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The minimum wage, informal pay and tax enforcement

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Abstract

We study the taxation of the minimum wage in an environment with imperfect enforcement and informality. We leverage an increase in the audit threat for earnings below a reporting threshold at twice the minimum wage in Hungary and estimate reporting and employment responses with administrative panel data. Using bunching estimators and difference-in-differences methods, we show that a substantial share of those who report earning the minimum wage earn at least the same amount off the books. When enforcement is imperfect, a taxed minimum wage serves as a backstop on underreporting and recovers some revenue but also increases informality.

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1 Introduction

Most analyses of the minimum wage focus on its role as a tool for redistribution to low-income workers (Lee and Saez, 2012) and its impact on employment (Clemens, 2021; Manning, 2021). The standard analysis of the taxation of the minimum wage (Lee and Saez, 2012) suggests that a positive tax rate on the minimum wage is inefficient: lowering the pre-tax minimum wage while keeping constant the post-tax minimum wage improves welfare. Yet most countries impose substantial tax wedges on the minimum wage (OECD, 2015).

In this paper we study the taxation of the minimum wage in an environment with imperfect enforcement (Kleven et al., 2011; Best, 2014; Almunia and Lopez-Rodriguez, 2018; Slemrod, 2019; Hungerman, 2021) and informality (Kuehn, 2014; Meghir, Narita and Robin, 2015; Rocha, Ulyssea and Rachter, 2018; Ulyssea, 2018, 2020). When it is possible to hire some workers informally or to underreport wages, the minimum wage is a critical threshold for tax enforcement. It is the lowest pay formally registered employers and employees can report. Registration may lower firms' risk of getting caught relative to having unreported employees. In many countries, it is also the lowest wage that a worker can legally report and still qualify for social security benefits or health insurance. This suggests that firms and workers may collude in substantial underreporting of earnings specifically at the minimum wage and that many workers who declare the minimum wage may have higher true earnings.

We demonstrate that misreporting at the minimum wage is an empirically relevant phenomenon even in a high-income country, with implications for the optimal taxation of the minimum wage. We do so by exploiting a unique policy in Hungary that introduced a new audit threshold at twice the amount of the monthly minimum wage. Between late 2006 and 2010, firms were required to pay social security contributions based on at least twice the amount of the monthly minimum wage or file an exemption form for workers who were earning below the threshold. We apply standard bunching techniques and difference-in-difference methods on administrative panel data to examine how firms' reporting behavior and the affected workers' employment changed.

In our panel, we can track workers over time, and examine at the individual level whether someone was moved by this regulation, the so-called "double minimum wage rule." We find that firms responded to the new threshold in ways that are consistent with substantial prior underreporting of earnings precisely at the monthly minimum wage. Specifically, we find that 10.5% of private sector employees and 19.2% of the self-employed who declared the monthly minimum wage before the reform in 2005 reported monthly earnings exactly double the minimum in 2007. This phenomenon suggests that they earned part of their income off the books and responded to the increased threat of audit by declaring earnings at the

audit threshold. The concentration of earnings at the audit threshold decreased in the years following the introduction of the audit threshold. Our analysis suggests that this decrease is consistent with firms revising downward their perception of the likelihood of audit at the double minimum wage threshold.

Making use of our detailed administrative data covering various domains on workers and firms, we document several patterns consistent with previous underreporting. First, there is no reporting response in the public sector which is unlikely to have much tax evasion. In order to evade taxes workers would need to collude with the government itself to underreport earnings and receive payments off the books. Second, the response is more pronounced in industries most prone to tax evasion according to survey evidence, such as construction and transportation. Third, the response is concentrated in small and domestic companies and is larger for less productive companies which we would expect to engage in more tax evasion. Employer-employee collusion is likely to be easier in smaller companies with less complex administration and less developed within-company compliance mechanisms, as well as less interest from tax authorities in enforcement. Similarly, foreign-owned companies (which are also larger on average) are likely to have stricter compliance requirements. Less productive companies are likely to find it harder to pay taxes and so have larger incentives to underreport earnings. Fourth, the response is concentrated within firms (a worker is more likely to respond if her coworkers respond) suggesting that we are observing a firm-level reduction in prior evasion behavior rather than individual workers responding. Fifth, it is also concentrated within specific geographic areas, consistent with differential local salience or norms around tax evasion.

Individuals who report earnings at the new audit threshold look different along a variety of dimensions from individuals who report just below or just above the threshold, suggesting that their true earnings fall higher in the earnings distribution and they are misreporting at the audit threshold. We are able to show anomalies in the distributions of characteristics that are unrelated to taxation, such as healthcare use, level of education, and gender. While we have panel data that allows us to detect reporting responses at the individual level, using the anomalous distribution of unrelated or "unused" observable characteristics (Finkelstein and Poterba, 2014) is a potentially useful methodology for detecting evasion in cross-sectional data.

Taken together, these findings suggest that in Hungary, a high-income country with imperfect enforcement of income taxes, a substantial share of those who report earning the minimum wage earn at least twice as much with at least half their pay off the books, a phenomenon that has been termed "envelope pay" (Williams and Padmore, 2013; Pelek and Uysal, 2016) because workers would receive part of their pay (in this case the amount of the

monthly minimum wage) officially and the rest in an envelope. This suggests that imposing some taxes on minimum wage earners or implementing a presumptive tax (Slemrod and Yitzhaki, 1994; Pashev, 2006; Yitzhaki, 2007) combined with an increased audit threat as was done in Hungary could recover some taxes from workers whose true earnings are much higher than the minimum wage.

However, in this environment firms face not only an intensive margin decision about what share of true earnings to declare (where the minimum wage is a lower bound if the firm is to declare any earnings) but also an extensive margin decision about whether to declare any earnings for a worker or move to complete informality. A policy that increases the costs of declaring formal earnings may lead firms to move workers into completely informal employment relationships. Using our population-wide administrative panel data, we are able to track people outside formal employment relationships as well and show that in response to the policy some workers exit formal employment.[1] Specifically, we show that when the government introduced the reform, workers who reported earning the minimum wage were more likely to leave formal employment than workers who reported low earnings above the minimum wage. We find that around 2% of private sector employees who earn the minimum wage exit formal employment as a consequence of the reform. This pattern is only observed in the private sector but not the public sector and only at the minimum wage and nowhere else in the wage distribution, consistent with differential exit from formal employment and entry into informal employment among those who declare earning the minimum wage but have higher true earnings. Workers who report earning the minimum wage and then leave formal employment are much less likely to appear on public benefit programs. Leaving formal employment is often temporary: workers who leave formal employment after reporting the minimum wage are much more likely to return to formal employment than workers who leave formal employment after earning even slightly above the minimum wage. Lower benefit claiming and higher return to formal employment suggest that these workers are in informal employment relationships after leaving formal employment. This informality response leads to a loss of tax revenues, in contrast with the higher tax revenue from those who respond by reporting higher earnings than before.

Our empirical findings imply a trade-off for governments taxing these low incomes: a broader tax base associated with some workers and firms reporting more of their income but also a concurrent loss associated with others becoming entirely informal. In the last part of the paper, we formalize this observed trade-off in a model. There are two sources of bunching at the minimum wage: workers who would earn less based on their productivity

[1] While in our population-wide administrative data we are able to observe people when they are not formally employed, the data do not allow us to directly observe whether they are informally employed.

absent the minimum wage and workers who earn more but whose earnings are misreported. Increasing the gross minimum wage impacts these two types of workers differently. It pushes some less productive workers who earn the minimum wage out of the formal labor market but it recovers tax revenue from workers whose earnings are underreported. The welfare impacts of raising the gross minimum wage as a substitute for improving enforcement depends on the productivity distribution and the social welfare weights assigned to workers with different productivities.

Our work contributes to four strands of the literature. First, we contribute to the recent literature that uses administrative data combined with quasi-experimental methods to reveal evasion. Recent studies (Artavanis, Morse and Tsoutsoura, 2016; Mortenson and Whitten, 2020; Al-Karablieh, Koumanakos and Stantcheva, 2021; Bjørneby, Alstadsæter and Telle, 2021) have demonstrated that underreporting remains a widespread phenomenon even in high-income countries with third-party reporting. We make two contributions to this literature. Our work documents a new aspect of misreporting: wages that are underreported specifically at the minimum wage.[2] We also suggest a new way to detect misreporting in cross-sectional data using the distribution of unrelated observable characteristics (Finkelstein and Poterba, 2014).

Second, we contribute to the literature on audits as a way to improve compliance.[3] Work in this area (Kleven et al., 2011; Hashimzade, Myles and Rablen, 2016; Bérgolo et al., 2017; Almunia and Lopez-Rodriguez, 2018; Choudhary and Gupta, 2019) generally finds that firms react to audit threats and when effective and well-targeted (Best, Shah and Waseem, 2021) audits and audit threats can improve compliance. We provide evidence on a policy, a mixture of presumptive taxation and a targeted audit threat, that can recover some tax revenue lost to misreporting. Recent work has also suggested that enforcement notches can be welfare improving (Hungerman, 2021), though firms may respond through revenue manipulation (Di Gregorio and Paradisi, 2021). Indeed, in our case, we find bunching around an enforcement threshold, suggestive of manipulation of reported wages.

Third, we contribute to the literature on informal employment and taxation.[4] Recent work in this area (de Mel, McKenzie and Woodruff, 2013; De Andrade, Bruhn and McKenzie, 2014; Kuehn, 2014; Meghir, Narita and Robin, 2015; Rocha, Ulyssea and Rachter, 2018; Ulyssea, 2018; Gerard and Gonzaga, 2021) has focused on policy interventions that can improve formalization. Our work suggests that tax enforcement may generate trade-offs for

[2]See Reizer (2011), Tonin (2011), Elek, Köllő, Reizer and Szabó (2012), and Tonin (2013) for some earlier evidence based on survey data in Hungary.

[3]See Andreoni, Erard and Feinstein (1998) and Slemrod (2019) for comprehensive reviews of the literature on tax compliance and enforcement.

[4]For a recent review on informality and development, see Ulyssea (2020).

informality: it can formalize the earnings of some workers, while other workers' earnings will become entirely informal.[5] Our results on the firm-level concentration of underreporting and the move to informal employment complement the results of Best (2014) who considers the role of firms in compliance.

Fourth, we contribute to the literature on the taxation on the minimum wage. The well-known result of Lee and Saez (2012) is that under perfect competition and efficient rationing of jobs the coexistence of a minimum wage with a positive tax rate on low-skilled work is Pareto inefficient. At the same time, a substantial tax burden falls on minimum wage earners in many countries; 13 out of the 27 countries surveyed by the OECD (2015) had a tax wedge at least as large as 40%. Our findings suggest that the revenue recovered from higher earners who misreport their earnings could partly rationalize taxing the minimum wage. In effect, the minimum wage serves as a backstop on underreporting. Our work is also related to recent evidence on the effects of minimum wage increases, see Bossavie, Acar and Makovec (2019), Cengiz, Dube, Lindner and Zipperer (2019), Harasztosi and Lindner (2019), and Dustmann et al. (2021).[6] Along with recent work by Gavoille and Zasova (2021), our results suggest that in a labor market characterized by envelope wages, wage underreporting may be an adjustment margin used by firms in response to changes in the minimmum wage.

The remainder of this paper proceeds as follows. We begin in Section 2 by providing background on the Hungarian tax system and the double minimum wage rule. Section 3 models bunching at enforcement thresholds, motivating our empirical strategy. In Section 4, we describe the data used. Section 5 summarizes our methods and empirical framework. Section 6 presents our results. Section 7 derives the welfare consequences of a higher gross minimum wage when underreporting is a concern at this point in the wage distribution. Finally, Section 8 concludes.

2 Background

2.1 Institutional Context

Hungary has long had a legal minimum wage. The minimum wage is mostly discussed as the monthly minimum for full-time workers, but proportional amounts are set for weekly and hourly pay as well. After a large 2001 raise, the gross minimum wage remained relatively

[5]The informal economy and pay misreporting is sizable not only in low- and middle-income countries but in the high-income countries of Central and Eastern Europe, where some estimates put the size of the informal economy to 20% of GDP (Williams and Padmore, 2013; Williams, 2013; Paulus, 2015).

[6]For recent reviews on the employment effects of the minimum wage, see Clemens (2021) and Manning (2021).

stable, while the net minimum wage fluctuated along with changes in the tax system. In real dollar terms, the net minimum wage rose 3.4% per year on average over this period. Income is taxed on an annual basis throughout the period, so our discussion of the tax treatment of the minimum wage assumes full-time, full-year employment at the prevailing minimum wage. We also abstract from tax deductions and credits. Gross and net monthly minimum wages are tabulated in Appendix Table A1, alongside a so-called Guaranteed Wage Minimum for skilled jobs assumed to require a high-school diploma, which was introduced in July 2006.

While some countries, notably the United States, the United Kingdom, and Germany, set and discuss hourly minimum wages, many others focus on monthly minimum wages. For example, as Panel (a) of Figure 1 shows, among the 12 OECD countries with the largest tax wedges on minimum earnings, Germany (which only introduced a national minimum wage in 2015) is the only one that does not set monthly minimum wages. Thus while governments usually tax annual income and not monthly earnings, the monthly minimum wage is salient to workers, firms, and tax authorities.

Labor income is taxed heavily in Hungary. Between 2003 and 2011, the years covered by our data, the average tax wedge varied between 46% an 55%, without any major reforms in the taxation of labor income. In 2006 for instance, Hungary had the third largest average tax wedge among 36 OECD countries (OECD, 2019) and the highest on minimum wage earners (Figure 1). Labor income taxes include a payroll tax (in 2006, 18% on the first 1,550,000 HUF or $7,400, 36% above), social security contributions paid by the employee (15.5% in 2006), and social security contributions paid by the employer (altogether 30% in 2006). Appendix Table A2 shows the payroll tax and social security contribution rates by year.

Two major forms of informal employment have been documented in Hungary. The first is undeclared work, when no employment relationship is reported to the tax authority, and consequently neither the employer, nor the employee pays any taxes. Based on discrepancies between pension fund microdata and survey evidence, in the early 2000s 16-17% of employees were undeclared (Elek, Scharle, Szabó and Szabó, 2009*b*; Benedek, Elek and Köllő, 2013). The second form is wage underreporting, when an employment relationship is reported to the tax authority but reported earnings are substantially lower than true earnings. This type of employment relationship is termed "envelope pay" in the literature (Williams and Padmore, 2013; Williams, 2013; Paulus, 2015). Since some taxes are paid on this work, this form of employment is more costly than undeclared work, but it also offers certain advantages for both employers and employees. Employers may appear more legitimate to the tax authority and they may be able to rely more on their employees since a formal employment contract exists. Employees can also enjoy some protections of a formal work contract and reporting some earnings qualifies them for a wide set of benefits, including public health insurance,

disability insurance, unemployment insurance, and pensions.[7] A common form of "grey" employment in Hungary is the reporting of wages at the minimum wage while supplementing earnings in cash (Elek, Scharle, Szabó and Szabó, 2009*a*; Elek, Köllő, Reizer and Szabó, 2012).[8]

2.2 Audit Policy

In order to reduce wage underreporting, Hungary introduced a so-called "double minimum wage rule" in 2006. This rule required employers to pay social security contributions on at least twice the minimum wage for an employee. Employers could ask for an exemption from this rule on a special form if their true wages were lower than twice the amount of the minimum wage, indicating the exact amount of wages. This then increased the probability of a tax audit. If the reported wage was below double the amount of the minimum wage but no exemption was requested then the employer had to pay the employers' social security contributions based on twice the amount of the minimum wage, plus also had to pay the employees' contributions for the discrepancy. This rule incentivized employers to either request an exemption or to report at least twice the amount of the minimum wage towards tax authorities. The rule applied to both private sector employees and the self-employed. The policy was in effect between September 1, 2006 and December 31, 2010.

This policy can be considered presumptive taxation. A presumed tax base is a substitute for a desired tax base; the former is derived from items that are easier to monitor. Presumptive taxation arises whenever the legislator is using one tax base in order to approximate another (Slemrod and Yitzhaki, 1994; Yitzhaki, 2007). The policy does not rely on additional observables, but it "presumes" that the taxpayer's earning is no less than double the minimum wage, unless the taxpayer proves otherwise.[9]

3 Bunching at Enforcement Thresholds and the Minimum Wage

This section introduces a model of labor demand and tax evasion that generates bunching both at the minimum wage and other enforcement thresholds. Bunching arises at enforcement

[7] Health insurance coverage does not change with the amount reported, and other benefits scale only loosely with earnings. Misperceptions and discounting of future benefits are prevalent in other contexts as well (Liebman and Luttmer, 2015).

