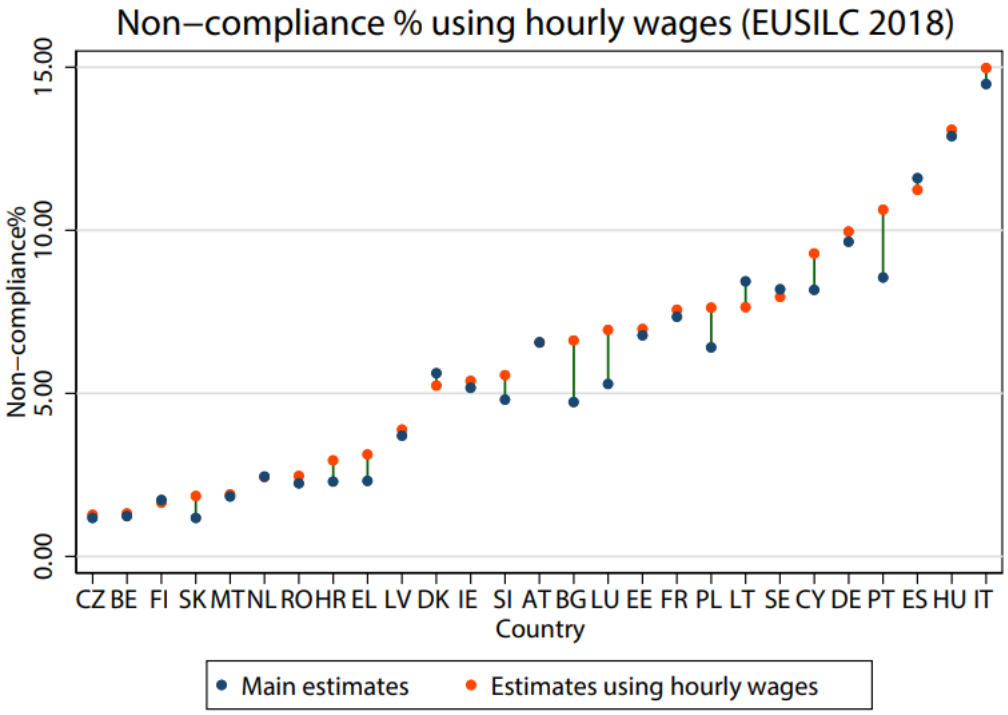
When we consider only part-time work, the tendency of workers paid below the minimum wage to have shorter schedules is confirmed on the EU-level average. There are, however, several country-specific exceptions. Full-time workers paid less than the minimum wage work on average longer schedules in 10 out of the 27 countries considered. Part-time workers paid below the minimum wage work longer schedules in 16 out of the 27 countries.

The evidence of Table 6 suggests that underpaid workers tend to be generally less attached to the labour market, since they are more likely to work part time. They also tend to have shorter schedules than full-time or part-time workers above the minimum wage, although this is not always the case for all countries. These tendencies could reflect different sorting of low-paid occupations into typically shorter schedules. They could also reflect the use of informal secondary jobs to complement regular income, even if no direct evidence of this mechanism can be provided.

In order to provide a more precise account of the effect that heterogeneities in working hours could have on the estimates of non-compliance, non-compliance is computed using hourly wages instead of their monthly level. Figure 14 shows the level of non-compliance estimated using hourly wages in EU-SILC and compares these results with our main estimates based on monthly wages. As can be observed, non-compliance is more likely to be higher when hourly wages are considered, although in several countries it is relatively similar using either hourly or monthly wages. Non-compliance with hourly minimum wages becomes higher in many countries, mainly in Portugal, Bulgaria, Poland, Luxembourg, Cyprus or, to a lower extent, in Croatia, Greece, Slovenia, Italy or Germany among others. However, the population-weighted EU average level of non-compliance is only marginally affected, as it grows from 8.1% to 8.4%. In general, when non-compliance is estimated using self-reported data, misreporting of actual working schedules could increase the measurement error, and this could in part explain such differences in the results. Nevertheless, the results suggest that hours worked are an important factor to consider when estimating non-compliance. Some employers could be using longer hours as a way to not comply with minimum wage regulations, even though they comply with the monthly minimum wage. The higher incidence of non-compliance when using hourly wages in Figure 14 seems consistent with this hypothesis.

Figure A7 replicates the analysis on non-compliance using hourly wages using SES. As can be seen, in this case too, noticeable differences emerge regarding several countries, even though non-compliance is not always underestimated when using monthly wages in this case. Countries where non-compliance appears to be particularly more prevalent when using hourly wages are Romania, Poland, Bulgaria, Estonia and Lithuania, among others.

Figure 14: Comparison of non-compliance rates using hourly wages and hourly pay floors with the main approach, EU-SILC 2018



Note: *Below-minimum-wage workers are those earning less than 95% of the minimum wage. All statistics are weighted using sampling weights. The sample includes workers aged 20–65. Hourly wages are obtained by dividing monthly wages by the reported number of hours worked, scaling up weekly amounts when necessary. Hourly minimum wages are obtained by scaling down the monthly rate, assuming a 40-hour working week.*

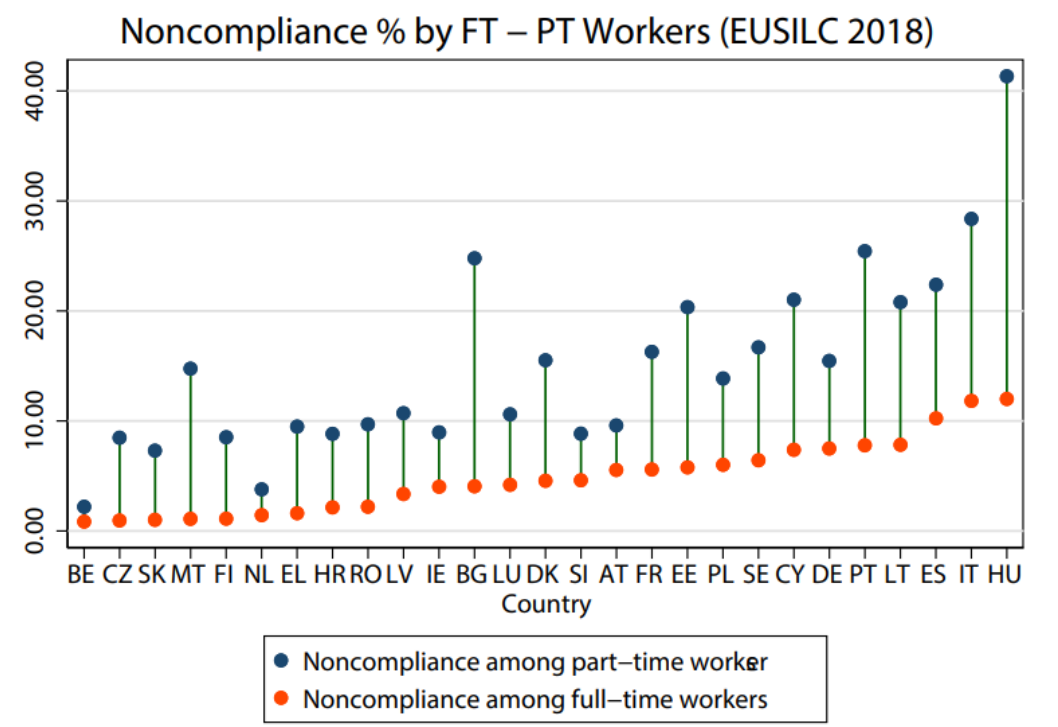
Source: *EU-SILC 2018 edition*

Box 5: Non-compliance estimates among part-time and full-time workers

To further consider the influence of working schedules on estimates of non-compliance, the EU-level average non-compliance is estimated separately for part-time workers and full-time workers. Using the main income definition and the approach detailed in 'Quantification of non-compliance', non-compliance is 15.7% among part-timers and 6.4% among workers with a full-time contract. It follows that, on average, non-compliance is much higher among part-time workers.

To further illustrate this point, Figure 15 reports, for each country, the non-compliance levels among part-time workers and full-time workers. As can be seen, non-compliance is considerably higher among part-time workers in all countries. Another tendency is that the difference in non-compliance among the two types of contracts is higher the higher the overall level of non-compliance in the country. There are some countries where this gap in non-compliance is particularly large, namely Hungary, Cyprus, Estonia, Bulgaria and Malta.

Figure 15: Non-compliance with minimum wages estimated separately by full-time and part-time contracts



Note: *Below-minimum-wage workers are those earning less than 95% of the minimum wage. All statistics are weighted using sampling weights. The sample includes workers aged 20–65.*

Source: *EU-SILC 2018 edition*

Incidence of non-compliance across industries and occupations

In this section, a more detailed analysis of the sectoral and occupational composition of the workforce below the minimum wage is provided. Table 7 provides an estimate of non-compliance across sectors and occupations, as derived from EU-SILC. Each cell of the table reports the percentage of employees earning less than 95% of the minimum wage within a sector and occupation group. In the table, green refers to lower non-compliance levels, and red to higher levels.

In Table 7, non-compliance is lowest among technicians and skilled workers (4.75%). It is highest among manual (11.6%) and clerical workers (10.5%). The group of managers and professionals has an incidence of non-compliance just below the total (7.4%).. However, this last occupational group may include several low-paid and relatively autonomous activities, which may play a role in explaining the result. This consideration is consistent with the prevalence of non-compliance across sectors for this occupational group, as it is highest in agriculture and construction and in trade, transport and tourism, where the incidences of small businesses and of low-paid professional activities tend to be high.

Considering sectors, non-compliance is relatively high in agriculture and construction, in trade, transport and tourism, and in other services. Manufacturing, on the other hand, is a sector where non-compliance is generally low. Considering sectors and occupations jointly, some estimates tend to be quite high. For example, non-compliance among manual workers in the 'other services' sector

is around 18%. These results, especially in the case of EU-SILC, should be treated with caution given the small (within-cell) sample sizes.

Table 7: Scoreboard on the incidence of non-compliance across sectors/occupations, EU-SILC (%)

Sector	Occupation				
	Managers, professionals	Technicians, skilled workers	Clerical workers	Manual workers	TOTAL
Agriculture, construction	11.32%	4.22%	8.46%	15.64%	13.13%
Manufacturing, mining, commodities	5.71%	2.28%	6.65%	6.95%	5.93%
Trade, transport, tourism	12.53%	5.91%	11.34%	9.69%	10.94%
Other services	6.14%	5.38%	10.44%	18.04%	8.19%
TOTAL	7.38%	4.75%	10.47%	11.62%	8.74%

Note: *Below-minimum-wage workers are those earning less than 95% of the minimum wage. All statistics are weighted using sampling weights. Agriculture and constructions are bundled together because of small sample size issues arising for both sectors.*

Source: *EU-SILC 2018 edition*

Box 6: Non-compliance across sectors and occupations using SES

The SES database contains a larger number of observations and more detailed information on sectors and occupations. For this reason, it is particularly appropriate for a more detailed analysis of non-compliance within narrower occupation and sector cells. Table 8 replicates the analysis described in Table 7, this time using SES.

The results show that non-compliance is highest in the services sectors and among manual and clerical occupations. Managers and professionals show a very low level of non-compliance, given that low-paid occupations typically classified as professional activities are less common in relatively large firms. In this case, non-compliance at the EU level appears to be most prevalent among manual workers in the trade, transport and tourism sector.

Given the larger sample size, SES allows for a more detailed decomposition of non-compliance across sectors and occupations. Table 9 provides estimates of non-compliance using a more granular definition of sectors. The results show that non-compliance is generally higher in the tourism sector than in the transport or trade sector. Moreover, it is quite high in 'other services'.

With respect to occupations, non-compliance also seems significant among technicians and skilled workers within these tertiary sectors.