[8] We discuss some reported audit statistics of the Tax Authority in Appendix B.

[9] Bulgaria introduced a similar rule in 2003, called the minimum insurance income thresholds, to curb the widespread practices of insuring employees at the level of the statutory minimum monthly wage instead of the actual wage (Pashev, 2006).

thresholds due to evasion. At the minimum wage, bunching arises for two reasons. First, it constrains firms from paying efficiency wages lower than the minimum wage (bunching from below). Second, it constrains the amount of tax that firms can evade while remaining in the formal labor market (bunching from above, in terms of true wages). We build our model in three steps. We start by demonstrating how bunching arises at an enforcement threshold for reported earnings, $\tilde{W}$. Then, we show how things differ if $\tilde{W}$ is not merely an enforcement threshold but the minimum wage, M. Finally, we show how bunching shifts when there is a second enforcement threshold at reported earnings D.

Setup. In partial equilibrium, firms post, create, and fill each job to maximize their profit. Abstracting away from the demand and input supply curves the firms face, employers (or the self-employed) will set a worker's wage w and evasion level e to maximize profit $V(w, e \mid \theta)$:

$$\max_{w,e} V(w, e \mid \theta) = f(w \mid \theta) - w - \tau \cdot \underbrace{(w - e)}_{\text{Declared Earnings } \tilde{w}} - \underbrace{\rho \cdot p \cdot \tau \cdot e}_{\text{Expected Audit Cost}} - \underbrace{g(e)}_{\text{Manipulation Cost}} \tag{1}$$

where $f(\cdot)$ is the production function for a job, e is the amount of manipulation in earnings, θ is a productivity parameter, p is the audit probability the firm faces, τ is the tax wedge on declared earnings, and ρ is the recovery rate (including potential fines) on misreported earnings if audited.

The production function defines input demand by the first-order conditions

$$f_w(w \mid \theta) = 1 + \tau, \tag{2}$$

$$\tau(1 - \rho p) = g'(e). \tag{3}$$

Assuming g' is well-behaved and strictly increasing, Equation (3) defines an optimal evasion function $E(\cdot)$, which is strictly increasing in $\tau(1 - \rho p)$.

We can assume without loss of generality that productivity types are ordered such that the marginal value product of labor is strictly increasing in productivity θ: $\partial^2 f / \partial w \partial \theta > 0$. For a well-behaved f, these first order conditions also define the implicit function for $\partial w / \partial \theta$, the relationship between wages and productivity.

3.1 Static Bunching at an Enforcement Threshold

This environment generates an excess mass of employment at reported income levels where enforcement changes discontinuously, as inframarginal evaders end up reporting the threshold amount for a range of jobs.

Assume that audit probability p drops from p_L to $p_U < p_L$ at some declared earnings threshold $\tilde{W}$: $p = p_L$ if $w - e < \tilde{W}$ and $p = p_U$ otherwise. For a continuous distribution of productivity, there is a lower threshold θ_L for jobs just productive enough to pay the threshold wage with less evasion, potentially facing the stricter evasion regime below:

$$w(\theta_L) - E\left(\tau - \rho p_L \tau\right) = \tilde{W}. \tag{4}$$

For less productive jobs, $\theta < \theta_L$, evasion is constant at $E\left(\tau - \rho p_L \tau\right)$, and production is at its unconstrained optimum with $w(\theta) < \tilde{W} + E\left(\tau - \rho p_L \tau\right)$.

Similarly, there is an upper threshold productivity level θ_U for unconstrained evaders facing the laxer enforcement regime, who report the cutoff income levels after bolder evasion:

$$w(\theta_U) - E\left(\tau - \rho p_U \tau\right) = \tilde{W}. \tag{5}$$

More productive jobs ($\theta > \theta_U$) also shade this higher amount ($e = E\left(\tau - \rho p_U \tau\right)$), and production is at its unconstrained optimum with $w(\theta) > \tilde{W} + E\left(\tau - \rho p_U \tau\right)$.

In between, for $\theta \in [\theta_L, \theta_U]$ the firm will produce and evade just enough that $w - e = \tilde{W}$, as illustrated in Panel (a) of Figure 2.[10] If H denotes the c.d.f. of the productivity distribution, this implies the mass of $H(\theta_U) - H(\theta_L)$ bunching at the enforcement threshold $\tilde{W}$. This is the mass missing from the left of the threshold $\tilde{W}$ in a world without frictions and noise.

3.2 Bunching at a Threshold That Is Also the Minimum Wage

In practice, the minimum wage is both an extremely well enforced threshold for potential evaders and a legal minimum on genuine remuneration. We can make both the evasion constraint ($M \leq w - e$)[11] and the participation constraint ($0 \leq V$) explicit. Zero misreporting

[10] The exact mix of suboptimal production and intermediate evasion depends on the marginal cost of each. If the shadow price of relaxing the $w - e = \tilde{W}$ constraint is the Lagrange multiplier λ, the following first-order conditions characterize the constrained optimum when this condition binds:

$$f_w(w \mid \theta) - (1 + \tau) + \lambda = 0, \tag{6}$$
$$-\tau(1 - \rho p) - g'(e) - \lambda = 0. \tag{7}$$

This links the marginal value product of labor to the tax rate and the costs of evasion:

$$f_w(w \mid \theta) = 1 + 2\tau - \rho p \tau + g'(e). \tag{8}$$

[11] The $w - e \geq M$ enforcement constraint is equivalent to non-negative evasion ($e \geq 0$) with an effective minimum wage ($M \leq w$). With neither constraint, bunching at M arises even without enforcement reasons, but not purely from the distorted efficiency wage decision but also people overreporting pay. Instead of this unrealistic scenario, we only discuss the minimum wage as two constraints in one.

below the minimum wage is a corner solution, but fits our framework with $p_L = \underline{p} \gg p_U = \bar{p}$ (and if $\underline{p} \leq 1$ would bind, allow for $\underline{\rho} \gg \rho$ as additional punitive fines).

In Appendix Section A.1, we derive how these constraints partition the parameter space into unconstrained evaders (Θ_3), bunching evaders (Θ_2) and bunching true minimum wage employers (Θ_1), as illustrated in Figure 2, Panel (b). The cutoff levels of productivity, whose shifts are key to the welfare analyses in Section 7, are denoted by the corresponding subscripts: θ_0, θ_1, and θ_2. For the intuitive and empirically relevant ordering of these cases, the derivation makes use of the following additional assumption.

Assumption 1. *For the sake of empirical relevance, assume that the marginal firm with zero profit is one that barely pays the minimum wage without shading (or would pay even worse than the minimum and misreport* better *pay if this were allowed).*

In practice, this assumption means that evaders and truthful reporters both bunch at the reported minimum wage, which we consider both empirically relevant and more interesting for enforcement. Otherwise all bunchers would reveal themselves to evade with no need for elaborate research designs.

3.3 Shifts in Bunching

We can easily extend the model to two thresholds, an extremely well enforced lower threshold M and an initially ineffective new threshold D. This reflects the Hungarian policy experiment in 2006, key in our empirical setting.

Initially, $p = \bar{p}$ for reported earnings above M and even above $D > M$, and the previous subsection describes the bunching at M. If p rises for reported earnings between M and D ($p = p_M > \bar{p}$ for $\tilde{w} \in [M, D)$), a bunch appears at D as in Subsection 3.1[12]. The excess mass at M becomes smaller, as some evaders move from M towards D with a new productivity cutoff $\theta_2' < \theta_2$ defined by

$$w(\theta_2') - E\left(\tau - \rho p_M \tau\right) = M. \tag{9}$$

How many jobs will report earnings between M and D? Reported earnings rise with less evasion, but any given reported earnings will correspond to lower productivity now. It can be reasonable to expect lower productivity jobs to be more prevalent than higher ones[13]. In this case, the density of observed jobs will rise for the segment with reported earnings facing stricter enforcement. However, the observed density of reported earnings will drop to 0 close

[12]The corresponding productivity cutoffs would be θ_3 and θ_0, delineating bunching evaders Θ_4 and unconstrained evaders Θ_5 above, as shown in Figure 2, Panel (c).

[13]This would be the case if the minimum wage M were high enough to leave θ_2' to the right of the mode of a unimodal distribution H.

to D for the new bunchers. Empirically, this leaves the sign of the changing average density for a broader segment between M and D ambiguous.

Would the extra mass at D be a lower bound on the prior mass of tax cheats at M (Θ_2 in Figure 2, Panel (b))? Common intuition might suggest so, especially with heterogenous proclivity to cheat. In a model with uniform incentives to misreport, this remains ambiguous. The tax cheats at D need not come from bunching evaders reporting M before. Figure 3 illustrates the impact of stricter enforcement over $[M, D)$.

4 Data and Sample

We use an administrative panel dataset that brings together information on earnings, occupations, benefit receipt, healthcare spending, and other domains for a random 50% sample of the Hungarian population for years 2003–2011.[14] Since our focus is on the working age population, we restrict the sample to individuals aged 18–65.

4.1 Employment and Worker Characteristics

We observe monthly employment and earnings at the individual-firm level, as well as monthly data on benefit take-up. The earnings and labor market status indicators originate from the pension authority. These records are in effect used in the calculation of pension benefits after retirement. An individual is defined to be formally employed if the pension authority records any type of employment or self-employment on the 15th of the given month. Although labor market status and earnings are observed at the monthly level, due to data limitations (some earnings are smoothed within a job spell), we keep data from only a representative month (March) for each year. We drop person-year observations for which an individual holds multiple jobs. We observe gross earnings, which include all earnings that enter pension benefit calculations. We do not observe actual taxes paid by firms or workers, nor capital income.

We use several individual-specific variables, including age, gender, initial residence, social security benefits received (if any) and skill level of occupation. Age, gender and residence come from a 2003 snapshot of the health insurance fund data; all labor market data come from the pension administration. From occupations, we impute skill levels by imputing the median education level of employees of the same occupation code as observed in the Labor

[14]The dataset was constructed by selecting a random 50% sample (for privacy reasons) of the Hungarian population aged 5–74 in 2003 and following this initial sample until 2011. Inclusion in the dataset is effectively random as individuals with certain days of birth are included. Sample attrition might arise from emigration or death, the latter of which we record directly, but neither is particularly relevant for our study sample.

Force Survey of the Central Statistical Office of Hungary. Area of residence is observed only in 2003, and not updated.[15] The data originating from the pension administration allow us to separate employment by sector; we divide workers into three groups: private sector employees, public sector employees, and the self-employed.[16] We restrict the group of the self-employed to individuals whom we observe to work in firms with observed size of one (70% of all self-employed). Thus, our analysis excludes freelancers and contractors who are not employees at a firm but who work in a firm which has two or more observed workers. Table 1 shows summary statistics for our sample of workers by sector.

An important limitation of our data is that earnings are smoothed within employment spells and calendar years. Specifically, employment spells are cut into calendar years and average within-spell, within-year earnings are reported. For example, if an individual remained in the same job throughout the year, then we observe her total annual earnings in that job divided by 12. If she remained in the job for several years, then we observe this measure specifically for each year. If she changed jobs within the year, then we observe separate spells for her jobs.[17] Because of this smoothing and the audit policy coming into effect in September 2006, people shifting from the minimum wage to its double are observed to earn between the two (the weighted average) throughout 2006 (including in March, the representative month we use). This data limitation guides our decision to exclude 2006 from most of our analyses, and instead focus on wage distributions in 2005 and 2007 and transitions between the minimum wage and its double between 2005 and 2007.

4.2 Firm Characteristics

Tax authority data on firm-specific indicators are available only for larger firms (with double-entry bookkeeping).[18] Based on this, we see ownership (foreign versus domestic), sector and industry, firm size, net revenues, the total wage bill, gross value added, tangible assets and material costs. The revenue and cost indicators are annual measures, corresponding to a calendar year. Using these indicators, we calculate total factor productivity (TFP) as the sum

[15] Cross-county migration can be approximated from 10-year census data. Over the 10-year period between 2001 and 2011, approximately 15% of the population moved between counties (Lakatos, L. Rédei and Kapitány, 2015).

[16] These sector definitions are consistent over years 2003-2009, less so for years 2010-2011, due to changes of definitions in the baseline data. We exclude from the group of private sector employees those who work at firms in which the ownership rate of the government is above 50% or where we observe in any year more than 10 public sector employees. Public sector employees are public servants whose earnings are regulated by the government, including teachers, physicians, and civil servants, among others.

[17] We also observe separate records for contemporaneous employment spells with multiple employers, but exclude workers who have more than one employer at the same time.

[18] Double-entry bookkeeping is compulsory for firms with annual income above 50 million HUF (approximately $160,000).

of fixed effects and residuals from a firm level regression of the log of net revenue regressed on log costs of labor, capital and materials. Since the calculated TFP is based on the tax authority's firm-level records, it is not affected by sampling noise in our 50% sample. For our analyses, we use the observed number of workers in a firm because this can be calculated for all firms, regardless of the availability of firm-specific indicators from the tax authority. By our definition, self-employed individuals work in firms with observed size of one. Appendix Table A3 shows summary statistics for private-sector firm characteristics.[19]

4.3 Wage Bin Definitions

Throughout our analyses, we use two bin definitions to partition the earnings distribution. For our cross-sectional analysis, we define absolute bins of size 5,000 HUF (≈$17) starting at 0. The advantage of these bins is that they are transparent and have the same absolute magnitude in each year. We also view them as relatively narrow: 5,000 HUF corresponds to 6-10% of the minimum wage in this period.[20] In order to facilitate comparisons over time, though, we also define relative wage bins.[21] The lower end of the first bin is the monthly minimum wage, the upper end of the first bin is 110% of the monthly minimum wage in years 2003-2005 (before the introduction of the guaranteed wage minimum), and the guaranteed wage minimum in years 2006-2011. Bins 2-6 are of equal width, the top of bin 6 equals the later audit threshold. Thus, the width of a bin equals around 18% of the monthly minimum wage. Bins 7-11 have the same width, the lower end of bin 7 equals the post-2006 audit threshold. Intervals 1-11 are left-closed and right-open. Finally, bin 12 is open ended, including all earnings at or above around three times the monthly minimum wage. The advantage of using relative wage bins is that they allow for temporal comparison in a way that makes the wage bins follow the minimum wage. Fixed-width bins would lead to substantial narrowing over time in relative terms, since the gross minimum wage was 56% higher in 2011 than in 2003.

We do not observe hours worked, and part-time workers can have monthly earnings below the monthly minimum wage. We do not exclude them because we are unable to exclude part-time workers earning above the minimum wage.

[19] In our matched employer-employee data, a firm identifier is attached to each worker. When analysing firm-level characteristics in the private sector, we first restrict the sample to private sector employees (thus exclude the self-employed, freelancers and contractors) and then conduct our analysis on the remaining subsample of firms. Therefore, we exclude firms which do not employ any private sector employees.

[20] In Section 6.3, we also examine the robustness of our main results about wage reporting around the later audit threshold using a relative band of 95-105% around the annual level of the threshold.

[21] For the alluvial plot in Figure 6, we use a limited number of coarser relative wage bins.

5 Empirical Framework

In our analyses, we use the introduction of the audit policy in 2006 to provide evidence on the underreporting of earnings at the minimum wage, and to estimate the impact of the rule on reported earnings and formal employment. In this section, we discuss our empirical strategy.

5.1 Underreporting of Earnings at the Minimum Wage

Bunching and Transition Patterns. The first set of analyses we present relies on the cross-sectional distribution of earnings before and after the introduction of the audit policy. We divide monthly earnings into 5,000 HUF (≈$17) bins and show histograms of the earnings distribution before (2005) and after (2007) the introduction of the policy, separately for private sector employees, the self-employed, and public sector employees. We start the bins at zero and censor the distribution at 300,000 HUF (≈$1,000) which is almost five times the minimum wage. In addition to this cross-sectional evidence, we exploit the panel nature of the data to directly analyze transitions of workers between different wage levels. We estimate two-year transition probabilities between each pair of wage bins.[22]

In our heterogeneity analyses, we focus on transitions from reporting earnings at the minimum wage in 2005 to reporting double the minimum wage in 2007. We calculate the percentage of workers who transition by worker characteristics (gender, age, and occupation skill level), firm characteristics (ownership, size, and industry), and total factor productivity as a measure of firm quality. We also break down these transition rates by 174 districts of Hungary, weighted by population, and analyze the relation between the district-specific transitions among private sector employees and the self-employed.

Regression Framework. Building on our descriptive results, we estimate event study regressions which describe the evolution over time of the probability of earning at the double minimum wage (DMW) among private sector employees and the self-employed, relative to public sector employees. Our estimating equation is

$$DMW_{it} = \beta_0 + \sum_{t \neq 2006} \beta_{1t} PE_{it} + \sum_{t \neq 2006} \beta_{2t} SE_{it} + \alpha_E + \tau_t + \varepsilon_{it} \tag{10}$$

where i indexes workers, PE_{it} is an indicator for private sector employees, SE_{it} is an indicator for the self-employed, α_E are sector fixed effects (public-sector employee, private sector employee, or self-employed), and τ_t are year fixed effects. The coefficients of interest are β_{1t}

[22] We analyze two-year transition probabilities to account for the problem of smoothed earnings in 2006 discussed in Section 4.1.

and β_{2t}, the differential change between private sector employees or the self-employed and public sector employees in the likelihood of reporting earning the double minimum by year t. In all our regressions, we cluster standard errors at the firm level.

In addition, we also estimate a constant treatment effect difference-in-differences version of this regression, essentially pooling all years before and after treatment:

$$DMW_{it} = \beta_0 + \beta_1 PE_{it} \times Post_t + \beta_2 SE_{it} \times Post_t + \alpha_E + \tau_t + \varepsilon_{it} \tag{11}$$

where we use the same notation as in Equation (10) and $Post_t$ is an indicator for the post-period (years 2007-2010). We exclude year 2011 from this regression because the policy was no longer in effect by then. The coefficients of interest are β_1 and β_2, the differential change between private sector employees or the self-employed and public sector employees in the likelihood of reporting earning double the minimum between the pre and post periods.

Identification. Our estimation relies on standard difference-in-differences assumptions. For the β_{1t} (β_{2t}) to represent a valid estimator of the impact of the audit policy on the share of private sector employees (the self-employed) who report earning the new audit threshold, we require that the evolution of the share of public sector employees who report those earnings be a valid counterfactual for the share of private sector employees and self-employed who report the same, absent the introduction of the policy.[23]

The only other contemporaneous policy change that we are aware of that would affect the overall distribution of wages in the sectors differently is the introduction of the guaranteed wage minimum for skilled jobs assumed to require a high school diploma. But we are not aware of any changes that would affect the distribution of wages specifically at the new audit threshold, including policies that would affect the three sectors diferentially. There are also unlikely to be any spurious wage dynamics that would affect the distribution of wages specifically at this point differentially in the three sectors.

We provide several pieces of evidence that suggest that the share of public sector employees who report earning the new audit threshold would be a good counterfactual for the same shares in the private sector and among the self-employed, absent the introduction of the audit policy. First, in Figure 4, we observe no bunching at the new threshold or at any other point in the wage distribution among public sector employees either before or after the introduction of the policy. Second, when we move from the cross-section to tracking people as they move between different wage bins in Figure 5, we find that the two-year earnings

[23]Parallel trends are a strong assumption for densities and CDFs, but as Roth and Sant'Anna (2021) discuss, Cengiz, Dube, Lindner and Zipperer (2019), amidst other minimum wage examples, provide a primary application of this assumption in empirical practice.

dynamics of public sector employees appears fairly symmetric (moving from bin i to bin j has about the same probability as moving from bin j to bin i) both before and after the reform. Indeed, both before and after the reform, most public sector workers' earnings are stable on a two-year time horizon. Third, looking at trends in the share of public sector workers reporting to earn the audit threshold in Figure 7, there are no changes in the share of public sector employees who report those earnings either before or after the change. Fourth, looking at the observable characteristics of workers with those reported earnings in Figure 9, there are no anomalies in public sector workers' wage distribution at the new audit threshold, either before or after the introduction of the policy. Fifth, addressing the concern that the audit policy could have affected wage dynamics among public sector employees through exits from formal employment (another outcome we examine below), Figure 12 shows that the policy change was not associated with any changes in exit from formal employment among public sector workers.

5.2 Impact on Formal Employment

Descriptive Evidence. The first approach we take to analyzing the impact of the reform on formal employment shows the evolution over time of the probability of leaving formal employment for workers earning the minimum wage and for workers in the three relative wage bins (bins 2-4) immediately above the minimum wage, separately for private sector employees and public sector employees. For this analysis, comparisons across relative wage bins are necessary because macroeconomic trends have a considerable impact on employment, as apparent during the Great Recession in our figures, and this impact is differential across sectors. There are few self-employed in wage bins 2-4, therefore we cannot include the self-employed in this analysis.

Since in this analysis, we compare workers reporting different earnings, we need to account for a specific problem caused by the smoothing of wages within job spells and calendar years discussed in Section 4.1. Recall that due to this smoothing and the audit policy coming into effect in September 2006, people shifting from the minimum wage to its double are observed to earn between the two (the weighted average) throughout 2006. This means that people who change their reported earnings from the minimum wage to the new audit threshold in September (or any other months during 2006) are not included among the observed minimum wage earners in March 2006. The problem for our analysis is that long-employed people shifting from the early-2006 minimum wage to its late-2006 double are likely to have a lower counterfactual probability of leaving their steady job by March 2007 than those who report the minimum wage throughout the year. This means that independently from the policy,

those observed to report the minimum wage for their entire spell in 2006 (whenever it ended) are much more likely to leave formal employment by next spring than those observed to report earning above the minimum wage. Hence, our naive estimates of the impact of the policy on exit from formal employment among observed minimum wage earners would likely overstate the effect.

To get around this issue, we estimate the impact of the policy on formal employment using earnings in December of year t, and looking at the rate of formal employment in January of year $t+2$ (i.e. 13 months later). Thus our estimates are not biased by our differential mismeasurement of earnings in 2006 as we analyze the probability of leaving formal employment between December 2005 and January 2007 by reported wage bin in December 2005. This approach likely underestimates the true annual effect because we miss spells starting in 2006.[24]

Regression Framework. Building on our descriptive results, we estimate event study regressions which describe the evolution over time of the probability of leaving formal employment among those earning the minimum wage in the previous year relative to those earning in one of the relative wage bins just above, separately for private sector employees, and public-sector employees. We cannot conduct this analysis for the self-employed because of the low number of self-employed reporting earnings above the minimum wage bin. Our estimating equation is

$$Exit_{it} = \beta_0 + \sum_{t \neq 2006} \beta_t MW_{i,t-1} + \alpha_B + \tau_t + \varepsilon_{it}, \tag{12}$$

where i indexes workers, $MW_{i,t-1}$ is an indicator for being in the minimum wage bin (vs. the control wage bin) the year before, α_B are wage bin fixed effects (minimum wage vs. control), and τ_t are year fixed effects. The coefficients of interest are β_t, the differential change between workers reporting to earn the minimum wage and workers reporting to earn just above the minimum wage in the likelihood of exiting formal employment by year.[25]

We also examine heterogeneous responses, re-estimating Equation (12) and splitting the sample by worker characteristics (gender, age, and occupation skill level), firm characteristics

[24] An alternative would be to analyze formal employment responses over a two-year time horizon, as we do in much of our analysis of reporting responses. The downside of this approach would be that we miss additional spells starting between March and December 2005.

[25] Unlike in our estimation strategy for reporting responses discussed in Section 5.1, we do not estimate a constant treatment effect version (the analogue of Equation (11)), because over time the composition of workers reporting to earn the minimum wage and reporting to earn in the wage bins just above changes due to our measured employment response. The Great Recession also appears to have had disparate impacts on workers in different parts of the wage distribution and in different sectors.

(ownership, size, and industry), and a measure of firm quality (total factor productivity).

Identification. Our estimation again relies on standard difference-in-differences assumptions. For β_t to represent a valid estimate of the impact of the audit policy on the share of private sector employees who leave formal employment, we require that the evolution of the share of employees in higher wage bins be a valid counterfactual for workers who report earning at the minimum wage. Pre-trends in this case are more challenging to examine with only two years of data on year-to-year exits prior to the policy. Nevertheless, the lack of pre-trends in this time period provides suggestive evidence on the validity of our assumptions. Further, we show that there is no effect among public sector employees who can act as a placebo group for this analysis. Another concern is the potential effect of the policy on the wage bins that we use as controls in this analysis. We do not observe any change in the pre-period or immediately following the policy change among the control wage bins, but again, our pre-period is short for this analysis. In a robustness analysis, we examine wage bins that are above the audit threshold (rather than between it and the minimum wage). The advantage of using these higher wage bins is that they are not affected by the audit policy. The disadvantage is that workers in these wage bins are likely different from workers who honestly report earning the minimum wage.

6 Results

In this section, we use the introduction of the audit policy at the end of 2006 to demonstrate the underreporting of earnings at the minimum wage. We start by providing cross-sectional evidence on the distribution of earnings prior to the change (in 2005) and after (2007). A spike appears in the distribution at double the minimum wage in 2007 among private sector employees and the self-employed. We then exploit the panel structure of our data to show transitions between different wage levels over time and demonstrate that a substantial fraction of workers report to have doubled their earnings after declaring just the minimum in 2005. In addition, our findings on transitions by industry, firm size, ownership, and measures of firm quality suggest these responses are larger where prior evasion was more likely. Observable characteristics of workers concentrated at the new threshold show an anomaly at the reporting thresholds; using the distribution of observable characteristics can provide a useful methodology when only cross-sectional data is available. When we analyze the concentration of the reporting effect across firms, we find that workers who reported earning the minimum wage and responded to the policy were likely to be pooled in the same firms with other such workers. The geographic concentration of the reporting response suggests

that either local economic factors were important in determining evasion behavior or the policy had different salience in different areas.

6.1 Main Results

Figure 4 shows the distribution of monthly earnings in 2005 (in blue) and 2007 (in red) separately for private sector employees in Panel (a), the self-employed in Panel (b), and public sector employees in Panel (c). In 2005, all three groups show a spike at the monthly minimum wage, though it is much larger for the private sector than for the public sector and it is especially large for the self-employed. 19.9% of private sector employees, 68.5% of the self-employed, and 1.1% of public sector employees report earnings at the monthly minimum wage in 2005. After the introduction of the audit policy, in 2007, the mass at the minimum wage decreases for private sector employees and the self-employed, though it is still substantial in these sectors. The mass remains the same for public sector employees. 5.8% of private sector employees, 30.9% of the self-employed, and 1.1% of public sector employees are reported to earn the minimum wage in March 2007. A new spike appears in the distribution of earnings for private sector employees and the self-employed, but not for public sector employees. In 2007, 5.4% (up from 1.9% in 2005, a 2.8-fold increase) of private sector employees and 16.3% (up from 0.3%, a 54-fold increase) of the self-employed report earning double the minimum wage. The share of public sector employees earning twice the minimum wage remains virtually unchanged at 2.51% in 2007 (2.57% in 2005), as we could expect from a group that is least likely to evade taxes by underreporting their earnings.

In these cross-sections, we integrate the total excess mass around the post-2006 audit threshold by contrasting the share of each sector in the bunching region against a counterfactual density flexibly fitted outside the obvious anomalies. Figure 4 illustrates the procedure and collects our results. None of the sectors show any meaningful excess mass at the future threshold in 2005 (0.35% for private employees, 0.1% for the self-employed, -1.3% for the public sector). By 2007, the public sector still exhibits no excess mass (-0.5%) at the new audit threshold, while 5.5% more of the private employees and 17% more of the self-employed report there beyond what their similarly earning peers would imply. These calculations identify the anomalous, spurious reports around the post-2006 threshold from within-sector interpolation in the cross-section. The anomalies are less tied to the sharp threshold than before but are calculated relative to a baseline expectation of some mass there even absent the anomaly. On the other hand, the procedure does not adjust for secular trends like the business cycle potentially affecting earnings around the threshold in particular. Our regression framework is able to control for such trends, under additional assumptions.

Making use of the panel structure of our data, we can tie the new anomalies to prior bunching at minimum pay earnings directly. As these transitions are atypical, this raises further suspicions about these reports both before and after the reform. Figure 5 shows transitions over time between different wage levels separately for private sector employees in Panels (a) and (b), the self-employed in Panels (c) and (d), and public sector employees in Panels (e) and (f). For each sector, the first panel displays the percentage of employees who transition between 2003 (on the x-axis) and 2005 (on the y-axis) between each of the wage bins, and the second panel displays the percentage of employees who transition between 2005 (on the x-axis) and 2007 (on the y-axis) between each of the wage bins. Consistent with the cross-sectional figures (Figure 4) the first panel for each sector shows some concentration of earnings at the minimum wage and also shows that wages are quite stable across years (39%, 82% and 38% of earnings remain in the same earnings bin relative to the minimum wage among the private sector employees, self-employed and public sector workers, respectively). The second panel shows that while wage dynamics do not change in the public sector between the 2003–2005 and 2005–2007 periods, the introduction of the audit policy is associated with a substantial share of workers reporting the minimum wage transitioning to reporting double the minimum wage among private employees. We find that 10.5% of private sector employees reporting the minimum wage in 2005 report at the new threshold in 2007. This means that around 2% of all workers in the private sector report at the minimum wage in 2005 and at the audit threshold in 2007. An even stronger transition response is observed among the self-employed, for whom it might have been the easiest to evade taxes before the new rule but also to report the minimum which they think lowers their chance to be audited. We find that 19.2% of the self-employed reporting at the minimum wage in 2005 report at the new audit threshold in 2007. This means that 10% of all the self-employed report at the minimum wage in 2005 and at the audit threshold in 2007, suggesting a large fraction of prior minimum wage earners falsely reporting the lowest possible earnings and paying the corresponding taxes.

Figure 6 connects the transitions of 2003 minimum wage workers over the following years across six earnings bins, including the status of being out of the labor force. Panel (a) follows private sector employees and Panel (b) presents the self-employed. Consistent with Figure 5 Panel (a), the modal earnings of 2003 minimum wage employees is still the minimum wage in 2005, with a barely discernible slice moving up to double the minimum wage. However, by 2007, the yellow box of 2005 breaks down to a smaller fraction continuing to report the minimum wage, a modal group transitioning to somewhere between the minimum wage and its double (which includes the guaranteed wage minimum by then) and a substantial fraction reporting the new audit threshold. The latter group then shows more downward wage mobility than in prior years, but moving out of the labor force much less than lower-earning

groups by the crisis year of 2009. There is little movement to the audit threshold in later years. This is again indicative that declaring double the minimum wage in 2007 is anomalous among 2003 minimum wage reporters, and consistent with the presumed behavior of more extensive underreporting before and after 2007. All these patterns are even more pronounced for the self-employed shown on Panel (b).

To estimate changes in reported earnings in a formal regression, Panels (b) and (c) of Figure 7 collect coefficients from event study estimates of the share of workers reporting to earn double the minimum wage, comparing private sector employees (in Panel (b)) and the self-employed (in Panel (c)) to public-sector employees, based on Equation (10). We show results with no additional controls (in blue) and controlling for gender, age group, and 2003 residence (in red). Panel (b) shows that prior to the introduction of the audit policy, the difference between the share of workers reporting earning at the audit threshold in the public and private sectors was stable. (Panel (a) shows that not only was the difference stable, but so was the level, in both sectors.) Among private sector employees, the share of workers reporting the audit threshold increased by 3.7 percentage points relative to public sector employees in 2007. Panel (c) shows that prior to the policy change, the difference between the share of workers declaring the future audit threshold in the public sector and among the self-employed was stable. (Again, Panel (a) shows stability also in levels.) Among the self-employed, the share of workers reporting this amount increased by 16 percentage points relative to public sector employees in 2007.

Table 2 shows our estimates after pooling the years prior to the reform (2003-2006) and after (2007-2010), based on Equation (11). We estimate that relative to public sector employees, the share of private sector employees reporting double the minimum wage was 2.3% higher and the share of the self-employed reporting double the minimum wage was 11.4% higher after the introduction of the audit policy. These pooled estimates are lower than the event study estimates comparing 2006 and 2007 because after 2007, the share of workers reporting earning double the minimum wage falls. We discuss these dynamics in more detail below in Section 6.3.