Table 8: Scoreboard on the incidence of non-compliance across sectors and occupations, SES (%)

Sector	Occupation				
	Managers, professionals	Technicians, skilled workers	Clerical workers	Manual workers	TOTAL
Construction	0.2	0.4	1.0	0.9	0.7
Manufacturing, mining, commodities	0.1	0.2	0.5	0.8	0.6
Trade, transport, tourism	0.5	0.6	1.5	3.6	1.6
Other services	0.3	0.6	1.1	2.5	1.8
TOTAL	0.4	0.6	1.2	2.3	1.4

Note: *Below-minimum-wage workers are those earning less than 95% of the minimum wage. All statistics are weighted using sampling weights. Agriculture is not covered by the data. Colours toward red indicate higher non-compliance rates in the cell with respect to other sector-occupation combinations.*

Source: *SES 2018 edition*

Table 9: Scoreboard on the incidence of non-compliance across detailed sectors and occupations, SES (%)

Sector	Occupation				
	Managers, professionals	Technicians, skilled workers	Clerical workers	Manual workers	TOTAL
Manufacturing, mining, commodities	0.1	0.2	0.5	0.8	0.6
Construction	0.2	0.4	1.0	0.9	0.7
Trade	0.2	0.4	1.2	2.0	1.4
Transport	0.3	0.4	0.7	1.9	1.3
Tourism	0.7	2.6	2.3	4.2	3.8

Communication, finance	0.2	0.5	0.9	3.4	0.6
Real estate, professional activities, support services	0.3	0.8	1.9	3.4	2.1
Public services, education, health	0.7	0.5	1.5	3.7	1.5
Other services	0.6	2.5	1.9	5.0	3.1
TOTAL	0.4	0.6	1.2	2.3	1.4

Note: *Below-minimum-wage workers are those earning less than 95% of the minimum wage. All statistics are weighted using sampling weights. Agriculture is not covered by the data. Colours toward red indicate higher non-compliance rates in the cell with respect to other sector-occupation combinations.*

Source: *SES 2018 edition*

In order to illustrate non-compliance at the sectoral level in more detail by Member State, Table 10 provides estimates by industry and Member State. This scoreboard allows us to uncover more nuanced mechanisms behind non-compliance estimates within each country. For example, among countries with high non-compliance levels, in Hungary this problem is concentrated mostly in some service sectors, while Greece and Cyprus have more even spreads of non-compliance across industries, and it is particularly prevalent in the tourism sector. Similarly, it emerges that manufacturing is an industry with an overall low level of non-compliance, but in some countries, in particular Cyprus, Slovenia and France, non-compliance tends to be relatively high within this sector.

Table 10: Scoreboard on the incidence of non-compliance across detailed sectors and Member States, SES (%)

Country code	Sector									
	Manufacturing, mining, commodities	Construction	Trade	Transport	Tourism	Communication, finance	Real estate, professional activities, support services	Public services, education, health	Other services	TOTAL
BE	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
BG	0.11	0.02	0.20	0.08	0.31	0.01	0.21	0.09	0.09	0.13
CY	7.03	5.99	10.00	5.38	10.72	0.36	3.41	1.57	13.03	5.94
CZ	0.54	1.94	1.29	0.33	4.39	0.27	3.24	0.34	1.41	1.10
DE	0.64	0.73	2.10	3.27	6.75	0.94	2.80	0.54	4.06	1.70
DK	0.60	0.48	2.98	2.04	5.72	0.31	1.95	3.97	2.40	2.67
EE	0.38	0.61	0.53	0.51	0.94	0.27	2.38	0.18	1.23	0.65

EL	1.74	2.92	2.36	1.65	10.67	0.55	3.18	1.24	6.99	3.71
ES	0.34	0.46	0.92	0.53	1.46	0.80	1.50	0.96	2.36	0.98
FI	0.02	0.25	0.10	0.04	0.17	0.04	0.30	0.17	0.47	0.15
FR	1.78	1.59	2.95	1.34	3.71	0.86	3.71	3.70	4.96	2.92
HR	0.69	0.12	0.65	0.28	1.82	0.09	1.13	0.24	0.34	0.56
HU	0.11	0.46	0.02	0.37	0.37	0.02	0.31	13.69	7.54	4.92
IT	0.19	0.48	0.29	0.16	0.93	0.64	1.21	0.90	1.82	0.63
LT	0.02	0.00	0.18	0.04	0.32	0.00	0.14	0.06	0.17	0.08
LU	0.97	0.55	0.75	1.19	1.81	0.74	1.36	0.24	0.00	0.82
LV	0.11	0.13	0.16	0.04	0.13	0.02	0.13	0.63	0.08	0.24
MT	0.00	0.20	0.00	0.00	0.00	0.00	0.03	0.21	0.00	0.08
NL	0.62	0.66	1.53	0.84	2.10	0.51	1.76	0.57	2.46	1.09
PL	0.06	0.18	0.08	0.23	0.13	0.01	0.08	0.04	0.03	0.07
PT	0.16	0.29	0.32	0.25	1.73	0.02	1.08	0.20	0.28	0.43
RO	0.08	0.27	0.00	0.00	0.05	0.00	0.05	0.00	1.48	0.08
SE	0.06	0.17	0.42	0.37	1.25	0.16	0.89	0.14	1.03	0.31
SI	2.75	2.29	3.34	2.06	4.49	1.75	3.89	2.73	6.62	2.98
SK	0.38	0.33	0.54	0.43	1.06	0.06	0.83	0.42	1.73	0.50
TOTAL	0.56	0.73	1.42	1.33	3.83	0.62	2.10	1.51	3.07	1.43

Note: *Below-minimum-wage workers are those earning less than 95% of the minimum wage. All statistics are weighted using sampling weights.*

Source: *SES 2018 edition*

Conclusions, challenges, limitations and improvements for data availability

This paper provides a comprehensive statistical portrait of non-compliance estimated using the best available harmonised cross-country databases for the EU27. Quantifying the size of the workforce that is paid below the minimum wage is not easy. Estimates crucially depend on the quality of the data available, and on the coverage of the sample. They are also sensitive to the estimation approach that is adopted.

Some common tendencies emerge clearly from our quantification exercise. The data suggest that non-compliance in the EU27 ranges between 0.01% in Belgium using SES and 14.5% in Italy using EU-SILC. The population-weighted EU average is around 8.1% based on EU-SILC and 1.43% based on SES. Countries where non-compliance is higher than the median level according to both EU-SILC and SES data are Cyprus, Denmark, Estonia, France, Germany, Hungary and Spain. Countries with non-compliance levels consistently lower than the median are Belgium, Bulgaria, Croatia, Finland, Latvia, Malta, Romania and Slovakia. Finally, no clear trends emerge concerning trends in non-compliance over time, even if we restrict the analysis to only a 4-year period between 2014 and 2018.

The analysis documented which workers were most likely to be paid less than the minimum wage. They are more likely to be younger, women, and fixed-term and part-time workers. Non-compliance is higher in the services, construction and agriculture sectors, and relatively lower in the manufacturing sector. Non-compliance is also higher when estimated using hourly instead of monthly wages, a tendency suggesting that some employers could be using longer hours as a way to not comply with minimum wage regulations, even though they comply with monthly minimum wages.

The results call for a reflection on the quality of data that can be used to quantify non-compliance with minimum wages in the EU Member States. The measurement of non-compliance requires the use of precise information on wages. In addition, the measurement of working hours is important for the effective enforcement of wage violations, since it constitutes a considerable margin of adjustment through which many violations might take place. Currently available harmonised datasets at the EU level differ widely with respect to the availability of information on wages and working hours, as has been shown extensively in this paper. They also differ in terms of sample and coverage. Another challenge regards information on minimum wage levels across the EU27. This information is currently available in countries with a government-legislated nationwide minimum wage; however, in countries where pay floors are set through sector-wide collective bargaining, information on their levels is seldom available or is very difficult to recover. Obtaining precise information on pay levels and being able to correctly match it to wage data would enormously improve estimates of non-compliance, and it is definitely one way to go in the near future.

As has been much discussed in this paper, EU-SILC and SES are the main sources of information currently available on pay levels harmonised at EU level, and thus the best available for researchers to estimate non-compliance with minimum wages. Both datasets have shortcomings.

SES is a large survey based on matched employer–employee data, providing accurate information on a large sample of enterprises about employees' gross wage levels, hours of work and individual characteristics, as well as plant attributes such as the size of the firm, its main economic activity and

the geographical location of the local unit. However, it takes place infrequently, every four years, includes only employers with more than 10 employees and does not cover the agricultural and informal sectors. This last characteristic is a particular problem for the analysis of non-compliance with minimum wage regulations, since underpaid workers tend to be concentrated in small firms and in the informal sector, which is not recorded in SES. However, being able to assess the amount of non-compliance among larger firms in the formal sector using reliable earnings data harmonised across countries still represents important information from a policy perspective that was mostly missing in the existing literature. Overall, estimates using SES are likely to underestimate the proportion of workers being paid below minimum wages.

In principle, EU-SILC is potentially an ideal dataset for the analysis of non-compliance rates, especially because it covers all types of workers, including, importantly, workers employed in the informal sector. Background household characteristics are well documented, and it appears frequently, being released on a yearly basis. A disadvantage is that apprentices are not included in the sample. Moreover, the sample is small (compared with SES); as has been observed in some analysis shown in this report, this leads to imprecise estimates when calculating non-compliance rates in narrower groups of workers or by industry. Earnings are self-reported and the measure is not always consistent across countries (see 'Sources of heterogeneity in non-compliance estimates').

For these reasons, estimates of the size of non-compliance can be quite different across databases, even when the same country is considered. This is mainly because of compositional effects, namely different coverage in terms of industries and types of workers. In general, it emerges clearly that data limitations operate in a non-neutral way depending on the characteristics of the country analysed. Enforcement practices in use in the country may also play a role.

In order to improve our knowledge on this phenomenon, better data, such as comprehensive and precise data on wages at EU level, should be promptly made available to researchers. In this respect, the recent proposal about the inclusion of precise information on wages in the harmonised EU LFS is a very positive step forward. Furthermore, hours of work are often not accurately recorded, and this may lead to problems of measurement error that could have severe consequences for the reliability of non-compliance estimates. Ideally, data sources from surveys and administrative records could be cross-validated, which would be a powerful strategy to overcome these challenges.

In order to gain further insights into non-compliance and advance its measurement, a direct question could be introduced, for example in the EU LFS, that allows workers paid below the minimum wage because they are legally exempt to be distinguished from those who are entitled to the minimum wage but do not receive it. That would lead to a sort of self-assessed measure of non-compliance that could be very informative and complement the information coming from wages on the share of workers paid below minimum wage. For example, the Irish LFS has recently introduced a question that indicates the current minimum wage rate to the respondents and asks them if they are paid more than, exactly or less than the minimum wage. Information like this could be very useful to compare with indicators of non-compliance calculated using information on pay floors.

Finally, more should also be done to collect data on subminima and on exemption clauses introduced in national legislation. Also of particular importance is the collection of data on pay floors set by collective bargaining, and on their domain of application (whether industry-based or geographically based). Currently, information on such contractual wage floors is scarce and not

adequately harmonised at EU level, making the estimation of non-compliance with wage regulations difficult and imprecise. Effort in this direction is particularly envisaged.

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Appendix

Table A1: Summary of literature review on non-compliance with minimum wages: Studies and reports

Publication details	Data and observation period	Geographical coverage	Methodological approach	Main findings
Ashenfelter, O. and Smith R. (1979), 'Compliance with the minimum wage law', *Journal of Political Economy*, Vol. 87, No. 2, pp. 333–350	Current Population Survey, May 1973	United States	Profit-maximising model of compliance, predictions about compliance with weak or random government enforcement	Overall compliance in 1973 is estimated to have been about 65%, whereas it was about 10 percentage points lower after the new minimum was established in 1975
Bernhardt, A., Spiller, M. and Theodore, N. (2013), 'Employers gone rogue: Explaining industry variation in violations of workplace laws', *Industrial and Labor Relations Review*, Vol. 66, No. 4, pp. 808–832	2008 Unregulated Work Survey	United States	Multivariate regression models to examine the relationships among workplace violations, industries, and a series of worker and employer characteristics	Differences in workforce composition are important, but job and employer characteristics account for most industry differences in compliance (2.5 times as strong as workforce composition)
Bhorat, H., Kanbur, R. and Mayet, N. (2013), 'A note on measuring the depth of minimum wage violation', *Labour*, Vol. 27, No. 2, pp. 192–197	LFS 2007	South Africa	Development of a family of indices of minimum wage violation to capture both the number of wage earners falling below the minimum and how far below they fall. Application to South Africa	45% of employees are paid below the minimum wage, with significant heterogeneity across sectors, and the depth of violation is also not uniform across sectors. Correlation across indices is high but not perfect
Bhorat, H., Kanbur, R. and Stanwix, B. (2015), *Minimum wages in sub-Saharan Africa: A primer*, IZA Discussion Paper No. 9204, Institute of Labor Economics, Bonn	Household survey data for seven sub-Saharan African (SSA) countries, in different years	Kenya, Mali, Namibia, South Africa, Tanzania, Uganda, Zambia	Analysis of wage distribution and minimum wages at country level. Application of index of violation introduced by Bhorat et al (2013)	58% of workers earn below the minimum wage in SSA countries (30% percent in non-SSA countries). Absolute levels of non-compliance are higher in Africa, while relative

Publication details	Data and observation period	Geographical coverage	Methodological approach	Main findings
				levels are higher in non-African developing countries. Higher Kaitz indices are associated with higher levels of non-compliance
Bhorat, H., Kanbur, R. and Stanwix, B. (2019), *Compliance with labor laws in developing countries*, IZA World of Labor, Institute of Labor Economics, Bonn	Review of research on enforcement and compliance in developing countries	n.a.	n.a.	An index of minimum wage violation would allow decision-makers to analyse the level and depth of non-compliance and act accordingly. A multidimensional index of non-compliance with wage and non-wage regulations might be used to compare compliance across countries and over time
Bruttel, O. (2019), 'The effects of the new statutory minimum wage in Germany: A first assessment of the evidence', *Journal for Labour Market Research*, Vol. 53, No. 1, pp. 1–13	Review of research on the effects of the new statutory minimum wage in the first three years after its introduction in Germany	Germany	Analysis of available evidence based on descriptive figures, qualitative research and difference-in-differences analyses	It has had a positive and substantial effect of minimum wage on hourly wages, while a smaller (if any) and mixed effect on employment. There is evidence of significant non-compliance (with cautions about measurement issues)
Caliendo, M., Fedorets, A., Preuss, M., Schröder, C. and Wittbrodt, L. (2017), *The short-term distributional effects of the German minimum*	German Socio-Economic Panel, 2012–2015	Germany	Regression framework (with difference-in-differences estimator) to assess changes in the distributions of hourly wages, contractual and	There is evidence of wage increases at the bottom of the hourly wage distribution in the year after the reform, but also considerable non-compliance among