In summary, different research designs yield similar estimates about the nature and prevalence of misreporting incomes at the audit threshold. Using only their peers' earnings in the same year for a counterfactual, 5.5% of private employees and 17% of self-employed reported earning at the new threshold unexpectedly. This cross-sectional excess mass calculation showed no bunching at the future threshold in earlier years, nor in the public sector after. Using the latter as a control group for a difference-in-differences design to control for potentially confounding trends, we found 3.5 percentage points more employees and 16 percentage points more of the self-employed at the threshold than secular trends

would have implied. Thus the additional assumptions about parallel earning trends in the public sector do not matter for our conclusions. Using the panel for a different argument about anomalous transitions (and thus suspicious earnings before and after the reform), we see 10.5% of 2005 minimum wage employees moving sharply to the new audit threshold in 2007, and 19.1% of the self-employed, while only 2% of the public sector. Even without any further assumptions to pin down a specific counterfactual, the first two of these numbers are so out of line with typical earnings dynamics, that they are highly suggestive or misreported minimum wage earnings in 2005, misreported audit threshold earnings in 2007, or most likely both. Irrespective of the plausibility of underlying assumptions, the robustness of the precision of the method, these patterns are all consistent with suspect tax filers at the new audit threshold after the reform, a considerable fraction of whom declared minimum wage earnings before.

6.2 Heterogeneous Effects

We examine heterogeneous responses along various characteristics of private sector employees who remain formally employed in 2007. Panel (a) of Figure 8 shows the share of minimum wage earners in 2005 who transition to the new audit threshold in 2007 by gender, age, and occupation skill level. Men who earned at the minimum in 2005 are 3.5 percentage points (43%) more likely to report earning double the minimum wage than women. The likelihood of transitioning between the minimum wage in 2005 and its double in 2007 is approximately the same by age group. Differences are starkest by skill. 4.6% of workers in an occupation with mostly primary education who reported earning the minimum wage in 2005 report earning its double in 2007, similar to workers in occupations with mostly lower secondary education or less, whose transition probability is 7%. By contrast, the transition probability is much higher among workers in higher-skilled jobs: 15.1% among those with mostly upper secondary education and 24.9% among those with mostly tertiary education prevalent in their occupation. These patterns are consistent with the interpretation that among more highly skilled workers those that reported the minimum wage prior were more likely to be earning at (much) higher levels in effect than their less skilled counterparts. (Appendix Figure A1 shows the evolution of the share of private sector employees who report earning at the audit threshold by worker characteristics, including gender, age, and occupation skill level, over our entire time period.)

Tax evasion might be less feasible in more prominent businesses. Panel (b) of Figure 8 shows the share of minimum wage earners in 2005 who transition to the new audit threshold in 2007 by ownership, firm size, and industry. It is apparent that the overall 10.5% transition

rate of 2005 minimum wage earners to double the minimum wage in 2007 (among those who remain formally employed) masks substantial heterogeneity along all three dimensions. Domestic firms have a 5.0 percentage point (75%) higher transition rate than foreign-owned firms, who are likely to have different internal systems and culture around truthful reporting. Workers in smaller firms also have much higher transition rates than workers in larger firms: firms of observed size between 1 and 5 have a transition rate of 13.8%, while firms of observed size between 6 and 50 have 8.2%, and those between 51 and 125 have 3.5%. Among the largest firms, with observed size above 125, only around 3.3% transitioned between the minimum wage and its double during the 2005–2007 period, no higher than in other years, as we show in Appendix Figure A2. Again, larger firms might have been much more conducive to honest reporting all along, if some collusion to evade is harder to coordinate in larger groups (Kleven, Kreiner and Saez, 2016). Construction, Trade, and Transportation have much higher transition rates (13.1%, 11.5%, and 11.8%, respectively) than Agriculture, Mining and Manufacturing, and Accommodation and Food (7.3%, 7.3%, and 6.2%, respectively). All three of these findings on heterogeneity by ownership, firm size, and industry are qualitatively consistent with studies that use other data sources, including surveys, and other methodologies to directly estimate tax evasion in Hungary (Elek, Scharle, Szabó and Szabó, 2009*a*; Elek and Köllő, 2019). (Appendix Figure A2 shows the evolution of the share of private sector employees who report earning at the later threshold by firm characteristics, including ownership, firm size, and industry, over our entire time period.)

Lower-quality firms might not be able to afford the full tax bill on their labor, though evaders might look more productive on paper (employing more labor off the books). In addition to standard firm characteristics, we also examine heterogeneity in total factor productivity as a proxy for "firm quality". Panel (c) of Figure 8 shows transitions by TFP quartiles. TFP is negatively associated with transition rates from the minimum wage to the new audit threshold. We interpret this finding to suggest that firms that are more productive are less likely to underreport worker earnings. (Appendix Figure A3 shows the evolution of the share of private sector employees who report earning at the later threshold by total factor productivity over our entire time period.)[26]

[26]Misreporting might bias our TFP estimates but the particulars depend on how the business accounts for underhand wage payments. The direct effect of underpaid labor is inflated TFP for evaders, which would dampen the interaction effects we observe. Estimated TFP is still correlated with indicators of minimum wage misreporting.

6.3 Additional Evidence

Observables at the Double Minimum Wage. So far, we have used the panel structure of our data to observe individual workers moving from the minimum wage to the new double minimum wage audit threshold to argue that these patterns are consistent with previous underreporting at the minimum wage. This method can deliver relatively precise individual-level and firm-level estimates of underreporting. However, it also requires us to have panel data on earnings. An alternative approach makes use of the richness of the administrative data available and the distribution of various worker characteristics throughout the earnings distribution. The advantage of this approach is that it only requires a single year of data, with the obvious disadvantage that it can only help us document the extent of likely underreporting but not its individual (or corporate) source. This approach is in some sense similar in flavor to the "unused observables" approach of Finkelstein and Poterba (2014). There the authors show that residential location is correlated in the U.K. with both the demand for annuities and mortality, but remains unused for the purpose of pricing annuities, demonstrating the presence of asymmetric information. In our context, we show that a variety of variables that are not used by tax authorities for audits and even variables that would not appear to be related to taxation at all have excess mass in their distributions at the double minimum wage threshold after the reform. Figure 9 demonstrates this phenomenon for four covariates: gender, occupation skill level, residing in the capital (in 2003), and utilizing any outpatient care in a year. All four variables have smooth distributions around the double minimum wage threshold among public sector employees both before and after the introduction of the audit policy and among private sector employees before. However, after the introduction of the policy, all four variables show excess mass among private sector employees at the double minimum wage threshold.[27]

Geographic Concentration. We also find the transition rates from the minimum wage to the new audit threshold between 2005 and 2007 by districts of Hungary closely move together for private sector employees and the self-employed. Figure 10 shows this rate to vary between 1% and 22% among private sector employees, with a wider dispersion (3–28%) for the self-employed. We see a strong positive association in the district-specific transition rates between the two sectors (the slope of the regression line is 0.92). This suggests strong spatial clustering of tax evasion or in the perception of the audit policy. The self-employed face different institutions for wage bargaining and somewhat different incentives to avoid or evade labor taxes, but their behavior is a good measure of local salience of the rules and prevalance

[27] Choudhary and Gupta (2019) analyze other outcomes in the treatment region of an audit notch on top of the density of the running variable.

of prior evasion (Chetty, Friedman and Saez, 2013). It is reassuring to see that in areas where only a small share of the self-employed reacted to the policy, transition rates were similarly low among private sector employees; this suggests that there are no confounding reasons for reporting at the new threshold in 2007.

Cross-Firm Concentration. An important conceptual question for understanding tax evasion around the minimum wage is whether this is primarily a firm-side or a worker-side phenomenon. With third-party reporting, the worker cannot underreport on their own (Kleven et al., 2011), but they could have a deciding say in an agreement with their employer about their reported earnings. While the reform is too short-lived to track workers moving between employers with different response rates, it is still instructive to look into correlated behavior without breaking the reflection problem (Manski, 1993). We relate responses to the audit policy measured at the level of individual workers to responses measured for other employees of the same private-sector employer. Figure 11 shows response rates of workers by the average response rate of their peers in the company. Panel (a) suggests that at lower levels of firm response, when less than half of one's coworkers moves from the minimum wage in 2005 to double the minimum wage in 2007 (among those who remain employed there), there is an overall positive association between individual and peer behavior. At higher levels of firm response, when more than half of one's coworkers respond, individual responses are less closely associated to peers', 70–80% of workers respond on average. Panel (b) shows something similar for exits from formal employment (foreshadowing Section 6.4), where we bin firms by differential relative exit rates of 2005 minimum wage workers compared to those earnings slightly more. Workers reporting to earn the minimum in 2005 are often less likely to leave than coworkers who are paid more, and for this group we see a tightly estimated 18% propensity to leave irrespective of peers' relative propensity (the slope being zero has a p-value of .19). At firms where others on the minimum wage are more likely to leave than higher earners, we do see the individual exit rates moving with peers' (with a slope of .69), which suggests the exits are concentrated only when firms let go disproportionately many minimum wage workers, consistent with this phenomenon being less of an organic feature of the labor market and more about collusion, the salience of the policy, and the extent of prior evasion.

These patterns are consistent with our understanding of market power of employers in wage setting. However, the concentrated responses might also bolster the story that these are responses to the tax rules by employers who previously underreported earnings, similarly to how the geographic correlation between the responses of private sector employees and the self-employed suggests a role for the salience of the reform. Exits being concentrated only if

disproportionately likely among minimum wage workers is similarly consistent with these workers underreporting earnings originally and either being priced out by the higher tax burden or continuing to work but completely undocumented, as we discuss in Section 6.4.

Dynamics of Concentration at the Threshold. Our analyses above rely on the 2007 introduction of the double minimum wage policy and document reported earnings responses relative to 2005. However, we observe earnings for the 2003–2011 period, which allows us to show the dynamics of concentration at the double minimum wage threshold over time. Panel (a) of Figure 7 shows the evolution of the share of workers by sector who declare double minimum wage earnings. Prior to the 2007 introduction of the policy, the share of workers at this wage level was stable among private sector employees (at 2.1 %), the self-employed (at 0.3 %), and among public employees (at 2.8 %). In 2007, the share of workers at the threshold increased sharply among private employees (to 5.4 %) and the self-employed (to 16.3 %), but remained stable for public employees. In the subsequent years, the concentration of workers at the threshold decreased gradually among both private sector employees (4.3 % in 2008, 3.4 % in 2009, and 2.8 % in 2010) and the self-employed (14.0 % in 2008, 9.8 % in 2009, and 5.5 % in 2010). Recall that after 2010, the policy is no longer in effect. Our panel only runs to 2011, when the share of workers at the erstwhile audit threshold is already the same as prior to 2007. We view the post-2007 gradual decrease in the share of workers at the threshold as evidence of dissipating perceptions of the audit threat.

By 2010, around 50% of those who initially moved from the minimum wage to its double declare earnings that are lower than double the minimum wage, both among private sector employees and the self-employed. By 2011, the same ratios are around 70%.[28] The complete dissipation of the excess mass of workers at the threshold after the policy was no longer in effect is consistent with the concentration being a consequence of a response to the audit threat and with earlier underreporting.

Appendix Figures A1, A2, and A3 show the evolution of the share of private sector employees who declare double minimum wage earnings by worker characteristics, firm characteristics, and measures of firm quality, respectively. They are analogous to those in Figure 8 extending the results to our entire time period. They show that in each subgroup, the share of workers reporting double the minimum wage is stable prior to 2006, jumps by a large amount in 2007 and then decreases gradually over time. In 2011, when the policy is no longer in effect, the

[28]Downward mobility more broadly suggests misreporting, especially as the transition patterns look qualitatively similar for those reporting the same employer in both neighbouring years (results available upon request). In a different environment and institutional setting, Grigsby, Hurst and Yildirmaz (2021) find that only 2% of continued job spells exhibit a nominal base wage cut within a year among the clients of a large American payroll processing company.

share of workers reporting double the minimum wage is roughly the same in each subgroup as their pre-reform level.

Additional Robustness. As described in Section 5, we use absolute wage bins of size 5,000 HUF (≈$17) for our main results on declaring the audit threshold. An alternative wage bin definition would fix the relative distance from the post-2006 audit threshold in each year. In Appendix Figure A4 and Appendix Table A4, we re-estimate our main results from Figure 7 and Table 2 defining a band between 95% and 105% of the annual level of the later audit threshold. We find that our results are virtually identical under this alternative definition.

6.4 Impact on Formal Employment

In addition to the increase in reported wages among some workers previously reporting to earn the minimum wage that we documented in Section 6.1, in this section we examine whether the introduction of the audit policy impacted apparent exits from formal employment. The underlying idea is that the perceived increase in audit probabilities below the new threshold made some workers who previously had higher off-the-books earnings report higher formal earnings, but for others this increase in the cost of formal employment may have been an incentive to report no formal earnings at all. We first show that there was an increase in the probability of leaving formal employment among workers who were most likely impacted by the reform. Relative to workers at wage bins above the minimum wage, workers at the minimum wage are more likely to leave formal employment when the policy is introduced. We then turn to examining which worker and firm characteristics are associated with an increased probability of leaving formal employment.

Figure 12 shows the probability of leaving formal employment in each year among those who earned the minimum wage and in three relative wage bins above the minimum the year before by sector. The raw trends in Panels (a) and (c) show clear patterns only for private sector employees. Prior to the introduction of the audit policy, the probability of leaving formal employment was relatively stable for each wage level among the private sector employees. When the policy is introduced in September 2006, the probability of leaving formal employment increases slightly among those reporting to earn the minimum wage, while it decreases for those who report higher earnings. Our event study regression estimates (Panels (b) and (d)) show that these results remain unchanged when we compare minimum wage earners to any of the relative wage bins above them and also when we include controls for gender, age group, and initial residence. We do not find evidence for an impact on formal employment among public sector employees. Among private sector employees reporting to earn the minimum wage, the probability of leaving formal employment increases by around 2

percentage points after the policy change relative to those who report higher earnings. The estimated coefficients for year 2007 are also reported in Table 3.[29] This differential increase in the probability of leaving formal employment for only the sector and only the wage level that we showed in Section 6.1 to be prone to underreporting is consistent with some firms opting to go informal in the face of higher costs of formality while others opting to become more formal given the audit threat.

Figure 13 shows heterogeneity in exit probability in 2007 by gender, age, occupation skill level, ownership, size, industry and total factor productivity, comparing those reporting earning the minimum wage to those in relative wage bin 3. We see little evidence for any heterogeneity in exit responses. The strongest finding is that the exit response is more pronounced among the low-skilled. (Appendix Figures A5, A6, and A7 show the evolution of the share of private sector employees who exit formal employment over our entire time period.)

Figure 14 shows what happens to private sector employees who initially exit formal employment when the presumptive tax and audit policy is introduced. The figure tracks the employment status and government program participation of those who reported earning the minimum wage (Panel (a)) or earning in relative wage bin 2 (Panel (b)) in December 2005 but did not work in January 2007. Overall, we find that approximately 60% of exits from formal employment are short-term (last for at most a year), while about 40% are long-term (last for at least 4 years). We find that employment and unemployment rates are similar among the two wage groups: within one year, 38% vs. 36% of them return to formal employment and this number increases gradually, reaching 45% vs. 41% by 2011. Initially, 35% are observed to be unemployed in both wage groups, this drops to 15% vs. 16% within one year, and then gradually decreases to 12% in both wage groups. Participation in other government transfer programs, including disability insurance, pension, and paid family leave, is much less likely among those who exit formal employment after declaring minimum wage earnings: throughout the period, those who exit formal employment after reporting earning in relative wage bin 2 are 8 percentage point more likely to receive a government benefit than those who exit after reporting the minimum wage. On the other hand, those who exit after reporting the minimum are 8 percentage points more likely to be out of the labor force and not receiving any government transfers. These findings are consistent with workers exiting after minimum wage reports moving into the informal sector at relatively high rates.

[29] Figure 12 reports exit results also for years 2008–2011, however, since the composition of minimum wage earners changes after the introduction of the audit policy, we focus on the estimated effects for 2007 only.

Robustness. Our analysis of the impact of the double minimum wage policy on formal employment relies on a comparison of employment dynamics of minimum wage earners with workers in higher wage bins. This has the advantage that we are comparing minimum wage filers to workers who should be similar to them if reported earnings are not manipulated. However, it has the disadvantage that workers in these wage bins may react to the policy if they had previously also manipulated their reported earnings, but not all the way down to the level of the minimum wage. In Appendix Figure A8 (analogous to Figure 12) and Appendix Table A5 (analogous to Table 3), we show results using the three wage bins just above the later threshold as reference groups. These wage bins are further from the minimum wage and are potentially less comparable, but are above the audit threshold and are thus not subject to the reporting incentives created by the policy. We find that our results are qualitatively similar, but quantitatively smaller than in our original specification.

6.5 Fiscal Effects of the Audit Policy

We provide a back-of-the-envelope calculation of how minimum wage filers' responses to the audit policy impacted the public budget. This would net out the mechanical effect of presumptive taxation (less evasion) of incomes jumping from minimum wage levels to its double with the behavioral response of leaving formal employment.[30]

Private Sector Employees. In March 2005, there were 383,834 minimum wage earners in the private sector. Approximately 7.8% (29,804) of them earned double the minimum wage in March 2007. Had they stayed at the minimum wage, they would have reported earning around 1,952 million HUF in March 2007. Since in fact, they shifted up to the new audit threshold, they reported earning 3,981 million.[31] The additional 2,029 million HUF of declared income meant roughly 1,359 million HUF additional tax and social security income for the government, including employer-paid taxes on the gross minimum wage. This makes up approximately 1.4% of the consolidated deficit.[32]

On the other hand, due to the presumptive tax and audit policy, around 2% (7,677) of minimum wage filers left formal employment over a 13-month horizon. Due to their exits, net government revenue from the audit policy among private sector employees shrinks to around

[30]This does not encompass all fiscal externalities on benefits, consumption taxes, or general equilibrium effects, for a policy elasticity for welfare analysis (Finkelstein and Hendren, 2020).

[31]The observed total is more than double the counterfactual because we classify all workers in a narrow bin above the threshold as targeting the threshold.

[32]Social security funds are nominally separate from the central government budget. Using the Maastricht criteria of the European Union, Hungary reported 1,188.92 million HUF higher public debt at the end of 2007 than 2006, or a 99,077 million HUF monthly deficit.

1% of the government deficit.

Moreover, 1.5% (i.e. roughly two thirds of those who left formal employment) of prior minimum wage filers claimed unemployment benefits. This imposed an additional, albeit transitory, negative fiscal externality, implying an overall negative budgetary effect of the new rule among private sector employees.

Self-Employed Workers. Comprehensive fiscal effects need to take account of the self-employed as well. 153,944 of them declared the minimum wage in March 2005, with 15.5% (23,830) moving to the novel threshold by March 2007. As a result of presumptive taxation, an additional 1,621 million HUF of income was declared, which meant roughly 592 million HUF additional personal income tax and social security income for the government. This makes up approximately 0.6% of the deficit. (Note that we cannot measure the effect of the policy on the probability of self-employed minimum wage earners leaving the formal labor market.)

Overall, we estimate the audit policy recovered 1.6% of the government deficit from the two affected sectors of the labor market. The moderate effect partly explains why the policy did not last long. However, our calculation did not estimate the government revenue lost to income misreporting, which can be much higher because earnings are likely higher than twice the minimum wage.[33] In addition, the weak policy came on top of the existing policy regime, which might already be distorted because of these fiscal externalities. We do not evaluate that prior status quo relative to a first-best (presumably with no evasion).

Note some limitations of our calculations here. We focused only on minimum wage filers and did not consider the rule's impact on other low earners. We neglected all other taxes paid by the self-employed. We also assumed that the self-employed pay taxes and social contributions the same way as private sector employees, neglecting the corporate tax deductions from their labor costs. Nevertheless, these results suggest that the policy's first-order effect on the public budget was small.

7 Welfare Under Evasion

We now present a more formal argument why underreporting at the minimum wage would justify higher taxation of those earnings than otherwise would be optimal. We do not evaluate presumptive taxation as a policy instrument but rely on the nature of the minimum wage being a strong enforcement threshold for formal employment.

[33] Artavanis, Morse and Tsoutsoura (2016) estimate that the Greek public lost out on 30% of the deficit in 2009 because 43-45% of self-employed income went unreported.

In our framework from Section 3, the only efficiency loss comes from some jobs being priced out as well as the evasion cost g wasting resources. However, the social planner could weight the surplus generated by different jobs differently, according to whom it accrues to. The weights will be the product of the density of those types overweighted or underweighted according to the social value of the capitalist entrepreneur (α), the worker (β), and the value of public funds (γ).[34] These weights can measure monetary losses and gains as the generalized social marginal welfare weights of Saez and Stantcheva (2016), though they are also reduced-form representations of income valued differently because of different disutility of work (not modeled directly) or because evasion affects the workers' moral standing. As our empirical work does not recover the true income of evaders, we do not base welfare on this latent primitive either.[35]

We can thus add up profits, wage costs, taxes and penalties as the monetary value of welfare:

$$W = \int_{\theta\in\Theta_1} \alpha(\theta)V(\theta) + \beta(\theta)M + \gamma(\theta)\tau M \,\mathrm{d}\theta + \int_{\theta\in\Theta_2} \alpha(\theta)V(\theta) + \beta(\theta)w(\theta) + \gamma(\theta)(\tau M + \rho p\tau e(\theta)) \,\mathrm{d}\theta + \int_{\theta\in\Theta_3} \alpha(\theta)V(\theta) + \beta(\theta)w(\theta) + \gamma(\theta)(\tau(w(\theta) - e(\theta)) + \rho p\tau e(\theta)) \,\mathrm{d}\theta.$$

The marginal value of a minimum wage hike simplifies to a sum of three terms:

Proposition 1. *The marginal social value of a higher minimum wage is the net total of three countervailing factors: (a) the lost profits but higher gross wages from minimum wage reporting firms, (b) the higher gross wages from lower evasion from bunching evaders, and (c) the lost surplus destroyed at the marginal entrant.*

$$\frac{\mathrm{d}W}{\mathrm{d}M} = \int_{\theta_0}^{\theta_2} (-\alpha(\theta)\lambda(\theta) + \beta(\theta) + \gamma(\theta)\tau) \,\mathrm{d}\theta + \int_{\theta_1}^{\theta_2} (\beta(\theta) + \gamma(\theta)\rho p\tau) \frac{\mathrm{d}e(\theta)}{\mathrm{d}M} \,\mathrm{d}\theta - \frac{\mathrm{d}\theta_0}{\mathrm{d}M} (\beta(\theta_0)M + \gamma(\theta_0)\tau M). \quad (13)$$

Proof. In Appendix Section A.2. □

Not suprisingly, the marginal value of a higher minimum wage can be positive or negative, depending upon a constellation of factors, and zero at the social optimum. The trade-off

[34] Note that for the self-employed, the first two of these should arguably be the same.

[35] For welfare analysis of marginal perturbations, we do not track the changes to these reduced-form weights, as they have only second-order effects due to the envelope theorem (Sinander, 2021).

between enforcement and the minimum wage is apparent from the cross-derivative of welfare with respect to the two policy instruments, p and M.[36]

It can be a reasonable assumption that any potential recipient of public funds is unsated and worthy (which would be violated by a social desire to hurt cheaters, for instance):

Assumption 2. *All reduced-form welfare weights are non-negative,* $\alpha(\theta) > 0$, $\beta(\theta) > 0$, $\gamma(\theta) > 0$, $\forall\theta$.

This is sufficient to prove that weaker enforcement raises the value of minimum wage increases.

Theorem 1. $\frac{\mathrm{d}^2 W}{\mathrm{d}M\,\mathrm{d}p} < 0$, *thus the marginal social value of raising the gross minimum wage rises when audit probabilities fall. Higher gross minimum wages are socially optimal in an environment with looser enforcement.*

Proof. In Appendix Section A.3. □

Enforcement and presumptive taxation can thus be substitutes. If presumptive taxation is tied to the minimum wage, as is often the case in practice, higher minimum wages in environments with poor enforcement can follow.

8 Conclusion

This paper demonstrates that even in a high-income country, wage misreporting, specifically at the minimum wage, can be an empirically relevant concern for tax policy. We showed that a large fraction of private sector employees and the majority of the self-employed report earnings at the minimum wage without presumptive taxation or targeted audits in Hungary. After a policy experiment that threatened firms with audits if they declared earnings below double the minimum wage, we document significant shifts in the earnings distribution consistent with previous underreporting. We show that 10.5% of private sector employees and 19.2% of the self-employed who previously reported earning the minimum immediately declare earnings that are twice as high. There is no such response among public sector employees. The response is concentrated in industries prone to tax evasion and in small and domestic firms that other studies found to have the highest rates of tax evasion. It is also concentrated among firms that are of lower quality. The correlation of suspicious declarations between coworkers, as well as between private sector employees and the self-employed nearby, further strengthen our case that some minimum wage earnings had been misreported before.

[36] For the normative exercise, we treat audit probabilities as uniform for all earnings.

We also demonstrate that the reform led to an increase in exits from formal employment, concentrated along similar margins, which highlights the implicit trade-off in raising the threshold of presumptive taxation (which is just the minimum wage in most cases) for potential evaders. The concurrent increase in reported earnings and exits among similar firms is consistent with the notion that some workers and firms chose full informality rather than semi-formal arrangements. On the one hand, tax policy can increase reported earnings, making some employment more formal and extracting more government revenue from it. On the other hand, an unintended consequence of such policies may be the loss of formal employment, decreasing tax revenue. We showed the latter to be small because of a smaller response, but even the former to be moderate in practice with very low earnings. Still, with policy limited to blunt instruments like linear taxes and poorly targeted audits, we argued that (presumably costly) enforcement and the gross minimum wage are substitutes for the social planner.

We believe that our findings are pertinent for tax and minimum wage policy and the taxation of potentially informal work in particular. The additional role of minimum pay as a natural, mechanical audit threshold in many jurisdictions is relevant for second-best policy. Policymakers should be cognizant of misreporting and the corresponding potential to boost tax revenues at the cost of some inefficiency in response to a minimum wage hike accompanied by a tax increase. Alternatively, if they already are, this could help explain why some countries have high gross minimum wages that are taxed heavily.

References

Al-Karablieh, Yazan, Evangelos Koumanakos, and Stefanie Stantcheva. 2021. "Clearing the Bar: Improving Tax Compliance for Small Firms Through Target Setting." *Journal of International Economics*, 130(1): 103452.

Almunia, Miguel, and David Lopez-Rodriguez. 2018. "Under the Radar: The Effects of Monitoring Firms on Tax Compliance." *American Economic Journal: Economic Policy*, 10(1): 1–38.

Andreoni, James, Brian Erard, and Jonathan Feinstein. 1998. "Tax Compliance." *Journal of Economic Literature*, 36(2): 818–860.

Artavanis, Nikolaos, Adair Morse, and Margarita Tsoutsoura. 2016. "Measuring Income Tax Evasion Using Bank Credit: Evidence from Greece." *Quarterly Journal of Economics*, 131(2): 739–798.

Benedek, Dóra, Péter Elek, and János Köllő. 2013. "Tax Avoidance, Tax Evasion, Black and Grey Employment." In *The Hungarian Labour Market 2013.* , ed. Károly Fazekas, Péter Benczúr and Álmos Telegdy. Hungarian Academy of Sciences, Centre for Economic and Regional Studies, Institute of Economics.

Best, Michael C. 2014. "The Role of Firms in Workers' Earnings Responses to Taxes: Evidence from Pakistan." *Mimeo.*

Best, Michael, Jaward Shah, and Mazhar Waseem. 2021. "Detection Without Deterrence: Long-Run Effects of Tax Audit on Firm Behavior." *Mimeo.*

Bjørneby, Marie, Annette Alstadsæter, and Kjetil Telle. 2021. "Limits to Third-Party Reporting: Evidence from a Randomized Field Experiment in Norway." *Journal of Public Economics*, 203(1): 104512.

Bossavie, Laurent Loic Yves, Aysenur Acar, and Mattia Makovec. 2019. "Do Firms Exit the Formal Economy after a Minimum Wage Hike?: Quasi-Experimental Evidence from Turkey." World Bank Policy Research Working Paper Series 8749.

Bérgolo, Marcelo L., Rodrigo Ceni, Guillermo Cruces, Matias Giaccobasso, and Ricardo Perez-Truglia. 2017. "Tax Audits as Scarecrows: Evidence from a Large-Scale Field Experiment." National Bureau of Economic Research Working Paper 23631.

Cengiz, Doruk, Arindrajit Dube, Attila Lindner, and Ben Zipperer. 2019. "The Effect of Minimum Wages on Low-Wage Jobs." *Quarterly Journal of Economics*, 134(3): 1405–1454.

Chetty, Raj, John N. Friedman, and Emmanuel Saez. 2013. "Using Differences in Knowledge across Neighborhoods to Uncover the Impacts of the EITC on Earnings." *American Economic Review*, 103(7): 2683–2721.

Choudhary, Keshav, and Bhanu Gupta. 2019. "Notching Really Matters: Effect of Third-Party Audit on Tax Compliance of Firms in India." *Mimeo.*

Clemens, Jeffrey. 2021. "How Do Firms Respond to Minimum Wage Increases? Understanding the Relevance of Non-employment Margins." *Journal of Economic Perspectives*, 35(1): 51–72.

De Andrade, Gustavo Henrique, Miriam Bruhn, and David McKenzie. 2014. "A Helping Hand or the Long Arm of the Law? Experimental Evidence on What Governments Can Do to Formalize Firms." *World Bank Economic Review*, 30(1): 24–54.

de Mel, Suresh, David McKenzie, and Christopher Woodruff. 2013. "The Demand for, and Consequences of, Formalization among Informal Firms in Sri Lanka." *American Economic Journal: Applied Economics*, 5(2): 122–150.

Di Gregorio, Enrico, and Matteo Paradisi. 2021. "Audit Rule Disclosure and Tax Compliance." *Mimeo.*

Dustmann, Christian, Attila Lindner, Uta Schönberg, Matthias Umkehrer, and Philipp vom Berge. 2021. "Reallocation Effects of the Minimum Wage." *Quarterly Journal of Economics*, Forthcoming.

Elek, Péter, and János Köllő. 2019. "Eliciting Permanent and Transitory Undeclared Work from Matched Administrative and Survey Data." *Empirica*, 46(3): 547–576.

Elek, Péter, János Köllő, Balázs Reizer, and Péter A. Szabó. 2012. "Chapter 4 Detecting Wage Under-Reporting Using a Double-Hurdle Model." In *Informal Employment in Emerging and Transition Economies*. 135–166. Emerald Group Publishing Limited.

Elek, Péter, Ágota Scharle, Bálint Szabó, and Péter András Szabó. 2009*a*. "A Bérekhez Kapcsolódó Adóeltitkolás Magyarországon." ELTE/PM Közpénzügyi Füzetek 23.

Elek, Péter, Ágota Scharle, Bálint Szabó, and Péter András Szabó. 2009*b*. "A Feketefoglalkoztatás Mértéke Magyarországon." *Rejtett Gazdaság. Be Nem Jelentett Foglalkoztatás és Jövedelemeltitkolás - Kormányzati Lépések és a Gazdasági Szereplők Válaszai*, , ed. András Semjén and István János Tóth Vol. 11 of *KTI Könyvek*, 84–102. MTA Közgazdaságtudományi Intézet.

Eurostat. 2021. "Monthly minimum wages - bi-annual data - country-specific information." Eurostat.

Fazekas, Károly Szabó-Morvai, Ágnes, ed. 2019. *The Hungarian Labor Market 2018.* Hungarian Academy of Sciences, Centre for Economic and Regional Studies, Institute of Economics.

Finkelstein, Amy, and James Poterba. 2014. "Testing for Asymmetric Information Using "Unused Observables" in Insurance Markets: Evidence from the U.K. Annuity Market." *Journal of Risk and Insurance*, 81(4): 709–734.

Finkelstein, Amy, and Nathaniel Hendren. 2020. "Welfare Analysis Meets Causal Inference." *Journal of Economic Perspectives*, 34(4): 146–67.