Publication details	Data and observation period	Geographical coverage	Methodological approach	Main findings
wage reform, IZA Discussion Paper No. 11246, Institute of Labor Economics, Bonn			actual working hours, and monthly earnings	eligible employees (7%). The reform also negatively affected working hours, with a larger decrease in contractual hours than in actual hours worked, suggesting an increase in unpaid overtime
Clemens, J. and Strain, M. R. (2020), *Understanding 'wage theft': Evasion and avoidance responses to minimum wage increases*, NBER Working Paper No. 26969, National Bureau of Economic Research, Cambridge, MA	Wages: Current Population Survey, 2011–2013 and 2016–2017. Minimum wages: data used by Clemens et al (2018); data used by Goraus-Tańska and Lewandowski (2019) for subminimum wage payment; data used by Galvin (2016) for enforcement regimes	United States	Regression framework (with difference-in-differences estimators) to analyse how minimum wage increases and the strength of enforcement regimes affect the prevalence of subminimum wage payments	There is evidence that higher minimum wages lead to a greater prevalence of subminimum wage payments, with increases in underpayment ranging between 10% and 25% of realised wage gains. Enforcement regimes play an important role in shaping compliance rates and how those rates respond to increases in minimum wages
Garnero, A., Kampelmann, S. and Rycx, F. (2015), 'Sharp teeth or empty mouths? European institutional diversity and the sector-level minimum wage bite', *British Journal of Industrial Relations*, Vol. 53, No. 4, pp. 760–788	Earnings and individual characteristics: EU-SILC 2008–2010. Collective bargaining: European Company Survey, 2007–2009. Minimum wages: WSI Mindestlohndaten bank	Austria, Belgium, Bulgaria, Cyprus, Denmark, Estonia, Finland, France, Germany, Hungary, Ireland, Italy, Latvia, Poland, Portugal, Romania, UK	Regression framework to test the link between institutional features of minimum wage systems and two indicators of the minimum wage bite (i.e. the Kaitz index and share of individuals earning wages below prevailing minima)	Systems with negotiated sectoral-level minima are associated with higher Kaitz indices than systems with statutory floors, but also with more individuals paid below the minima. This difference is partly compensated for by higher levels of collective bargaining

Publication details	Data and observation period	Geographical coverage	Methodological approach	Main findings
Garnero, A. (2018), 'The dog that barks doesn't bite: Coverage and compliance of sectoral minimum wages in Italy', *IZA Journal of Labor Policy*, Vol. 7, No. 1, pp. 1–24	Sectoral minima: ISTAT data, 2008–2015. Earnings: Italian LFS, Structure of Earnings Survey and administrative data from Italian social security (INPS), 2008–2015	Italy	Regression framework to estimate the degree of non-compliance with sectoral minimum wages using the index of violation proposed by Bhorat et al (2013)	Sectoral wage floors are relatively high both in absolute terms and relative to the median wage. Around 10% of workers are paid 20% less than the collectively agreed minimum wage. Non-compliance is particularly high in the South, in small firms, among women and among temporary workers
Garnero, A. and Lucifora, C. (2020), 'L'erosione della contrattazione collettiva in Italia e il dibattito sul salario minimo legale', *Giornale di diritto del lavoro e di relazioni industriali*, Vol. 166, pp. 295–315	Earnings and individual characteristics: LFS, 2008–2015. Minimum wages: sample of the most representative collective agreements collected and monitored by ISTAT	Italy	Regression framework to investigate the relationship between non-compliance with minimum wages and employment. An average rate of non-compliance for firms in each industry–region cell is computed as the share of workers paid 90%, or less, of the reference wage floor set by the collective agreement in the sector of reference	A higher proportion of subminimum workers is associated with more employment, with an estimated elasticity of around 2%. The relationship is found to be non-linear, with high rates of non-compliance (above 40%) reversing the positive employment effect
Goraus-Tańska, K. and Lewandowski, P. (2019), 'Minimum wage violation in central and eastern Europe', *International Labour Review*, Vol. 158, No. 2, pp. 297–336	EU-SILC 2003–2012 and Eurostat data on minimum wages	Bulgaria, Czechia, Estonia, Hungary, Latvia, Lithuania, Poland, Romania, Slovakia, Slovenia	Analysis of non-compliance with minimum wages, based on the index of violation proposed by Bhorat et al (2013)	Non-compliance ranges from 1.0% in Bulgaria to 6.9% in Lithuania, while the average pay shortfall ranges from 13.7% of the minimum wage in Estonia to 41.7% in Slovenia. Workers who are female, less educated, in the services or agricultural sector,

Publication details	Data and observation period	Geographical coverage	Methodological approach	Main findings
				employed in small firms or with a temporary contract are more likely to earn less than the minima
Green, A. (2017), *Hours off the clock*, Center for Economic Studies, US Census Bureau, Suitland, MD	Hours worked: from US Census Bureau's American Community Survey. Hours paid: administrative data from US Census Bureau's Longitudinal Employer–Household Dynamics programme	United States	Construction of a unique dataset of hours worked and hours paid at individual level, to infer causes, incidence and implications of off-the-clock work. Ordinary least squares and instrumental variables framework	Firms poorly track the hours of workers who work more than the standard working week. Off-the-clock work is probably procyclical, driven by low-skilled workers and concentrated in industries where wage and hour violations are prevalent. Smaller firms are much less likely to comply with labour regulations
Ji, M. and Weil, D. (2015), 'The impact of franchising on labor standards compliance', *Industrial and Labor Relations Review*, Vol. 68, No. 5, pp. 977–1006	Pooled cross-sectional sample of establishment-level investigations for 2001–2005: (i) Wage and Hour Investigation Support and Reporting Database; (ii) FRANdata and data from Dun & Bradstreet list of all franchisee-owned restaurants	United States	Profit-maximising model using the natural log of total back wages per investigation in a given establishment as the main dependent variable. Ordinary least squares and Tobit estimation	Franchised outlets have far higher levels of non-compliance than comparable company-owned establishments
Kampelmann, S., Garnero, A. and Rycx, F. (2013), *Minimum wages in Europe: Does the diversity of systems lead to a diversity of outcomes?* European Trade Union Institute Report 128, European Trade	Earnings and individual characteristics: EU-SILC 2008–2010. Collective bargaining: ICTWSS database. Minimum wages: WSI Mindestlohndaten bank	Austria, Belgium, Bulgaria, Cyprus, Denmark, Estonia, Finland, France, Germany, Greece, Hungary, Ireland, Italy, Latvia, Poland, Portugal, Romania, UK	Regression framework to estimate the effect of a national statutory minimum wage and the degree of collective bargaining coverage on the Kaitz index, the share of individuals earning wages	Both higher collective bargaining coverage and a national statutory minimum wage are associated with lower levels of Gini inequality. Non-coverage and non-compliance are empirically

Publication details	Data and observation period	Geographical coverage	Methodological approach	Main findings
Union Institute, Brussels			below the minima and inequality outcomes	important phenomena in almost all countries. Higher Kaitz indices are associated with higher levels of non-compliance
Kanbur, R., Ronconi, L. and Wedenoja, L. (2013), 'Labour law violations in Chile', *International Labour Review*, Vol. 152, No. 3, pp. 431–444	National Socioeconomic Characterisation Survey 1990–2009	Chile	Descriptive analysis of compliance with four dimensions of labour law: minimum wage, hours worked, having a contract and having a pension	Labour laws are violated in at least one dimension for a third of workers, with significant variations over time, across laws and worker and firm characteristics. Compliance is lower among female workers, the less educated, those employed in small firms, those working in agricultural regions, and foreign-born or indigenous workers
Mansoor, K. and O'Neill, D. (2020), *Minimum wage compliance and household welfare: An analysis of over 1500 minimum wages*, IZA Discussion Paper No. 13298, Institute of Labour Economics, Bonn	National Sample Survey Office data matched with administrative data from a report on the working of the Minimum Wages Act, both 1999–2011	India	Regression framework to estimate the labour market outcomes associated with minimum wages and non-compliance (as well as the determinants of non-compliance), based on the index of violation proposed by Bhorat et al (2013)	Non-compliance is as high as 90% for some unskilled workers. The positive effect of higher minimum wages on wages and consumption is significantly reduced in low-compliance regimes
McGuinness, S., Redmond, P. and Delaney, J. (2020), *Minimum wage non-compliance: Evidence from Ireland*, IZA	LFS 2016–2018	Ireland	Analysis of incidence and determinants of non-compliance, using self-assessed measure of compliance:	Around 6% of workers are paid below the minimum, for reasons other than those permitted under legislation.

Publication details	Data and observation period	Geographical coverage	Methodological approach	Main findings
Discussion Paper No. 12884, Institute of Labour Economics, Bonn			question reporting current minimum wage to the respondents and asking whether they are paid at, above or below the minimum	Compliance is lower if they are male, Irish, aged over 35, self-employed or on temporary contracts, or working in the domestic personnel sector or in agriculture
Milkman, R., González, A. L. and Ikeler, P. (2012), 'Wage and hour violations in urban labour markets: A comparison of Los Angeles, New York and Chicago', *Industrial Relations Journal*, Vol. 43, No. 5, pp. 378–398	2008 Unregulated Work Survey	United States	Logistic regression models of workplace violations. Independent variables: city dummy variables to understand the factors underlying the inter-city differences in four violations: payment below the legal minimum wage, not receiving a pay document, non-payment for work performed and late payment	Los Angeles has higher violation rates than New York City and Chicago, due to such factors as its industrial composition and disproportionately large number of small establishments, as well as its vast unauthorised immigrant population. In addition, Los Angeles's higher rates reflect the stricter legal standards in California
Ram, M., Edwards, P. and Meardi, G. (2017), 'Non-compliance and the National Living Wage: Case study evidence from ethnic minority and migrant-owned businesses', workshop paper, Low Pay Commission Research Workshop, April	Case-study approach on 24 small businesses and their workers (12 long-established firms in low-paying sectors and 12 businesses owned by new migrant communities, primarily in retail), over several years	UK	Case study approach to analyse non-compliance with the National Living Wage	Several firms do not comply with the National Living Wage, both among long-established firms and among new businesses, and the boundary between compliance and non-compliance is fluid. Non-compliance is fostered by intense competition, the existence of 'helpers' (people doing specific tasks for a limited time),

Publication details	Data and observation period	Geographical coverage	Methodological approach	Main findings
				a low perceived risk of being penalised and workers' acceptance of the situation
Rani, U., Belser, P., Oelz, M. and Ranjbar, S. (2013), 'Minimum wage coverage and compliance in developing countries', *International Labour Review*, Vol. 152, Nos. 3–4, pp. 381–410	Household and LFS from 11 developing countries in the 2000s	Brazil, Costa Rica, India, Indonesia, Mali, Mexico, Peru, Philippines, South Africa, Turkey, Vietnam	Analysis of rates of non-compliance with legal minimum wages using the share of workers earning less than the minimum, and depth of violation, using the method proposed by Bhorat et al (2013)	A third of wage earners are covered but paid less than minimum wages, receiving 50% to 75% of applicable minima (often less than minimum living wage). Countries with national minimum wages have higher compliance rates than those with multiple minimum wages, and the rate of compliance is (negatively) dependent on the level of minimum wages
Ritchie, F., Veliziotis, M., Drew, H. and Whittard, D. (2017), 'Measuring compliance with minimum wages', *Journal of Economic and Social Measurement*, Vol. 42, Nos. 3–4, pp. 249–270	Case study on UK apprentices, using a dedicated survey on pay, 2011–2015	UK	Measurement of non-compliance through different statistical sources	'Measurement error' can be composed of several elements: inappropriate samples or population estimates; timing of survey; interpretation of questions; ability to answer accurately; willingness to answer honestly; errors introduced by data processing