Gavoille, Nicolas, and Anna Zasova. 2021. "What We Pay in the Shadow: Labor Tax Evasion, Minimum Wage Hike and Employment." *Mimeo.*

Gerard, François, and Gustavo Gonzaga. 2021. "Informal Labor and the Efficiency Cost of Social Programs: Evidence from Unemployment Insurance in Brazil." *American Economic Journal: Economic Policy*, 13(3): 167–206.

Grigsby, John, Erik Hurst, and Ahu Yildirmaz. 2021. "Aggregate Nominal Wage Adjustments: New Evidence from Administrative Payroll Data." *American Economic Review*, 111(2): 428–71.

Harasztosi, Péter, and Attila Lindner. 2019. "Who Pays for the Minimum Wage?" *American Economic Review*, 109(8): 2693–2727.

Hashimzade, Nigar, Gareth D. Myles, and Matthew D. Rablen. 2016. "Predictive Analytics and the Targeting of Audits." *Journal of Economic Behavior & Organization*, 124(1): 130–145.

Hungerman, Daniel M. 2021. "Tax Evasion, Efficiency, and Bunching in the Presence of Enforcement Notches." National Bureau of Economic Research Working Paper 28826.

Kleven, Henrik Jacobsen, Claus Thustrup Kreiner, and Emmanuel Saez. 2016. "Why Can Modern Governments Tax So Much? An Agency Model of Firms as Fiscal Intermediaries." *Economica*, 83(330): 219–246.

Kleven, Henrik Jacobsen, Martin B. Knudsen, Claus Thustrup Kreiner, Søren Pedersen, and Emmanuel Saez. 2011. "Unwilling or Unable to Cheat? Evidence From a Tax Audit Experiment in Denmark." *Econometrica*, 79(3): 651–692.

Kuehn, Zoë. 2014. "Tax Rates, Governance, and the Informal Economy in High Income Countries." *Economic Inquiry*, 52(1): 405–430.

Lakatos, Miklós, Mária L. Rédei, and Gabriella Kapitány. 2015. "Mobilitás és Foglalkoztatás." *Területi Statisztika*, 55(2): 157–179.

Lee, David, and Emmanuel Saez. 2012. "Optimal Minimum Wage Policy in Competitive Labor Markets." *Journal of Public Economics*, 96(9): 739–749.

Liebman, Jeffrey B., and Erzo F. P. Luttmer. 2015. "Would People Behave Differently If They Better Understood Social Security? Evidence from a Field Experiment." *American Economic Journal: Economic Policy*, 7(1): 275–99.

Manning, Alan. 2021. "The Elusive Employment Effect of the Minimum Wage." *Journal of Economic Perspectives*, 35(1): 3–26.

Manski, Charles F. 1993. "Identification of Endogenous Social Effects: The Reflection Problem." *Review of Economic Studies*, 60(3): 531–542.

Meghir, Costas, Renata Narita, and Jean-Marc Robin. 2015. "Wages and Informality in Developing Countries." *American Economic Review*, 105(4): 1509–1546.

Mortenson, Jacob A., and Andrew Whitten. 2020. "Bunching to Maximize Tax Credits: Evidence from Kinks in the US Tax Schedule." *American Economic Journal: Economic Policy*, 12(3): 402–32.

OECD. 2015. "Minimum wages after the crisis: Making them pay." http://www.oecd.org/social/Focus-on-Minimum-Wages-after-the-crisis-2015.pdf.

OECD. 2019. "Tax Wedge." https://data.oecd.org/tax/tax-wedge.htm.

Pashev, Konstantin V. 2006. "Presumptive Taxation: Lessons from Bulgaria." *Post-Communist Economies*, 18(4): 399–418.

Paulus, Alari. 2015. "Tax Evasion and Measurement Error: An Econometric Analysis of Survey Data Linked with Tax Records." University of Essex, Institute for Social and Economic Research Working Paper 2015-10.

Pelek, Selin, and Gokce Uysal. 2016. "Envelope Wages, Underreporting and Tax Evasion: The Case of Turkey."

Reizer, Balázs. 2011. "The Effect of the "Twofold - Minimum Wage" Rule on the Labour Market in 2006." Hungarian Academy of Sciences Institute of Economics Budapest Working Papers on the Labour Market 2011/4.

Rocha, Rudi, Gabriel Ulyssea, and Laísa Rachter. 2018. "Do Lower Taxes Reduce Informality? Evidence from Brazil." *Journal of Development Economics*, 134(1): 28–49.

Roth, Jonathan, and Pedro H. C. Sant'Anna. 2021. "When Is Parallel Trends Sensitive to Functional Form?" *Mimeo*.

Saez, Emmanuel, and Stefanie Stantcheva. 2016. "Generalized Social Marginal Welfare Weights for Optimal Tax Theory." *American Economic Review*, 106(1): 24–45.

Sinander, Ludvig. 2021. "The Converse Envelope Theorem." *Mimeo*.

Slemrod, Joel. 2019. "Tax Compliance and Enforcement." *Journal of Economic Literature*, 57(4): 904–54.

Slemrod, Joel, and Shlomo Yitzhaki. 1994. "Analyzing the standard deduction as a presumptive tax." *International Tax and Public Finance*, 1(1): 25–34.

Tax and Financial Control Administration of Hungary. 2007. "Bulletin - Review of Activites by APEH in 2006." Retrieved from https://nav.gov.hu/magan/nav/archiv/Kiadvanyok/bulletin/bulletin.html?classname=M2Portlet&allinheading=1_1225&keywords=M2.

Tax and Financial Control Administration of Hungary. 2019. "Annual Reports - World of the APEH." http://www09.nav.gov.hu/nav/archiv/Kiadvanyok/evkonyvek/APEH_vilaga.

Tonin, Mirco. 2011. "Minimum Wage and Tax Evasion: Theory and Evidence." *Journal of Public Economics*, 95(11): 1635–1651.

Tonin, Mirco. 2013. "Underreporting of Earnings and the Minimum Wage Spike." *IZA Journal of European Labor Studies*, 2(1): 2.

Ulyssea, Gabriel. 2018. "Firms, Informality, and Development: Theory and Evidence from Brazil." *American Economic Review*, 108(8): 2015–2047.

Ulyssea, Gabriel. 2020. "Informality: Causes and Consequences for Development." *Annual Review of Economics*, 12(1): 525–546.

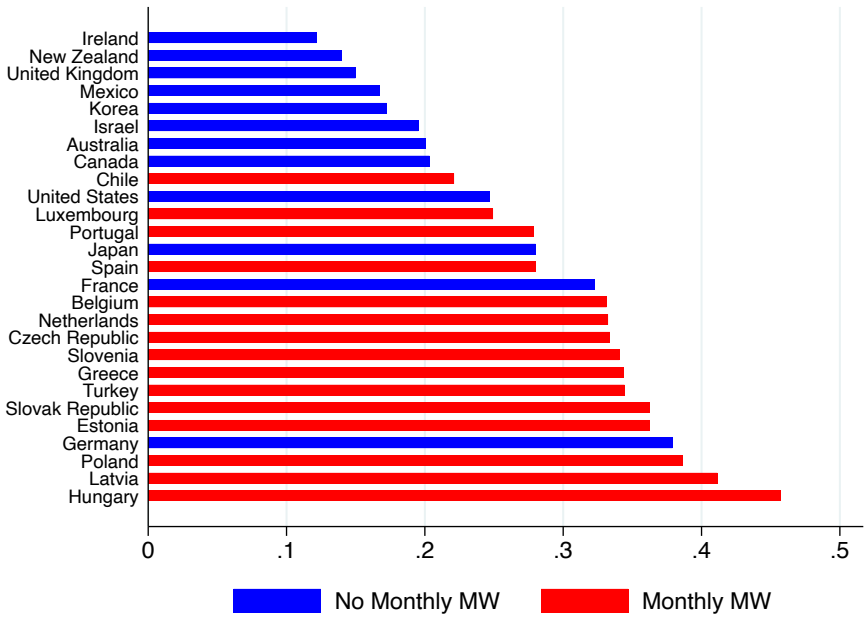
Williams, Colin C. 2013. "Evaluating Cross-National Variations in the Extent and Nature of Informal Employment in the European Union." *Industrial Relations Journal*, 44(5-6): 479–494.

Williams, Colin C., and Jo Padmore. 2013. ""Envelope Wages" in the European Union." *International Labour Review*, 152(3-4): 411–430.

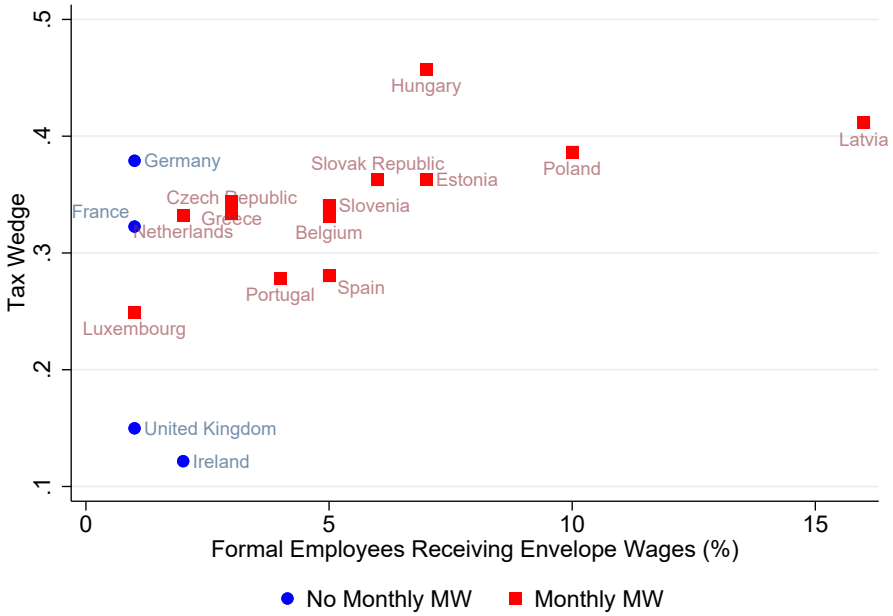
Yitzhaki, Shlomo. 2007. "Cost-Benefit Analysis of Presumptive Taxation." *FinanzArchiv: Public Finance Analysis*, 63(3): 311–326.

Figure 1: Minimum Wage Taxation and Envelope Pay Across Countries

(a) Tax Wedges on Full-Time, Full-Year Minimum Wage Earnings

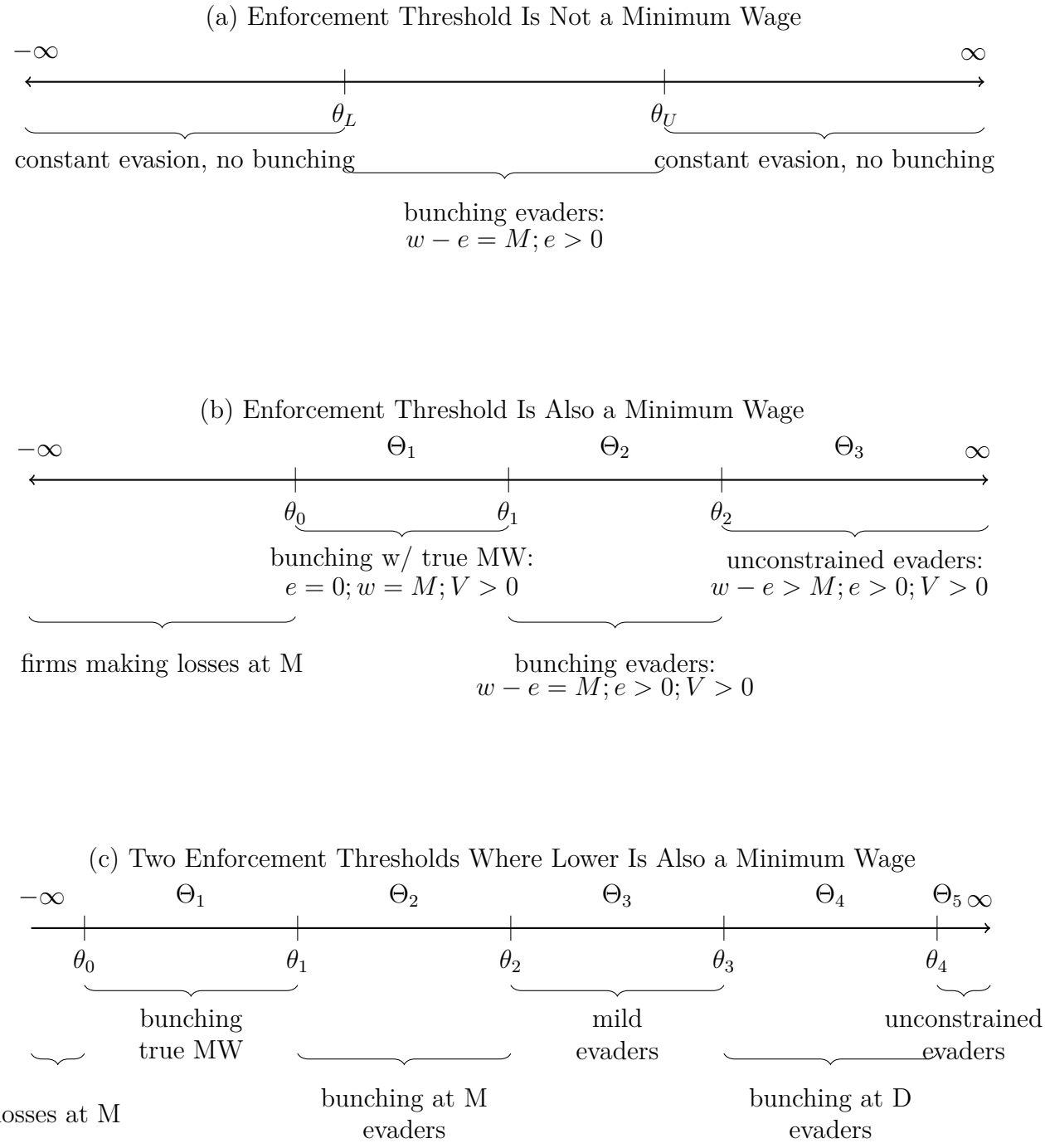


(b) Tax Wedges and Envelope Pay Prevalence



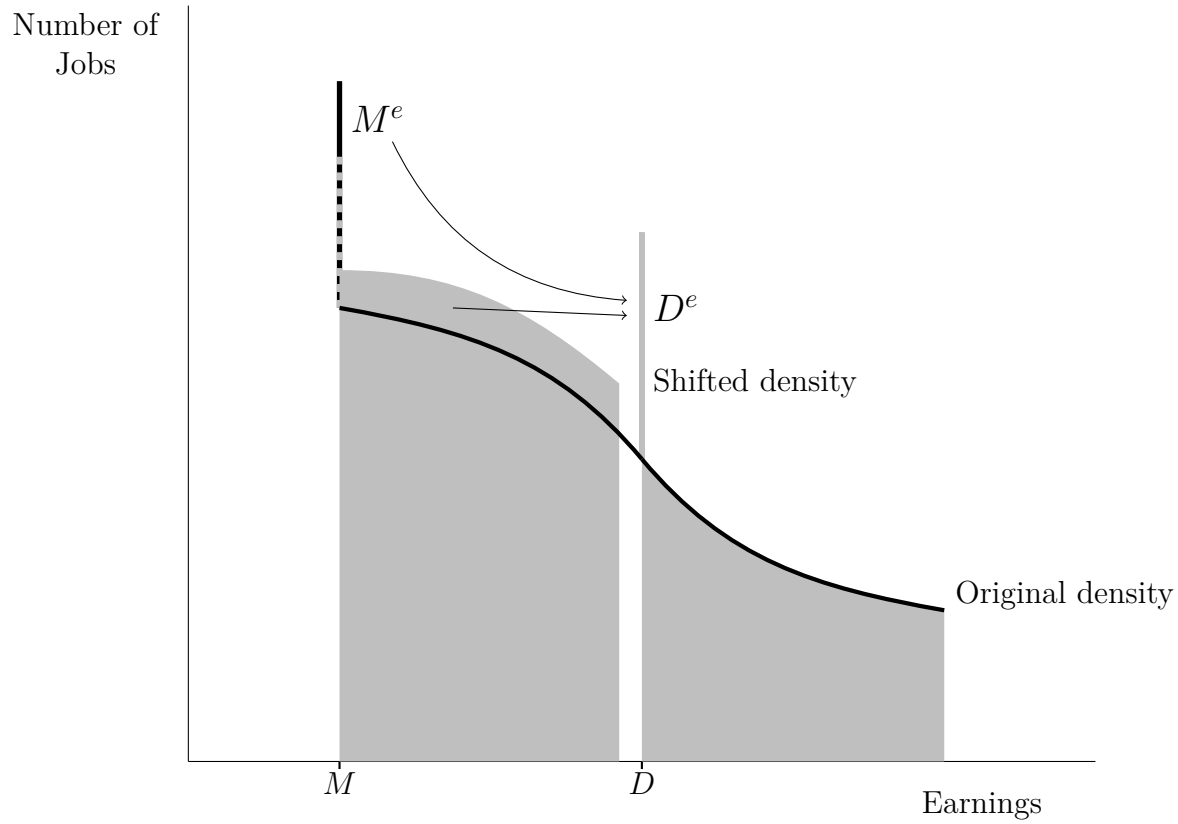
Note: Panel (a) plots the tax wedge on full-time, full-year minimum wage earnings in the latest available year by the OECD's (2015) tabulation. Countries with red bars set a monthly minimum salary (for the prevalent form of full-time employment on monthly pay cycles). The full tax wedge is calculated from numbers the OECD published in the accompanying spreadsheet. The list of countries with monthly minima comes from Eurostat's (2021) collection. Panel (b) plots the tax wedge on full-time, full-year minimum wage earnings as in Panel (a) against survey reports of formal employees receiving envelope wages from Williams and Padmore (2013). Countries with red markers set a monthly minimum salary.

Figure 2: Tax Evasion and Bunching by Productivity Categories



Note: This figure collects the partition of the productivity space for jobs under the model of Section 3. MW stands for the minimum wage, coinciding with the lower enforcement threshold M in the notation of Subsections 3.2 and 3.3. D is the higher threshold in Subsection 3.3.

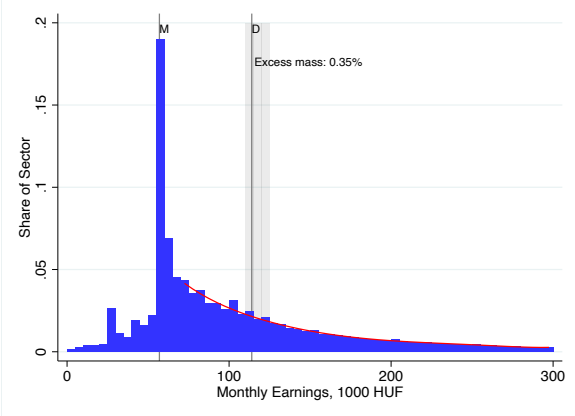
Figure 3: Conceptual Framework With underreporting: Impact of Stricter Enforcement on [M,D)



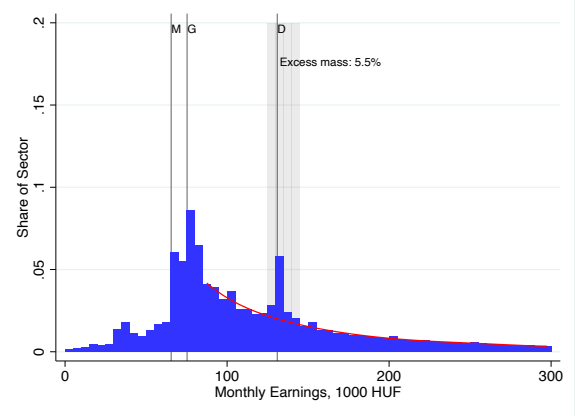
Note: This figure shows the impact of stricter enforcement for reported earnings in [M,D). The original density of reported earnings are outlined in black. The predicted density after the change is shaded with light gray. The spike (M^e) at M denote the original excess mass at M coming from some firms underreporting their earnings. This partly shifts towards D after stricter enforcement.

Figure 4: Excess Mass at the Post-2006 Audit Threshold, by Sector

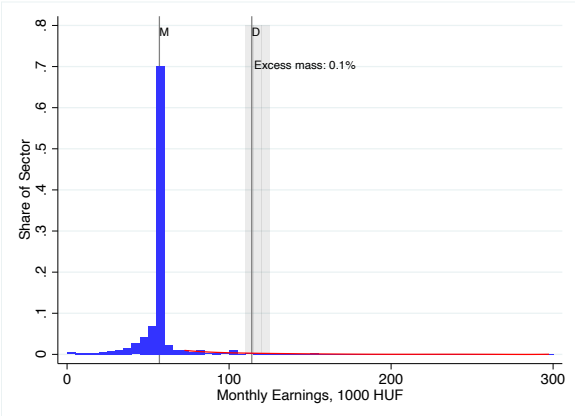
(a) Private Sector Employees, 2005



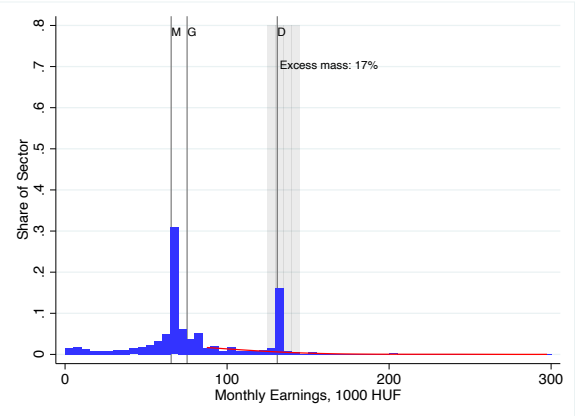
(b) Private Sector Employees, 2007



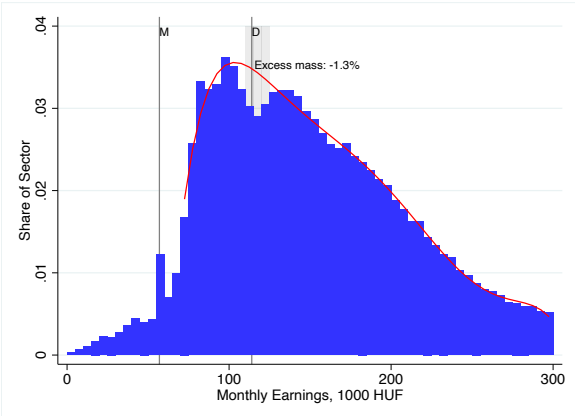
(c) Self-Employed, 2005



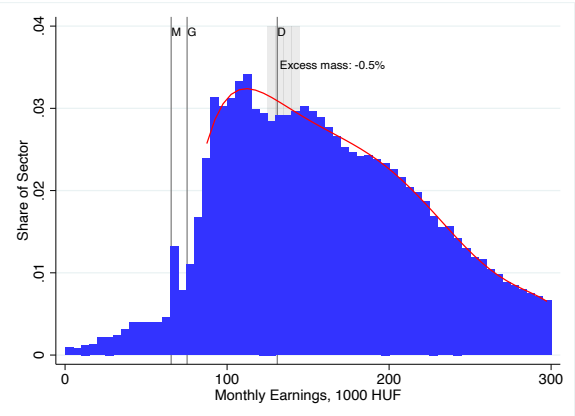
(d) Self-Employed, 2007



(e) Public Sector Employees, 2005



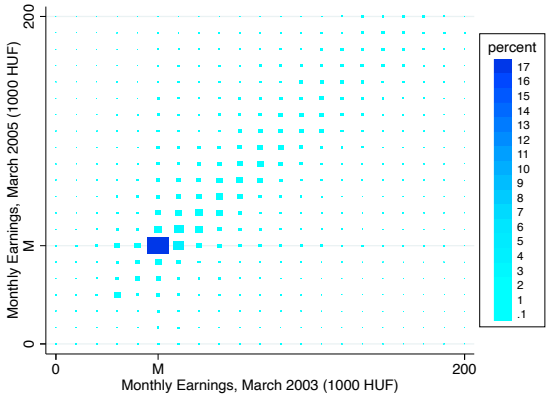
(f) Public Sector Employees, 2007



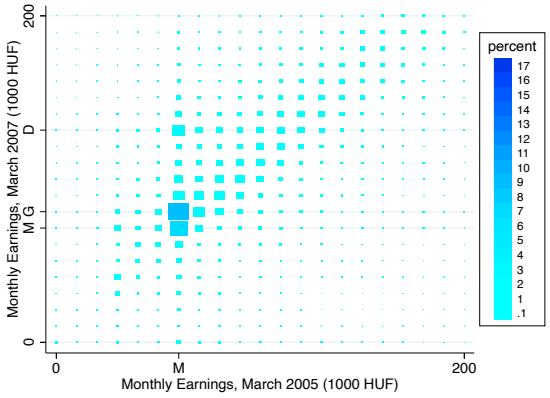
Note: This figure overlays a counterfactual density of monthly earnings over the histogram, and highlights the calculated excess mass in the shaded bunching region around twice the minimum wage. The histograms show the distribution of earnings in March 2005 and March 2007 by sector in 5,000 HUF (≈$17) bins. The counterfactual densities in the solid red lines are from a seventh-order polynomial over the bins above the bunch around the minimum wage (M) and outside the shaded bunching region around twice the minimum wage (D). The excess mass is the difference of the areas under the histogram and the counterfactual density in the shaded region, as a fraction of total employment in the sector. Panels (a) and (b) show private sector employees, Panels (c) and (d) the self-employed, and Panels (e) and (f) public sector employees. The vertical lines show the month's minimum salary (M) and its double (D), which became the audit threshold by 2007, and also the guaranteed wage minimum (G) in effect by then. For more details, see Section 5.

Figure 5: Biennial Dynamics of Monthly Earnings, by Sector

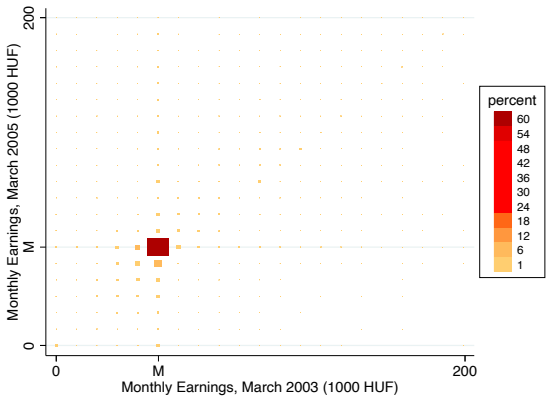
(a) Private Sector Employees, 2003 to 2005



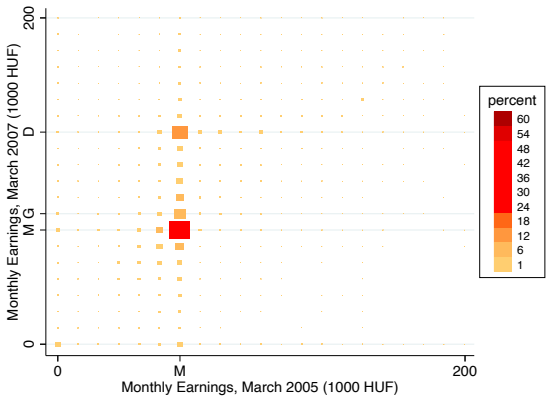
(b) Private Sector Employees, 2005 to 2007



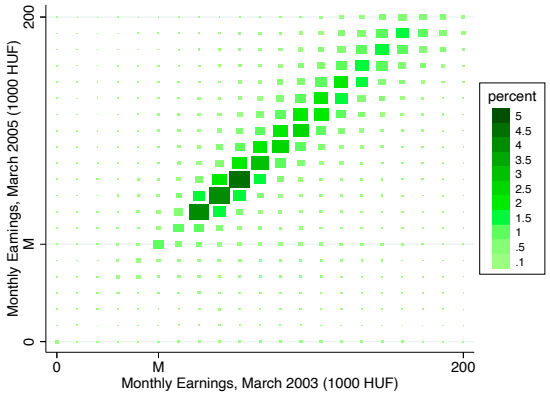
(c) Self-Employed, 2003 to 2005



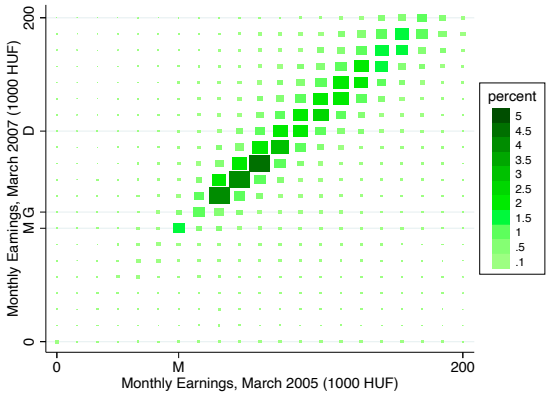
(d) Self-Employed, 2005 to 2007



(e) Public Sector Employees, 2003 to 2005



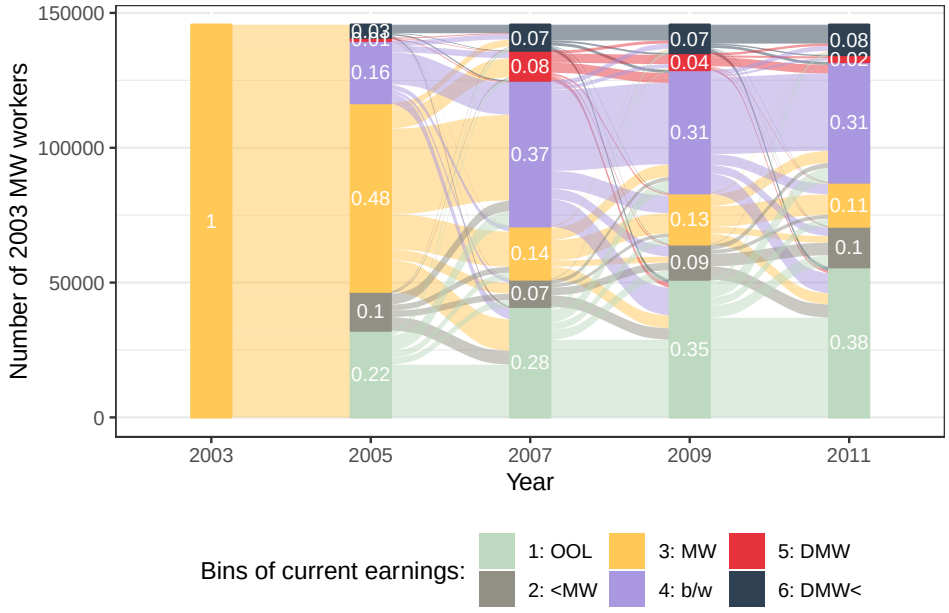
(f) Public Sector Employees, 2005 to 2007



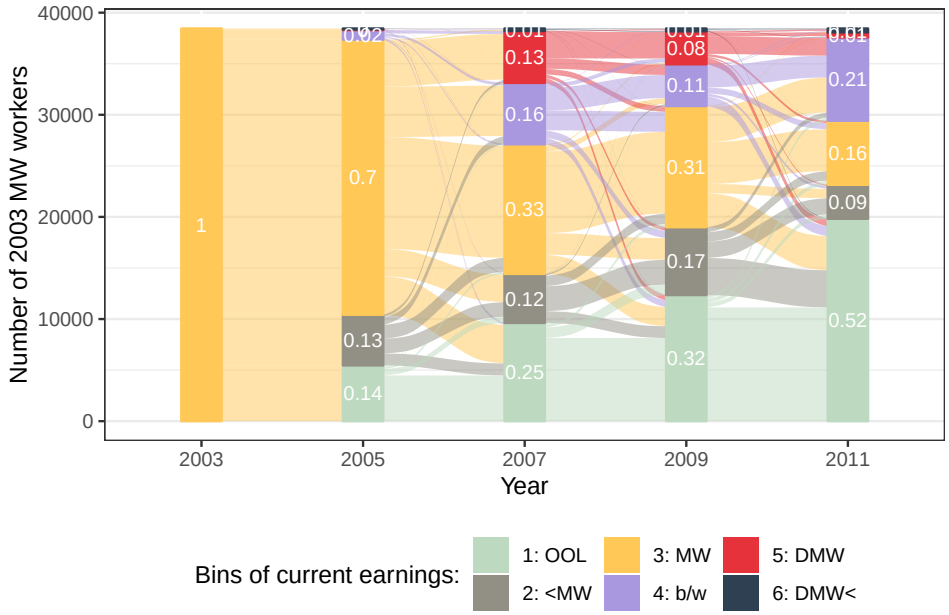
Note: This figure shows two-year transition probabilities of earnings between March 2003 and March 2005 and between March 2005 and March 2007 by sector. For each pair (w_1, w_2) of year t and year $t+2$ earnings, we show what percentage of all workers in the sector who earned w_1 in year t and w_2 in year $t+2$, with both the color and the size of the rectangles corresponding to the share of the sector in the bin defined by the origin and destination in the earnings distribution. Both coloring and sizing is consistent over the years within each sector, but reset for each sector separately. Panels (a) and (b) show private sector employees, Panels (c) and (d) show the self-employed, and Panels (e) and (f) show public sector employees. Panels (a), (c), and (e) show transition rates between years 2003 and 2005 and Panels (b), (d), and (f) show transition rates between years 2005 and 2007. The horizontal and vertical lines stand for the year-specific level of the minimum wage (M), the year-specific level of the guaranteed wage minimum (G), and the year-specific level of the double minimum wage (D). For more details, see Section 5.