Publication details	Data and observation period	Geographical coverage	Methodological approach	Main findings
Ronconi, L. (2010), 'Enforcement and compliance with labor regulations', *Industrial and Labor Relations Review*, Vol. 64, No. 4, pp. 719–736	Compliance: Permanent Household Survey. Enforcement: panel data from the Argentine Labour Ministry, available from 1995 to 2002	Argentina	Regression framework (with two-stage least squares) to estimate the effect of enforcement on compliance with six employment and social security regulations. Number of labour inspectors per capita is used as a proxy for enforcement, while compliance is measured by the percentage of private sector employees who receive legally mandated benefits	Two-stage least squares estimates suggest enforcement increases compliance
Ye, L., Gindling, T. and Li, S. (2015), 'Compliance with legal minimum wages and overtime pay regulations in China', *IZA Journal of Labor & Development*, Vol. 4, No. 1, pp. 1–35	Matched employer–employee dataset on six provinces of China, 2009	China	Analysis of the extent of compliance with minimum wage and overtime pay regulations in the Chinese formal sector, based on the proportion of workers paid less than the minimum wage	There is evidence of broad compliance with minimum wages, with fewer than 3.5% of full-time workers earning less than the monthly minimum wage, but substantial non-compliance with overtime pay regulations, with 29% of employees not paid for overtime work and 70% paid less than the legally required 1.5 times the regular wage

Box A1: Cross-country databases available for estimating non-compliance in EU Member States

Structure of Earnings Survey

Description: SES is a large enterprise survey, conducted in the Member States of the EU, in the EU candidate countries and in the European Free Trade Association countries. It provides comparable and EU-wide harmonised structural data on gross earnings, hours paid and annual days of paid holiday leave, as well as detailed and comparable information at EU level on relationships between the level of earnings, individual characteristics of employees (sex, age, occupation, length of service, educational level) and their employer (economic activity, size of the enterprise, etc.). However, being filled in by the employer, SES is more likely to report only legal workers, and information on wages and working hours more in line with those fixed by the rules (Garnero, 2018), thus making it less likely to pick up informal workers or unpaid extra hours. Since 2002, the survey has been conducted every four years, and the last publicly released edition relates to 2018. SES covers enterprises with at least 10 employees in the areas of economic activity defined by sections B to S, excluding O, of NACE Rev. 2, thus excluding agriculture and the public sector. SES collects the earnings actually received by an employee of a business in the reference month and year. The information collected relates to the earnings paid to each job holder. It does not cover earnings by the same employee elsewhere in a second or third job.

Sample: The sample covers enterprises with at least 10 employees in the areas of economic activity defined by sections B to S, excluding O, of NACE Rev. 2.

Country coverage: It has been implemented in 35 countries and it covers all EU27 countries. The dataset has very good coverage across countries.

Period: The last year available is 2018. SES editions from 1995, 2002, 2006, 2010 and 2014 are also available. Comparison over time is possible, but it may take into account possible changes in definitions, coverage and methods as a result of amendments of EU legislation as well as revisions of national methodologies.

Pros: It contains matched employer–employee data; data on earnings are reliable and harmonised; it has a large sample size.

Cons: Data are collected at a low frequency; it does not cover firms with fewer than 10 employees or the informal sector; there is little information on workers' backgrounds.

European Union Statistics on Income and Living Conditions

Description: EU-SILC is a cross-sectional and longitudinal sample survey, coordinated by Eurostat, based on national data provided by the EU Member States. It is a multidimensional instrument focused on income but covering at the same time housing, material deprivation, labour, health, demography and education. This rich set of household- and individual-level information allows the study of social exclusion using a multidimensional approach. Seven countries launched EU-SILC in 2003, before it was extended to 15 countries in 2004, 27 countries in 2005 and 31 countries in 2009. The questionnaire contains questions on individual gross income from various sources; however, this variable is not available for all EU Member States.

Sample: It is household based, representative of the population in the country in question.

Country coverage: Since 2009, all EU Member States have been included in the sample.

Period: The survey is conducted on a yearly basis and data since the 2005 wave are available for most countries.

Pros: All sectors and the informal economy are covered; it gives precise information on earnings from all sources of income; data are collected at a high frequency; there is rich information on individual workers' backgrounds. This is particularly important in measuring non-compliance with minimum wages, since one of the characteristics that several studies have associated with a higher level of non-compliance with minimum wage legislation is the small size of firms; such information is not included in SES.

Cons: It contains limited information on employers' characteristics; there are potential measurement error and non-response problems in the earnings variable; data on annual earnings do not necessarily refer to one job in particular; the income can be earned in different jobs (either at the same time or consecutively); data are self-reported. These are well-recognised limitations to the use of EU-SILC data for the analysis of wages; see for example Brandolini et al (2011) or Jenkins and Van Kerm (2014).

European Working Conditions Survey

Description: The EWCS is a cross-sectional survey conducted by Eurofound every five years since 1990, through face-to-face interviews with a random sample of workers across European countries. This survey paints a wide-ranging picture of Europe at work, across countries, occupations, sectors and age groups. In March 2017 the sixth edition of EWCS was released; we now use six editions of this survey covering 25 years for up to 35 countries in Europe (the 28 current and former EU Member States, the five EU candidate countries, and Norway and Switzerland: the largest number of countries is covered in the most recent edition). The seventh edition, scheduled to be conducted in 2020, was terminated because of the COVID-19 pandemic; it will now be conducted in 2024. An extraordinary edition of the survey, the European Working Conditions Telephone Survey (EWCTS), was conducted in 2021 in which respondents were interviewed via computer-assisted telephone interviewing (CATI).

The EWCS represents a unique source of data combining a large coverage of countries, with detailed information on workers' demographics, employment status, firm characteristics and job attributes. The EWCS contains a wide set of information about working conditions, exposure to risk factors and indicators of mental and physical health, as well as accurate information on absence from work, with details on the duration and causes. All the above information might be used to construct a multidimensional index of non-compliance with non-wage regulations to compare non-compliance across countries and over time.

Sample: The sample is representative of the population of workers. The sample size ranges between 1,000 and 3,000 observations for each country.

Country coverage: All 27 current Member States are included in the sample.

Period: The survey was conducted every five years from 1990 to 2015. The most recent available edition covers 2015. Data from 2021 should be available soon.

Pros: It provides harmonised data at the EU level with complete coverage of the EU27; this dataset is very important to obtain information about job characteristics and in particular about the quality of jobs.

Cons: The data are collected infrequently (every five years); the sample size is small (disaggregated statistics are not feasible); earnings data are reported only net of taxes.

Box A2: Relevant variables

Hours worked: In the SES database, this variable counts the number of hours in the reference month for which the employee was actually paid (normal + overtime + hours paid for annual leave, public holidays, paid sick leave, paid vocational training, paid special leave, etc.). We subtract overtime hours. In the EU-SILC database, this variable represents the weekly number of hours spent on the main job.

Principal economic activity of the local unit (SES)/main job (EU-SILC): In SES, this variable is available at the NACE one-digit level. We have aggregated sectors as trade, transport and tourism; construction; manufacturing, mining and utilities; and other services.

Occupation in the reference month (SES)/main job (EU-SILC): In both datasets, occupation is coded according to the International Standard Classification of Occupations (ISCO-08).

Highest education level attained: In both the SES and EU-SILC databases, this variable education is reported using the International Standard Classification of Education level.

Size of the firm: This variable is reported in categories that differ between the SES and EU-SILC data. In SES, no information on firms with fewer than 10 employees is available for any country, owing to the sampling design.

Duration of the contract: The SES and EU-SILC databases report whether employees are hired on a fixed-term or open-ended contract.

Age: This variable is reported in years in the EU-SILC data, while it is only available in broader ranges in SES.

Sex: This variable is available in both EU-SILC and SES data.

Table A2: Availability rates for the estimation of non-compliance in EU-SILC 2018 by definition of income adopted

Country code	Sample size (employees aged 20–65)	% of observations (employees aged 14–65) for which non-compliance can be estimated		
		Baseline income definition	Brandolini et al (2011) income definition	Goraus-Tańska and Lewandowski (2019) income definition
AT	4979	84.64%	96.28%	43.14%
BE	4664	88.01%	96.23%	28.17%
BG	5926	92.34%	97.32%	77.67%
CY	3960	86.84%	98.18%	46.16%
CZ	6905	93.35%	98.93%	79.48%
DE	10054	89.21%	97.67%	49.35%
DK	4525	90.08%	97.39%	22.30%
EE	5706	86.59%	97.95%	74.80%
EL	11661	89.98%	96.42%	61.61%
ES	10901	85.02%	93.74%	59.76%
FI	7840	92.16%	99.86%	29.63%
FR	8342	90.51%	98.32%	30.10%
HR	6221	89.57%	96.43%	76.50%
HU	5739	83.48%	98.41%	83.05%
IE	3514	88.56%	98.92%	31.19%
IT	14988	89.49%	92.70%	51.51%
LT	4162	89.81%	97.96%	78.57%
LU	4275	86.85%	97.43%	68.19%
LV	4476	84.45%	97.18%	76.30%
MT	3402	87.86%	99.38%	74.81%
NL	10251	77.69%	95.61%	25.20%
PL	10260	88.05%	98.12%	76.08%
PT	12237	88.61%	97.03%	62.87%
RO	5368	97.52%	99.11%	94.54%
SE	5684	84.13%	97.55%	62.86%
SI	9751	92.34%	97.18%	79.71%

Notes: *The table reports the percentage of observations, out of the total number of observation referring to employees aged 14–65, for which non-compliance can be estimated. Availability rates depend on the number of missing observations in the income variable; availability of tax rates to discount minimum wages when income is reported net of taxes or social security contribution records; sample restriction choices implied by each income definition. * Income is defined using current period gross earnings. See Box 2 for a full description of each income definition.*

Source: *Authors' calculations based on EU-SILC 2018*

Table A3: List of subminima and minimum wage exemptions

Country	Group of workers		% exemptions/levels, 2018
Belgium	From the age of 20 with 12 months' seniority		Minimum wage for young employees has been abolished. There are, however, specific minimum wages for working students and those in a system of alternative learning, who receive a percentage increase based upon the minimum wage
	At the age of 19.5 with 6 months' seniority		
	At the age of 18		
	At the age of 17		
	At the age of 16 and younger		
Czechia	Disabled people		
France	17 years of age with less than 6 months of experience in the sector		90% of the statutory minimum wage
	15/16 years of age with less than 6 months of experience in the sector		80% of the statutory minimum wage
	Under 16 years of age, working during summer holidays		80% of the statutory minimum wage
	Professionalisation contract		55%–100% of the statutory minimum wage, depending on age and previous qualifications
	Apprentices		25%–78% of the minimum wage for interprofessional growth depending on age, seniority and the applicable sectoral agreement
	Trainees		Permissible not to pay the minimum wage if they work less than 2 months per year. If they work 2 months or more, the minimum wage is €3.70 per hour
	Disabled workers employed in specific centres		55%–110% of the statutory minimum wage
Germany	Under 18 years of age, seasonal workers, foreign workers on seasonal contracts, and some workers in agriculture and forestry, temporary agency work, textile and garments, and laundry		Under-18s are exempted. Specific rates have been abolished since 1 January 2018. Only exceptions for seasonal workers: employers may subtract board and lodging costs from the minimum wage
Greece	Under 25 years of age		€510.95
Hungary	Jobs requiring at least a secondary level of education		HUF 185,000 (€593.16) – higher than the minimum wage
	Public works programmes (from 2016/2017)	No further requirements	HUF 81,530 (€261.41)
		Requiring secondary educational attainment (from 2016/2017)	HUF 106,555 (€341.65)
Ireland	Under 18 years of age		70% of the statutory minimum wage
	First year of employment since turning 18		80% of the statutory minimum wage
	Second year of employment since the date of first employment and over 19 years of age		90% of the statutory minimum wage

	Over 18 years of age on a training course	First third of training course	75% of the statutory minimum wage
		Second third of training course	80% of the statutory minimum wage
		Final third of training course	90% of the statutory minimum wage
Luxembourg	15 and 16 years of age		75% of the statutory minimum wage
	17 years of age		80% of the statutory minimum wage
	Qualified employees over 18 years of age		120% of the statutory minimum wage
Malta	16 years of age		94% of the statutory minimum wage
	17 years of age		96% of the statutory minimum wage
Netherlands	15 years of age		30% of the statutory minimum wage
	16 years of age		34.5% of the statutory minimum wage
	17 years of age		39.5% of the statutory minimum wage
	18 years of age		47.5% of the statutory minimum wage
	19 years of age		55% of the statutory minimum wage
	20 years of age		70% of the statutory minimum wage
	21 years of age		85% of the statutory minimum wage
	22 years of age		100% of the statutory minimum wage
Poland	First year of employment		

Source: *Authors' calculations based on Eurofound (2016, 2018)*

Table A4: List of subminima related to apprenticeship contracts in France (%)

* Apprenticeship in France (both 2014 and 2018)			
Year of apprenticeship contract	**15–17 years old**	**18–20 years old**	**21+ years old**
First	25	41	53
Second	37	49	61
Third	53	65	78

Note: *Applicable only in SES, considering weighted average of the rates. Apprentice and age-class = 14–19: 45% minimum wage. Apprentice and age-class ≠ 14–19: 64% minimum wage. In EU-SILC, apprenticeship contracts are not identifiable.*

Source: *Authors' calculations based on Eurofound (2016, 2018)*

Table A5: Application of subminima in EU-SILC 2018 and SES 2018

Country	Application in EU-SILC		Application in SES	
	Age	Level	Age	Level
Greece	< 25	€510.95	14–19	€510.95
			20–29	90% of minimum wage
France	17	90% of minimum wage		
	< 17	80% of minimum wage		
Germany	< 18	no minimum wage		
Ireland	< 18	70% of minimum wage		
Luxembourg	< 17	75% of minimum wage	14–19	85% of minimum wage
	17	80% of minimum wage		
Netherlands	15	30% of minimum wage	14–19	41.3% of minimum wage (average of the percentages)
	16	34.5% of minimum wage	20–29	Full rate, as average minimum wage in this age class lies within 95% of the minimum wage and is accounted by the doughnut correction
	17	39.5% of minimum wage		
	18	47.5% of minimum wage		
	19	55% of minimum wage		
	20	70% of minimum wage		
	21	85% of minimum wage		
Malta	< 17	94% of minimum wage		
	17	96% of minimum wage		

Source: *Authors' calculations based on the subminimum rates available in Eurofound (2016, 2018)*

Table A6: Estimates of non-compliance with minimum wages based on EU-SILC that are reported in 'Results of quantification of non-compliance' (%)

Country code	Workers below minimum wage, main estimates (20–65 years old)	Workers within 95%–105% of minimum wage, main estimates	Workers within 105%–150% of minimum wage, main estimates	Workers below minimum wage, full sample (14–65 years old)	Workers below minimum wage, Brandolini et al (2011) definition	Workers below minimum wage, Goraus-Tańska and Lewandowski (2019) definition	Workers below minimum wage, full sample using subminima	Workers below minimum wage, hourly wages	Workers below minimum wage in 2014, main estimates
AT	6.57%	2.15%	16.37%	8.22%	11.04%	6.56%		6.55%	7.21%
BE	1.23%	0.51%	8.77%	1.23%	4.39%	0.49%	1.23%	1.32%	1.40%
BG	4.73%	3.41%	34.27%	4.77%	18.44%	16.17%		6.62%	3.95%
CY	8.18%	4.07%	23.47%	8.26%	9.80%	9.41%		9.29%	10.85%
CZ	1.18%	1.09%	10.12%	1.18%	1.56%	0.94%		1.28%	0.76%
DE	9.65%	2.82%	16.21%	11.41%	15.07%	6.46%	11.30%	9.97%	
DK	5.62%	1.25%	12.97%	6.24%	8.85%	2.30%		5.24%	4.44%
EE	6.78%	2.16%	14.98%	6.79%	8.07%	5.86%		6.97%	5.93%
EL	2.32%	1.41%	18.69%	2.33%	3.53%	1.05%	1.01%	3.13%	2.50%
ES	11.60%	2.32%	13.45%	11.70%	13.49%	12.52%		11.24%	6.78%
FI	1.73%	0.92%	8.01%	1.75%	2.90%	0.26%		1.65%	1.69%
FR	7.35%	1.89%	25.93%	7.57%	11.80%	4.85%	5.44%	7.56%	8.11%
HR	2.29%	3.49%	27.30%	2.30%	2.65%	2.78%		2.95%	2.57%
HU	12.88%	5.78%	33.00%	12.88%	16.71%	12.35%		13.08%	4.92%
IE	5.18%	3.35%	18.13%	5.59%	8.76%	3.83%	5.24%	5.38%	3.95%
IT	14.48%	2.80%	17.96%	14.55%	15.76%	13.76%		14.97%	10.85%
LT	8.44%	4.57%	22.63%	8.49%	10.53%	10.00%		7.65%	8.26%
LU	5.29%	4.67%	21.38%	5.68%	7.58%	4.15%	5.68%	6.94%	2.82%
LV	3.70%	2.75%	17.75%	3.74%	4.49%	3.09%		3.89%	5.30%
MT	1.84%	1.84%	14.29%	1.92%	3.03%	1.06%	1.89%	1.91%	1.97%
NL	2.45%	0.92%	9.97%	2.52%	6.93%	1.16%	2.36%	2.44%	2.37%
PL	6.41%	7.57%	29.90%	6.48%	7.22%	4.82%	3.07%	7.63%	8.49%
PT	8.55%	9.13%	32.41%	8.57%	10.38%	8.79%		10.63%	5.07%
RO	2.24%	1.87%	30.19%	2.24%	2.48%	1.83%		2.47%	2.62%
SE	8.19%	2.17%	21.29%	8.24%	11.15%	6.43%		7.95%	12.62%
SI	4.80%	1.34%	23.24%	4.81%	5.12%	3.39%		5.56%	4.68%
SK	1.18%	2.19%	22.32%	1.18%	1.51%	1.59%		1.85%	1.85%

Note: *Estimates reported in this table summarise all the results based on EU-SILC that are reported in the figures and tables of the section 'Results of quantification of non-compliance'. All estimates except the rightmost column refer to the 2018 edition of EU-SILC.*

Sources: *Authors' calculations based on EU-SILC 2014 and 2018*

Table A7: Estimates of non-compliance with minimum wages based on SES that are reported in 'Results of quantification of non-compliance' (%)

Country code	Workers below minimum wage, main estimates (20–65 years old)	Workers within 95%–105% of minimum wage, main estimates	Workers within 105%–150% of minimum wage, main estimates	Workers below minimum wage, full sample (14–65 years old)	Workers below minimum wage, full sample using subminima	Workers below minimum wage, hourly wages	Workers below minimum wage in 2014, main estimates
AT							
BE	0.01	0.01	14.26	0.01		0.00	0.02
BG	0.13	16.29	29.58	0.13		7.03	0.07
CY	5.94	6.29	27.67	6.18		6.56	10.69
CZ	1.10	2.88	16.29	1.10		0.41	0.54
DE	1.70	5.17	23.60	4.89		0.18	
DK	2.67	3.79	29.21	7.06		0.88	7.95
EE	0.64	5.93	15.26	0.64		3.92	0.59
EL	3.71	3.90	22.13	4.25	2.89	1.47	1.90
ES	0.98	1.78	19.16	1.31		0.33	0.35
FI	0.15	0.11	14.20	0.18		0.07	0.25
FR	2.93	4.55	34.26	3.96	3.09	2.06	3.08
HR	0.56	3.79	18.59	0.64		2.40	1.70
HU	4.92	6.69	26.88	4.94		6.87	3.07
IE							
IT	0.63	0.53	18.02	0.79		0.57	3.69
LT	0.08	7.01	23.79	0.08		2.74	0.33
LU	0.83	2.47	25.70	1.44	1.39	0.71	0.86
LV	0.24	6.04	21.37	0.24		2.49	1.06
MT	0.08	0.59	10.86	0.11		0.00	0.04
NL	1.09	1.65	22.50	9.27	2.38	0.44	4.75
PL	0.07	10.16	21.31	0.07		7.30	0.21
PT	0.43	3.74	42.05	0.46		0.25	0.09
RO	0.08	12.32	28.20	0.08		9.58	0.09
SE	0.31	1.64	39.12	0.79		2.00	0.22
SI	2.98	3.38	30.22	3.02		1.18	
SK	0.50	5.06	21.18	0.53		1.11	

Note: *Estimates reported in this table summarise all the results based on SES that are reported in the figures and tables of the section 'Results of quantification of non-compliance'. All estimates except the rightmost column refer to the 2018 edition of SES.*

Sources: *Authors' calculations based on SES 2014 and 2018*

Table A8: Descriptive statistics on workers paid less than the minimum wage and on the rest of the population, SES

Characteristics	Workers below the minimum wage	Workers at or above the minimum wage	Significance of difference
% women	52.7	48.6	** (+)
% part-time workers	40.0	25.9	** (+)
Hours worked per week	26.0	34.8	** (-)
% aged 14–19	27.5	0.9	** (+)
% aged 20–29	32.8	14.1	** (+)
% aged 30–39	12.8	24.0	** (+)
% aged 40–49	11.5	26.5	** (-)
% aged 50–59	10.4	25.5	** (-)
% aged 60+	5.0	8.9	** (-)
% with basic education	45.5	15.1	** (+)
% with secondary education	44.2	51.1	** (-)
% with tertiary education	7.5	17.5	** (-)
% with master's degree/PhD	2.8	16.3	** (-)
% on fixed-term contract	26.5	15.6	** (+)
% firm size 10–49 employees	39.2	31.6	** (+)
% firm size 50–249 employees	21.0	22.9	** (-)
% firm size 250+ employees	39.8	45.4	** (-)

Note: *Below-minimum-wage workers are those earning less than 95% of the minimum wage. All statistics are weighted using sampling weights. ** Significant at 1% level; * significant at 5% level.*

Source: *SES 2018*

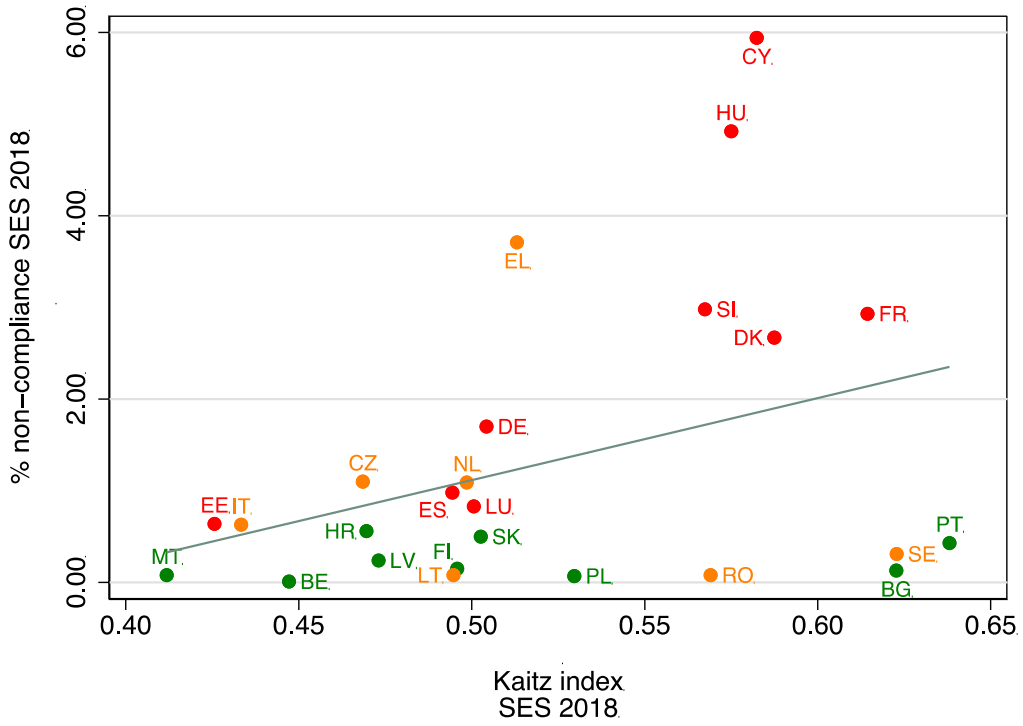
Table A9: Working hours above and below the minimum wage by country and dataset, SES 2018 edition

Country code	Below minimum wage	Above minimum wage
AT		
BE		
BG	32.4	40.5
CY	34.9	38.1
CZ	33.6	38.4
DE	16.2	31.1
DK	23.8	31.3
EE	29.3	39.2
EL	25.3	36.1
ES	27.7	35.2
FI	31.0	36.5
FR	31.5	33.8
HR	40.9	42.0
HU	41.7	40.2
IE		
IT	32.7	37.4
LT	32.5	38.7
LU	36.7	39.6
LV	26.4	35.8
MT	24.6	37.5
NL	23.9	30.7
PL	41.2	39.7
PT	31.0	37.9
RO	42.8	42.1
SE	31.2	36.7
SI	23.4	41.0
SK	30.8	38.6
TOTAL	26.0	34.8

Note: *Below-minimum-wage workers are those earning less than 95% of the minimum wage. All statistics are weighted using sampling weights. The sample includes workers aged 20–65 and excludes apprentices. Colours toward red indicate a longer working schedule compared to the other countries and worker groups.*

Source: *SES 2018 edition*

Figure A1: Relationship between non-compliance rates and the Kaitz index in SES



Note: *The percentage of workers earning below 95% of the minimum wage is reported on the vertical axis, and the Kaitz index (the ratio between the minimum wage and the median wage) is reported on the horizontal axis. For countries characterised by multiple minimum wages set by collective bargaining, the lowest pay floor is selected in defining the Kaitz index. The sample includes workers aged 20–65 and excludes apprentices. Countries in green have a non-compliance level below the EU27 median level in both SES and EU-SILC. Those in orange have a non-compliance level above the median in only one of the two databases. Those in red have a non-compliance level above the median according to both datasets. The correlation between non-compliance rates and the Kaitz index is of 0.36.*

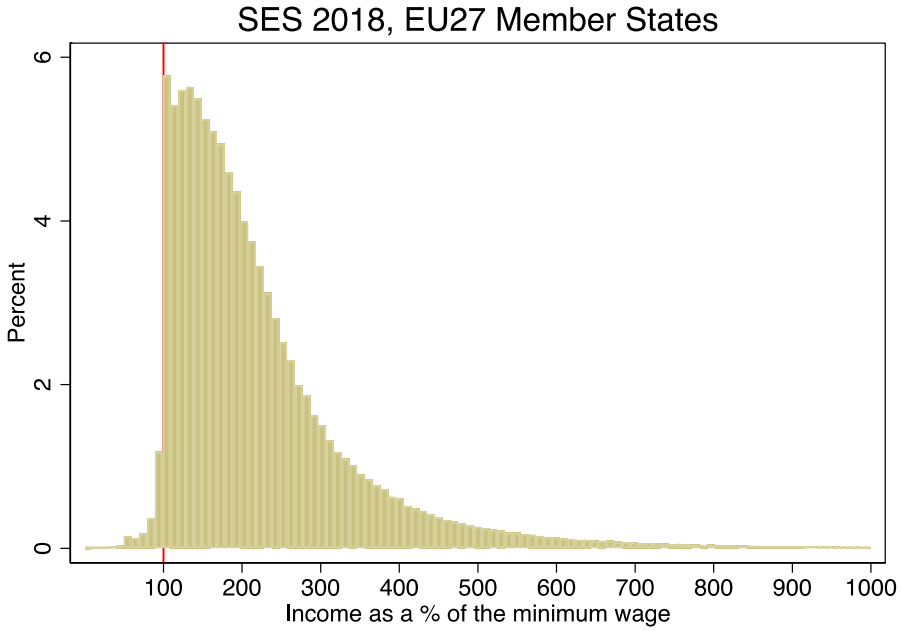
Source: *SES 2018 edition*

Figure A2: Relationship between non-compliance rates and share of workers paid below 1.5 of minimum wage in SES

Note: *The percentage of workers earning below 95% of the minimum wage is reported on the vertical axis, and the percentage of workers earning below 150% of the minimum wage is reported on the horizontal axis. The sample includes workers aged 20–65 and excludes apprentices. Countries in green have a non-compliance level below the EU27 median level in both SES and EU-SILC. Those in orange have a non-compliance level above the median in only one of the two databases. Those in red have a non-compliance level above the median according to both datasets. The correlation between non-compliance rates and the percentage of wages bbelow 150% of the minimum wage is of 0.22.*

Source: *SES 2018 edition*

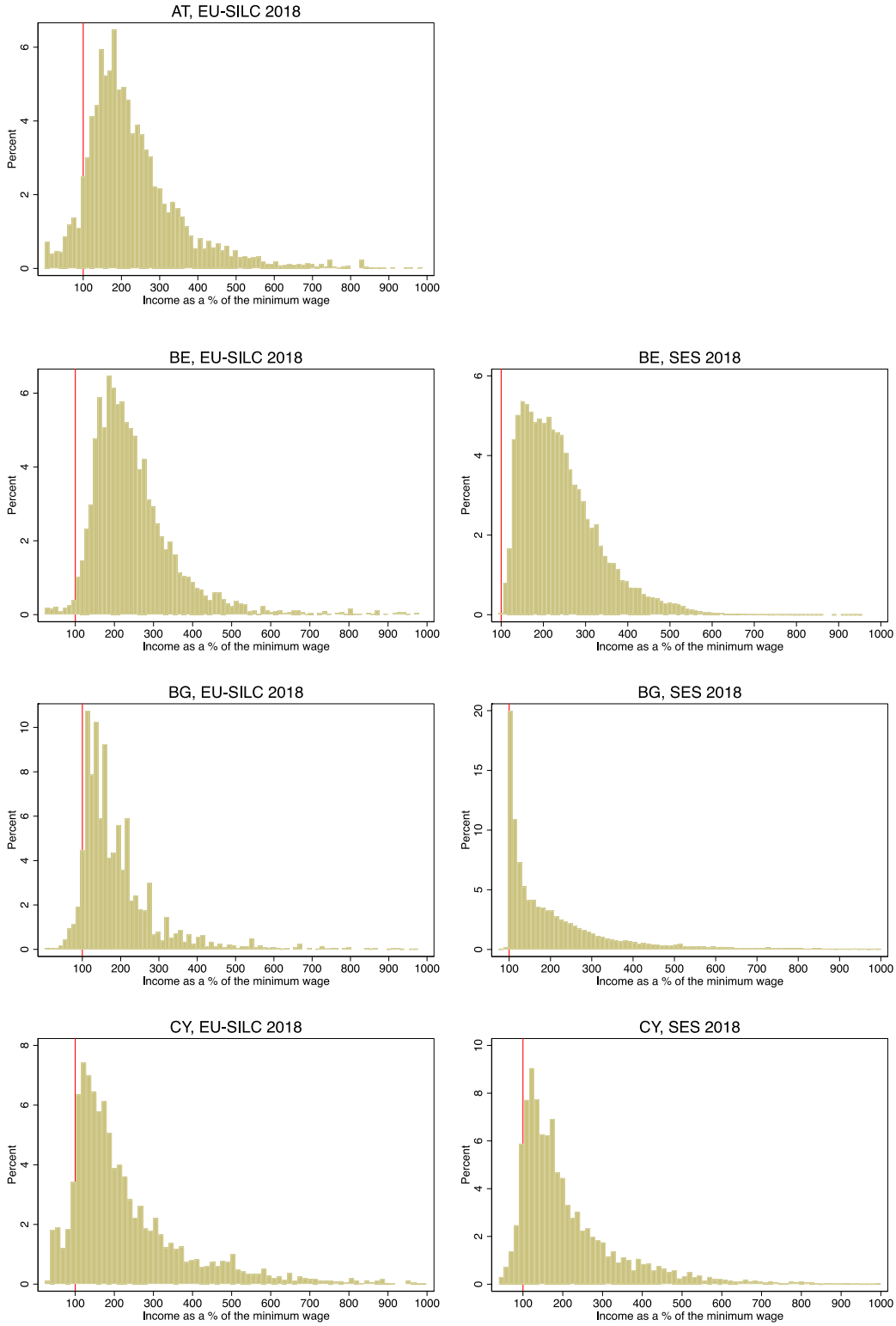
Figure A3: Wage distribution as a percentage of the minimum wage in the EU27, SES 2018

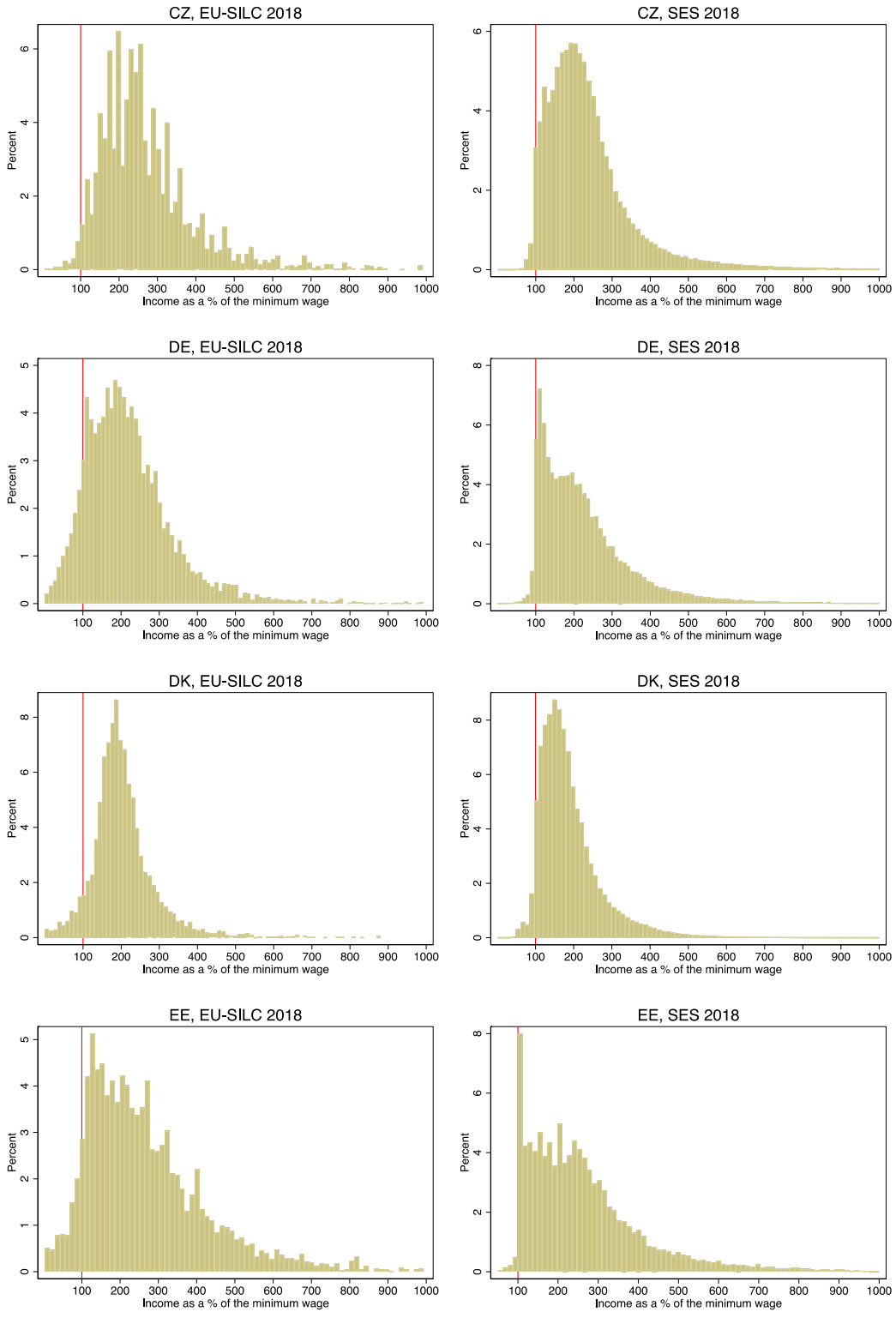


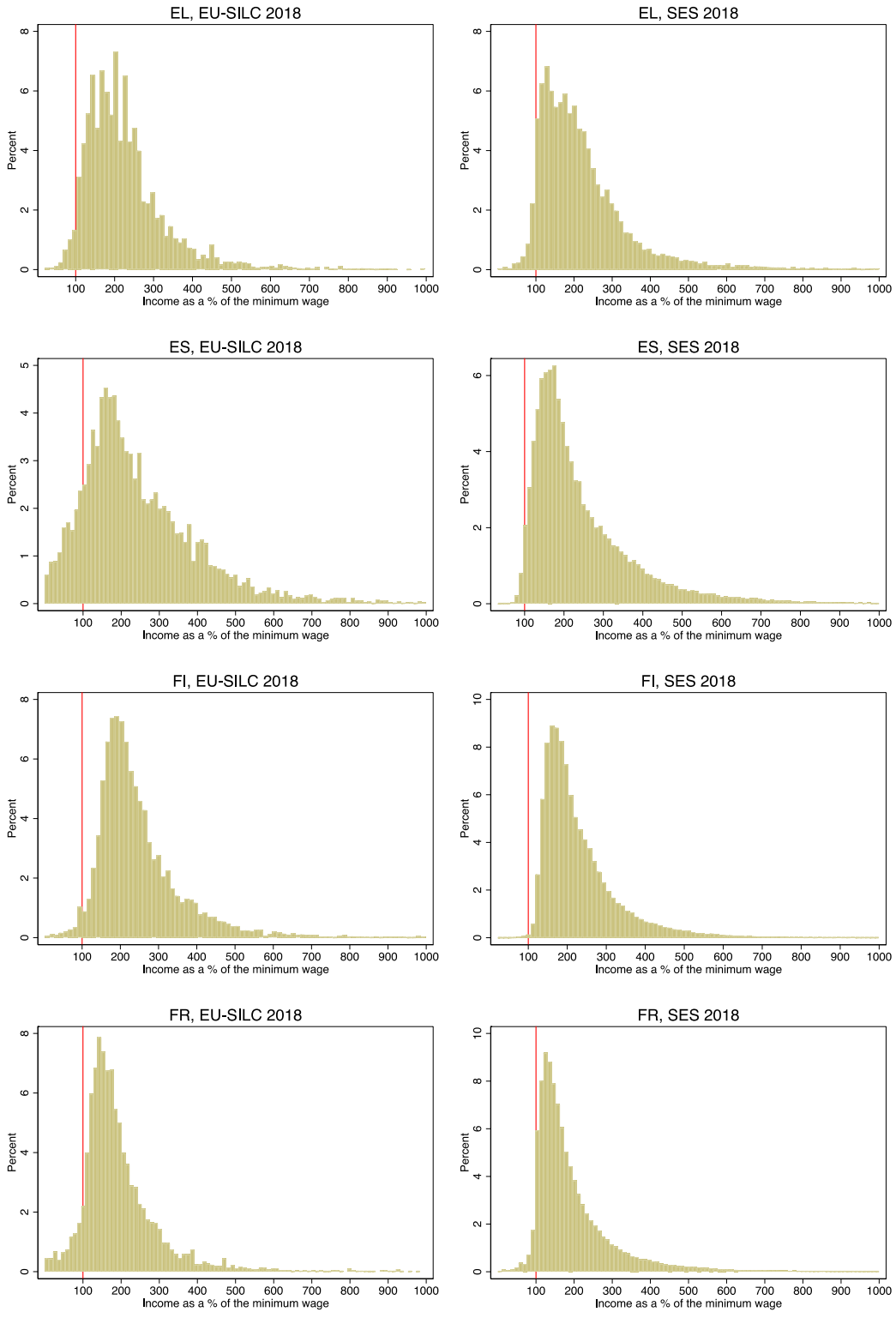
Note: *The graph shows the density function of wages expressed as a percentage of the national minimum wage in the EU27. For countries where minimum wages are set by collective contracts, sectoral minimum wages have been used. The vertical red line represents the minimum wage. The sample includes workers aged 20–65 years old excluding apprentices.*

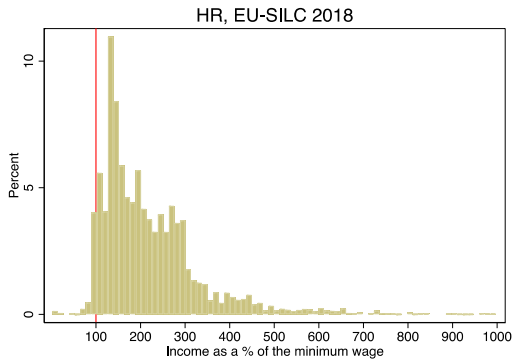
Source: *SES 2018 edition*

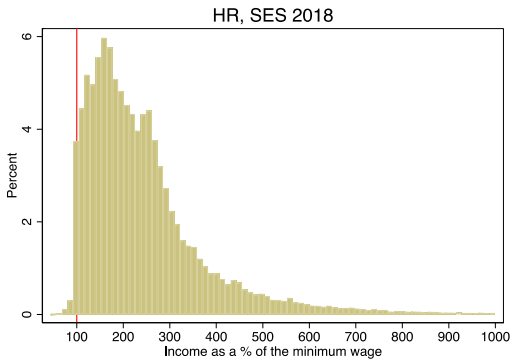
Figure A4: Wage distribution as a percentage of the minimum wage by country, EU-SILC 2018 and SES 2018

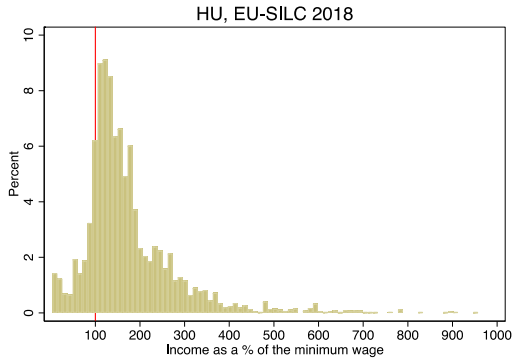


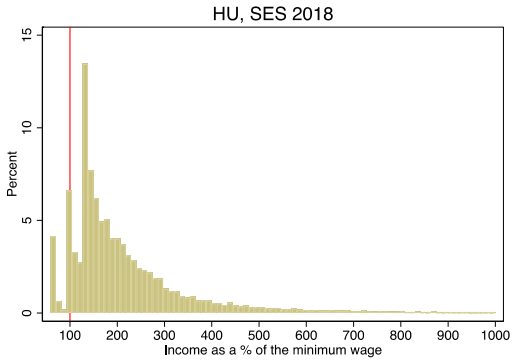

CZ, EU-SILC 2018
CZ, SES 2018
DE, EU-SILC 2018
DE, SES 2018
DK, EU-SILC 2018
DK, SES 2018
EE, EU-SILC 2018
EE, SES 2018
Percent
Income as a % of the minimum wage

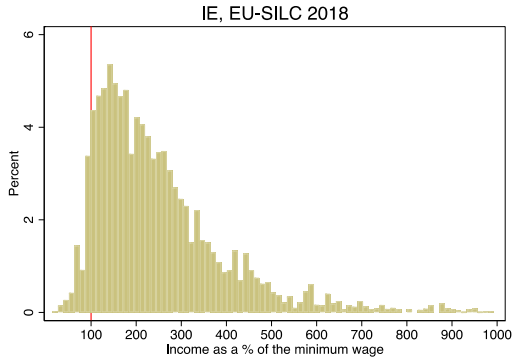


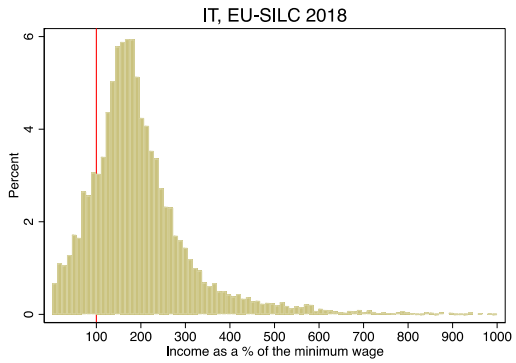


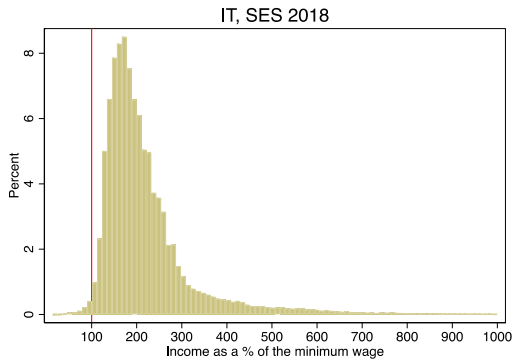


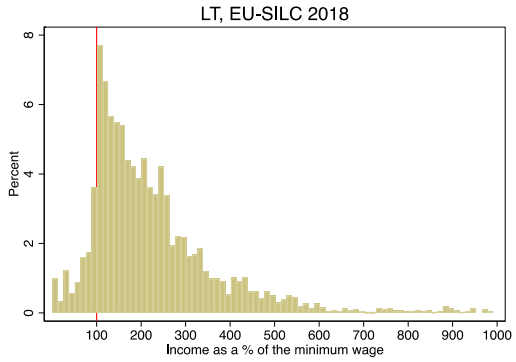


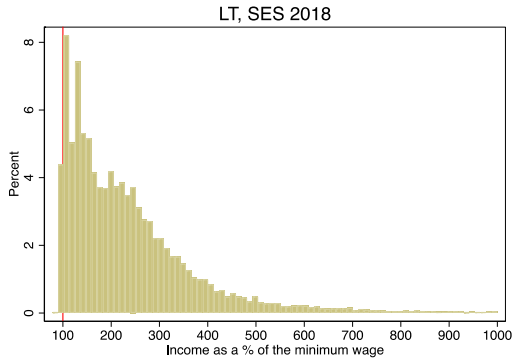


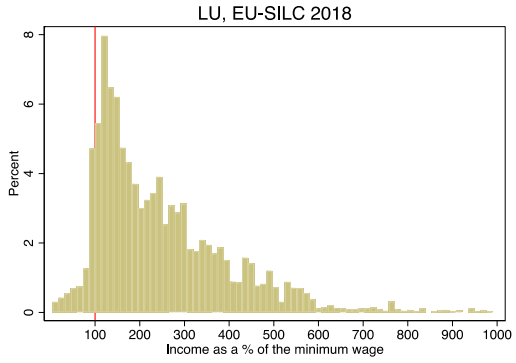


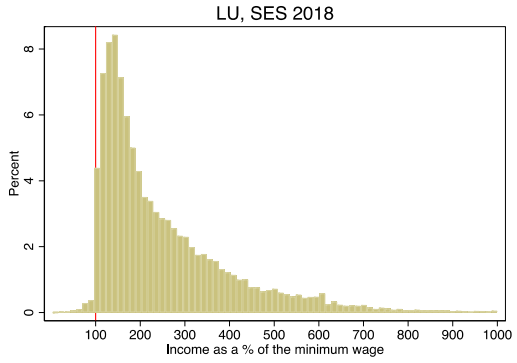


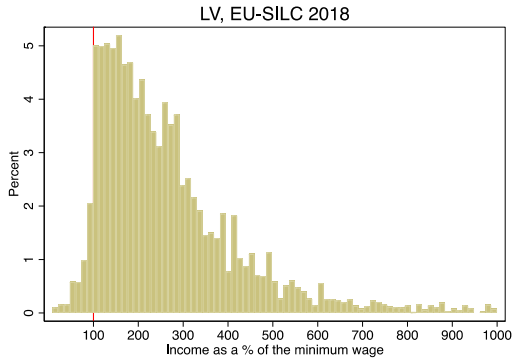


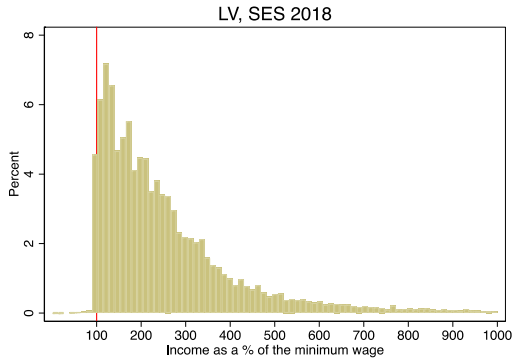


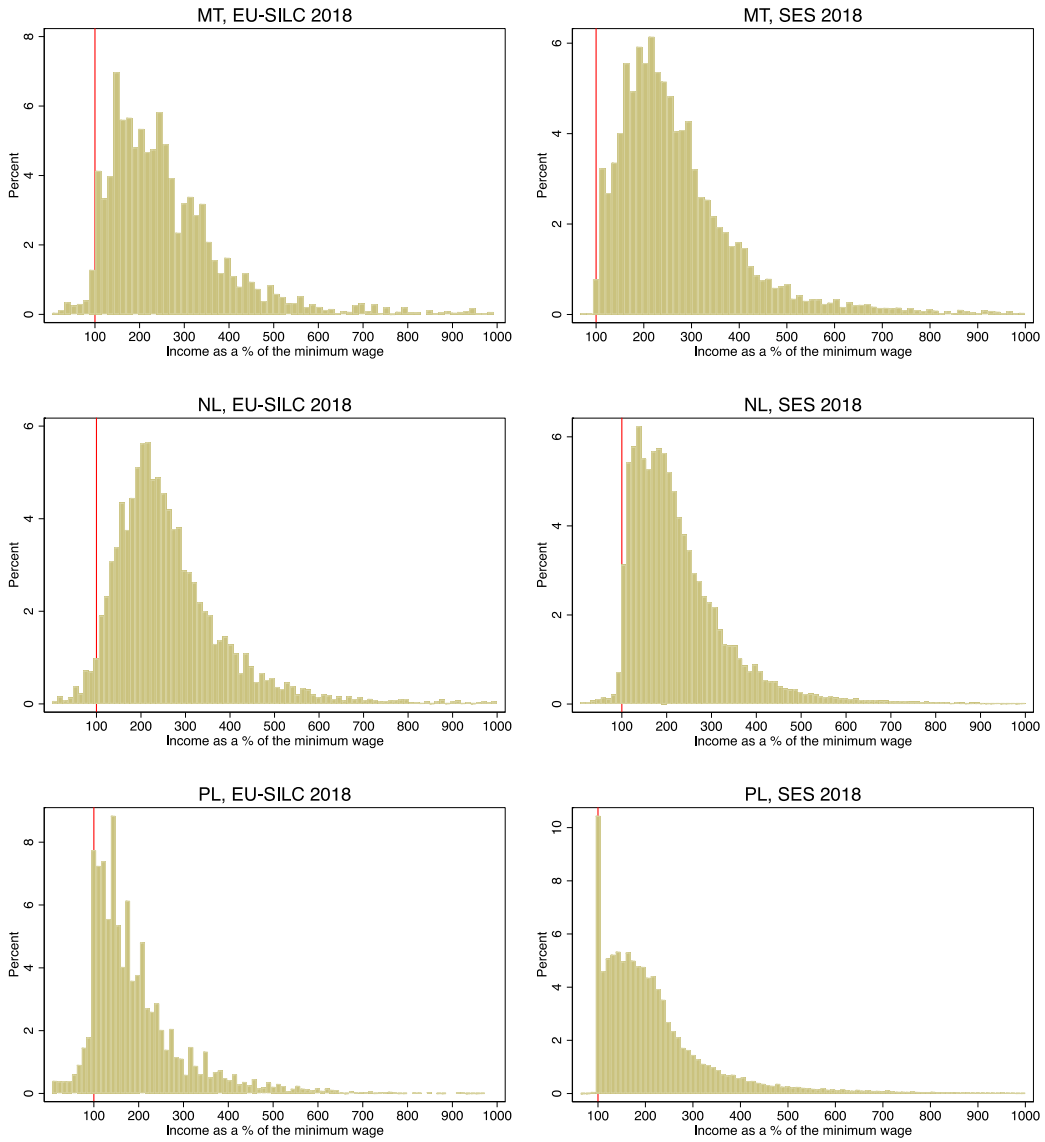


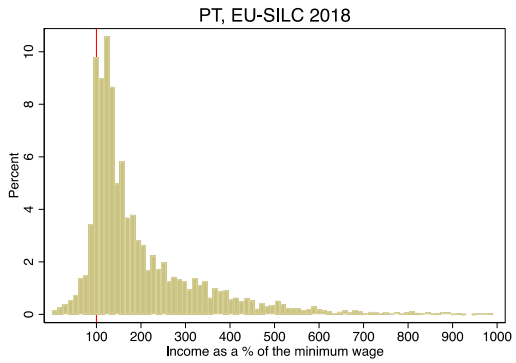


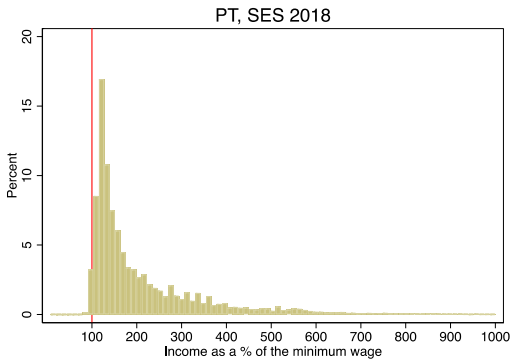


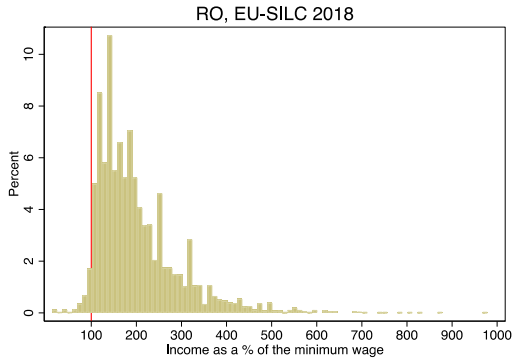


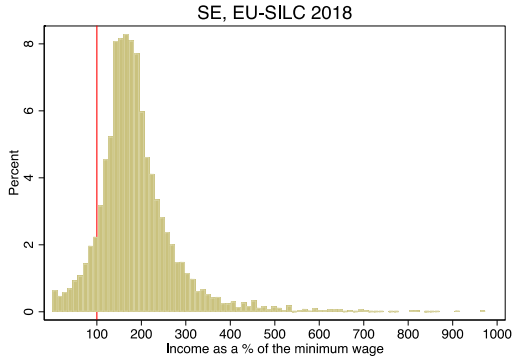


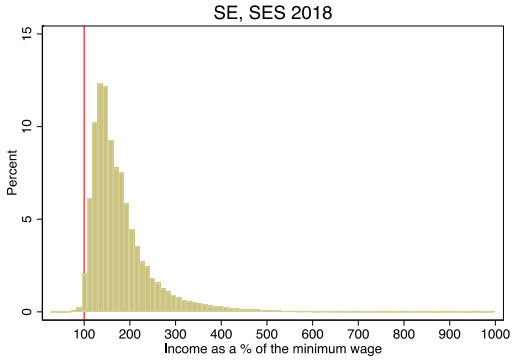

MT, EU-SILC 2018
MT, SES 2018
NL, EU-SILC 2018
NL, SES 2018
PL, EU-SILC 2018
PL, SES 2018
Percent
Income as a % of the minimum wage

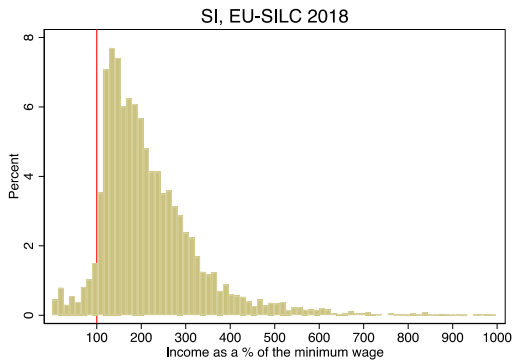


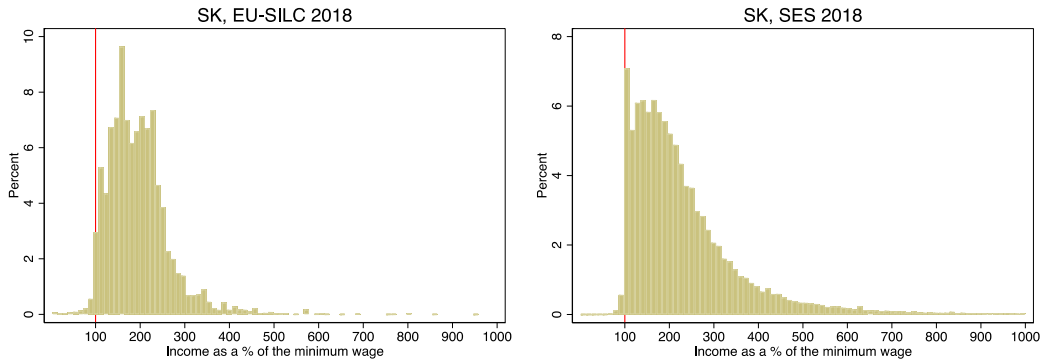








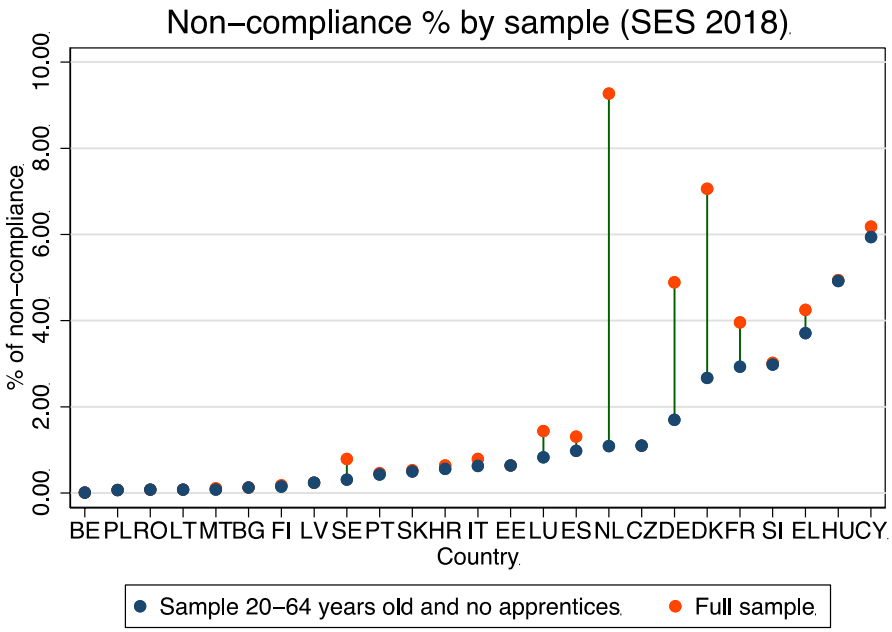




Note: *Each graph shows the density function of wages expressed as a percentage of the national minimum wage in the Member State. For countries where minimum wages are set by collective contracts, sectoral minimum wages have been used. The vertical red line represents the minimum wage. The sample includes workers aged 20–65 years old and, in SES, excludes apprentices. For some countries, non-compliance could not be computed using both EU-SILC and SES databases due to data availability and consistency issues.*

Sources: *EU-SILC and SES 2018 editions*

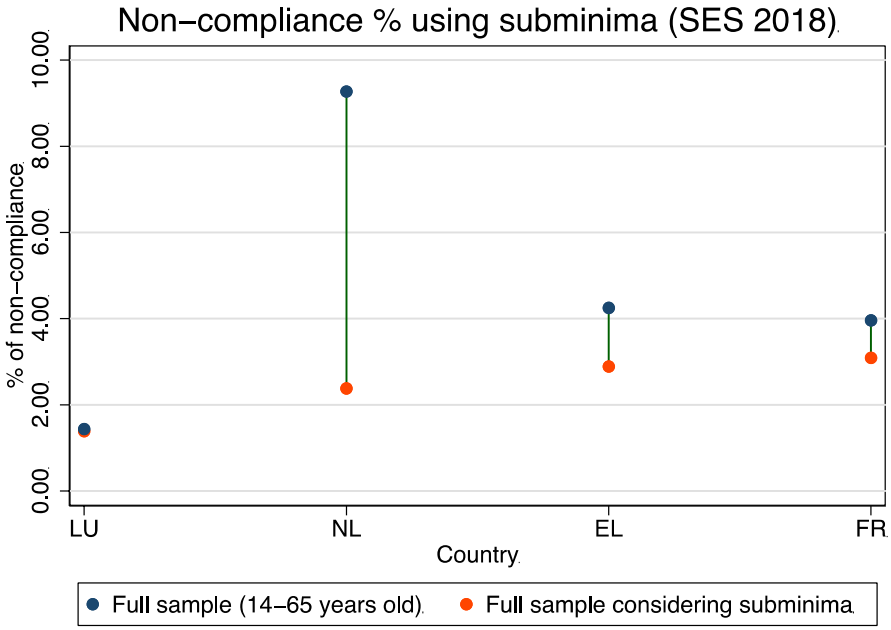
Figure A5: Comparison between non-compliance estimated in the restricted sample of non-apprentice workers aged 20–65, and in the full sample of workers aged 14–65, SES 2018



Note: *Below-minimum-wage workers are those earning less than 95% of the minimum wage. All statistics are weighted using sampling weights. The sample includes workers aged 20–65 and excludes apprentices for estimates highlighted in blue, and it includes workers aged 14–65 and apprentices for estimates highlighted in orange. The definition of income is consistent across sample selection choices.*

Source: *SES 2018 edition*

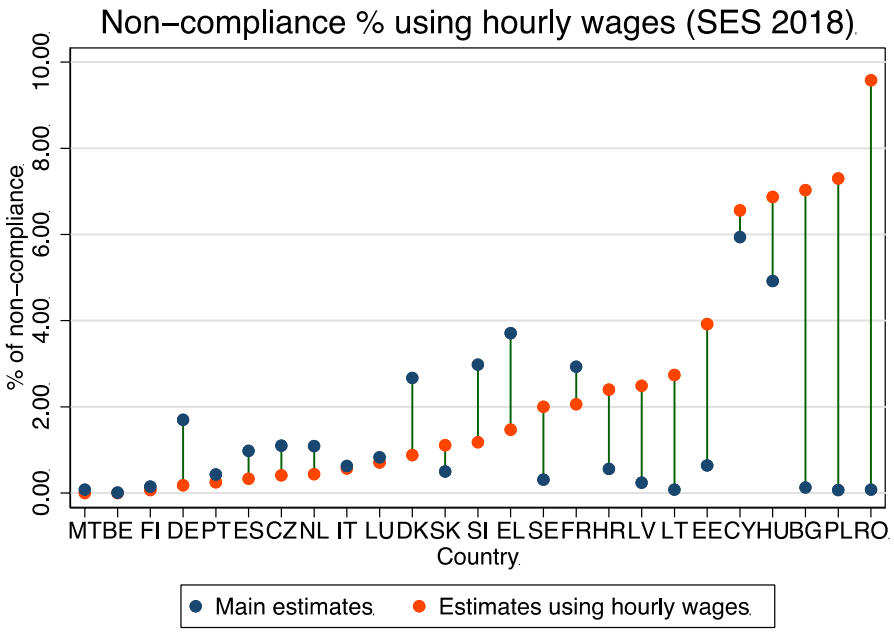
Figure A6: Comparison between non-compliance estimated using subminimum wage levels and using only the main nationwide level, SES 2018



Note: *Below-minimum-wage workers are those earning less than 95% of the minimum wage. All statistics are weighted using sampling weights. The sample includes workers aged 14–65. For estimates highlighted in blue, only the main nationwide minimum wage level is considered. For estimates highlighted in orange, the subminima rate provided by Table A3 have been considered. The definition of income is consistent across estimates.*

Source: *SES 2018 edition*

Figure A7: Comparison of non-compliance estimates using hourly wages and hourly pay floors with the main approach, SES 2018



Note: *Below-minimum-wage workers are those earning less than 95% of the minimum wage. All statistics are weighted using sampling weights. The sample includes workers aged 20–65 and apprentices. Hourly wages are obtained by dividing monthly wages by the reported number of hours worked, scaling up weekly amounts when necessary. Hourly minimum wages are obtained by scaling down the monthly rate, assuming a 40-hour working week.*

Source: *SES 2018 edition*

The European Foundation for the Improvement of Living and Working Conditions (Eurofound) is a tripartite European Union Agency established in 1975. Its role is to provide knowledge in the area of social, employment and work-related policies according to Regulation (EU) 2019/127.