Figure 6: Two-Year Transition Dynamics of 2003 Minimum Wage Earners

(a) Private Sector Employees



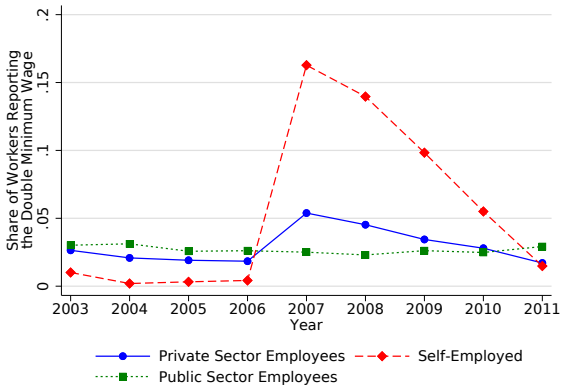
(b) Self-Employed



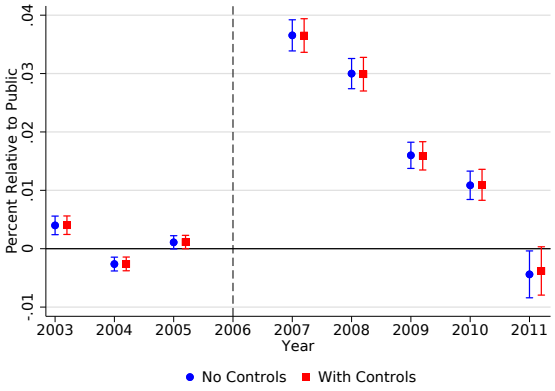
Note: This figure shows two-year flows between six earnings bins between 2005, 2007, 2009, and 2011, measured in March each year. The categories distinguish (1) those out of the labor force (OOL), (2) those reporting earning below full-time full-year minimum wage equivalents, (3) those reporting full-time full-year minimum wage earnings (MW), (4) those reporting earning between the minimum wage and its double, (5) those reporting earning the double minimum wage (DMW), and (6) those reporting earning more than twice the minimum wage. Each bar adds up to the number of minimum wage earners in 2003 in the sample. The stacked bars are apportioned and colored according to the earnings categories bins (using the current year's minimum wage definitions). The flows are colored using the same colors for the initial (left-hand side) year. Panel (a) show private sector employees, Panel (b) the self-employed.

Figure 7: Share of Workers Reporting Earnings at the Post-2006 Audit Threshold Over Time

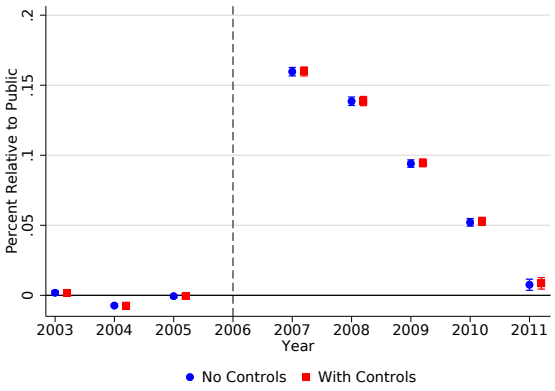
(a) Raw Trends



(b) Regression Estimates: Private Sector Employees



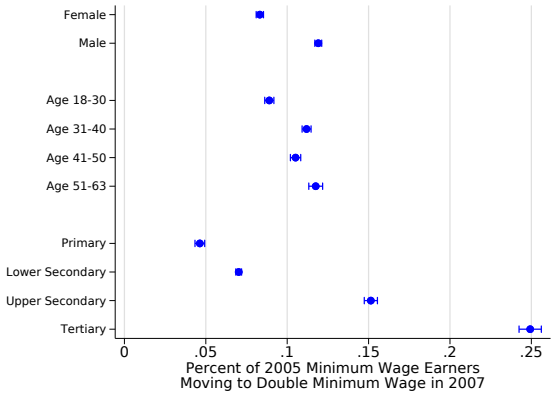
(c) Regression Estimates: Self-Employed



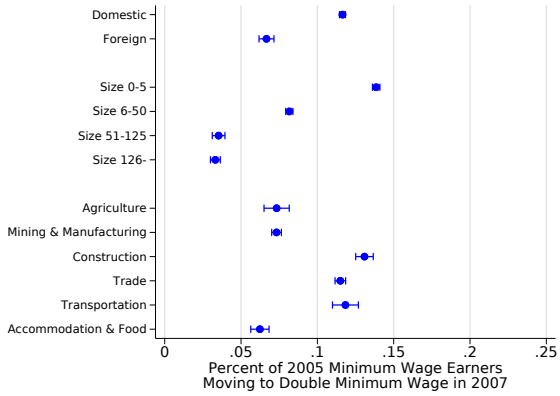
Note: This figure shows the share of workers who report earning double the minimum wage over time by sector. Panel (a) shows shares separately for private sector employees, the self-employed, and public sector employees. Panel (b) shows event study regression estimates comparing private sector employees to public sector employees, based on Equation (10). Panel (c) shows shows event study regression estimates comparing the self-employed to public sector employees, based on Equation (10). In Panels (b) and (c) the blue dots show estimates with no additional controls and the red dots show estimates controlling for gender, age group, and location (capital vs not). Standard errors are clustered at the firm level, 95% confidence intervals are displayed. For more details, see Section 5.

Figure 8: Heterogeneity in Reporting Response

(a) By Worker Characteristics



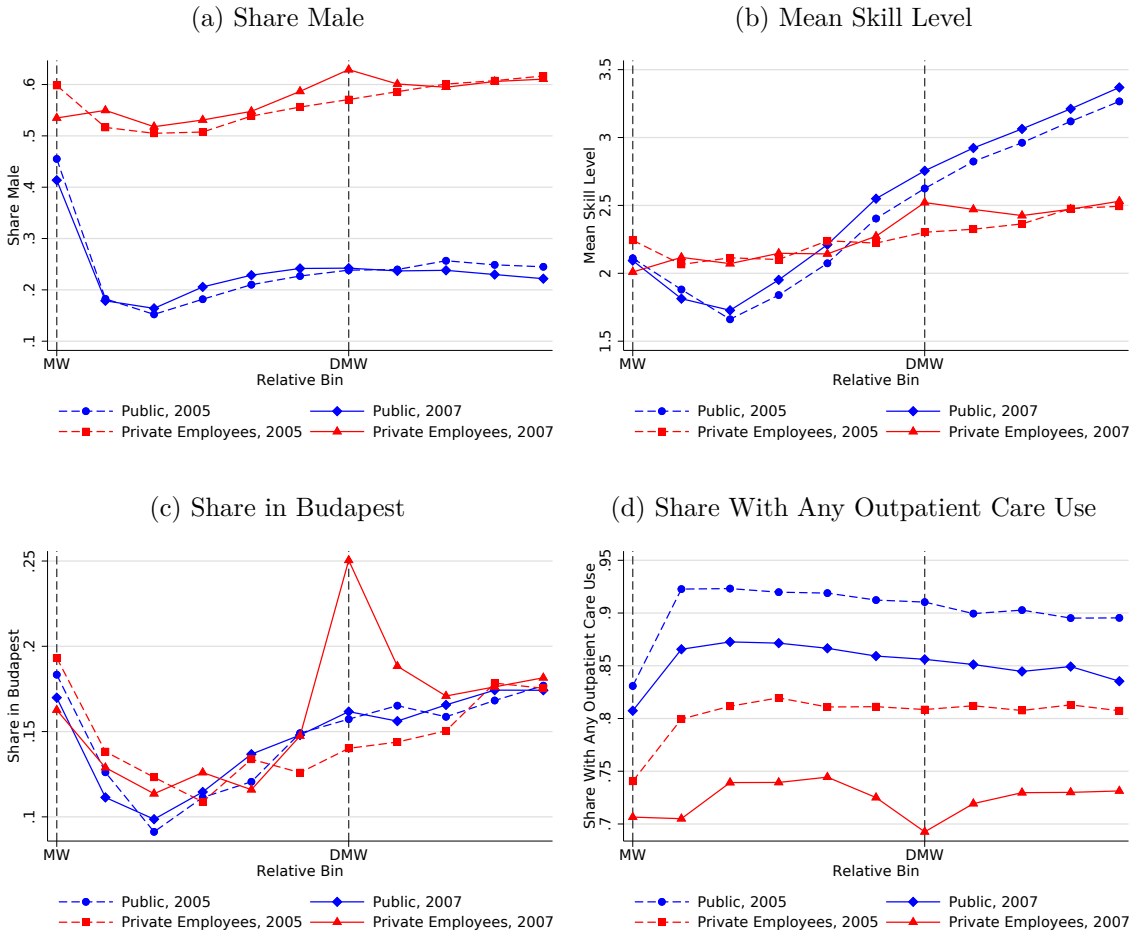
(b) By Firm Characteristics



(c) By Firm Quality

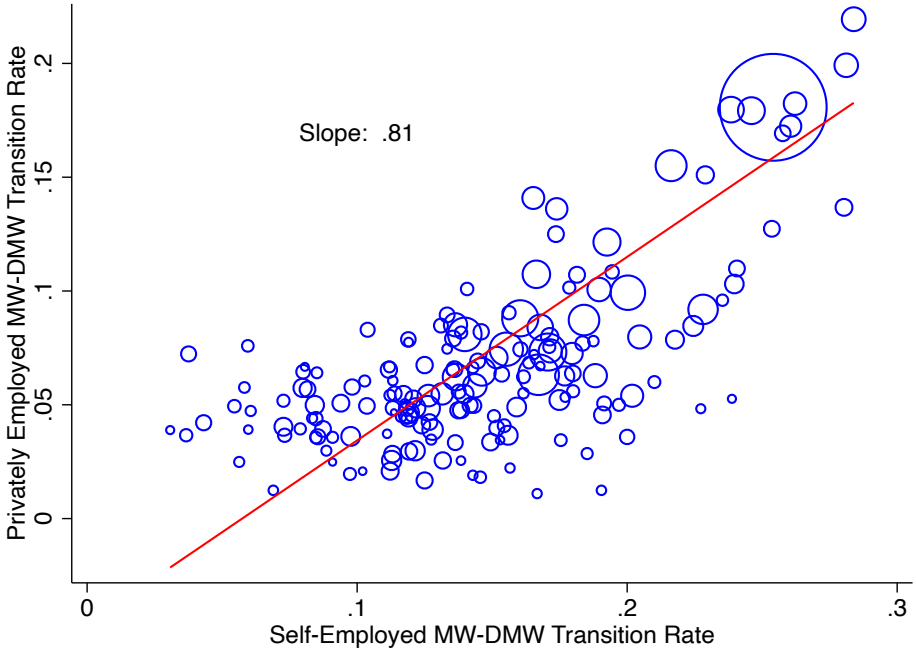
Note: This figure shows the share of private sector employees who report earnings at the minimum wage in March 2005 and report earnings at the new audit threshold in March 2007 by worker characteristics, firm characteristics, and measures of firm quality. Panel (a) shows estimates by worker characteristics, including gender, age, and occupation skill level. Panel (b) shows estimates by firm characteristics, including ownership, observed size, and industry. Panel (c) shows estimates by total factor productivity. The error bars show 95% confidence intervals. For more details, see Section 5.

Figure 9: Distribution of Observable Characteristics Over the Wage Distribution



Note: This figure shows the distribution of four observable variables over the wage distribution for public sector employees (blue lines) and private sector employees (red lines) in 2005 (dashed lines) and in 2007 (solid lines). For each relative wage bin, Panel (a) shows the percent of workers who are male, Panel (b) shows the mean skill level (measured on a 1-to-4 scale, with 1 corresponding to primary education and 4 corresponding to tertiary education prevalent in one's occupation), Panel (c) shows the percent of workers in Budapest, and Panel (d) shows the percent of workers with any outpatient care use. M stands for the year-specific level of the minimum wage and D stands for the year-specific level of the double minimum wage. For more details, see Section 5.

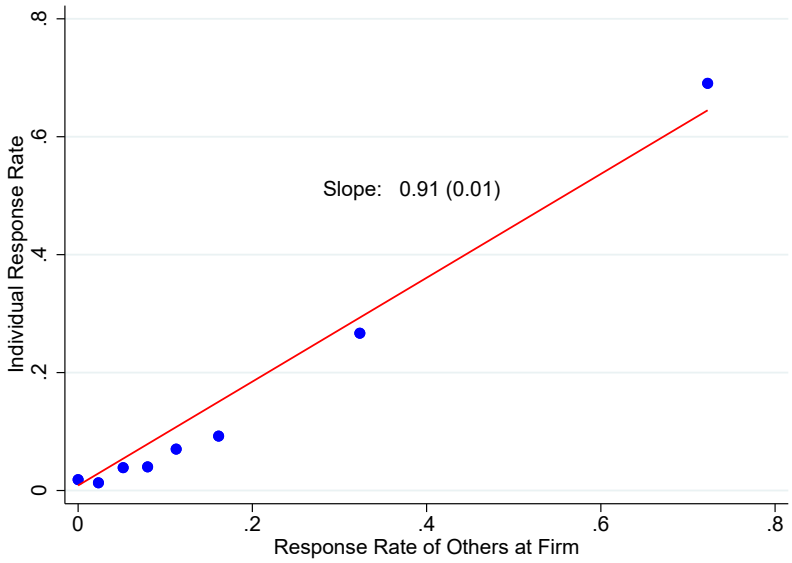
Figure 10: Reporting Response by District and Sector



Note: This figure shows the share of private sector employees (y-axis) against the self-employed (x-axis) who report earnings at the minimum wage in March 2005 and report earnings at the new audit threshold in March 2007 by district. The size of the circles reflects the population of a district. The red line is the best linear prediction, weighted by population (slope = .81).

Figure 11: Responses of Workers and Others at the Same Firm

(a) Share of Minimum 2005 Minimum Wage Earners Moving to the New Audit Threshold in 2007

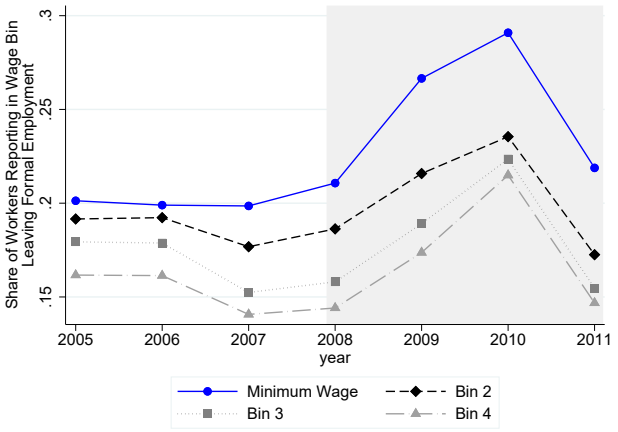


(b) Share of Minimum 2005 Minimum Wage Earners Leaving Formal Employment in 2007

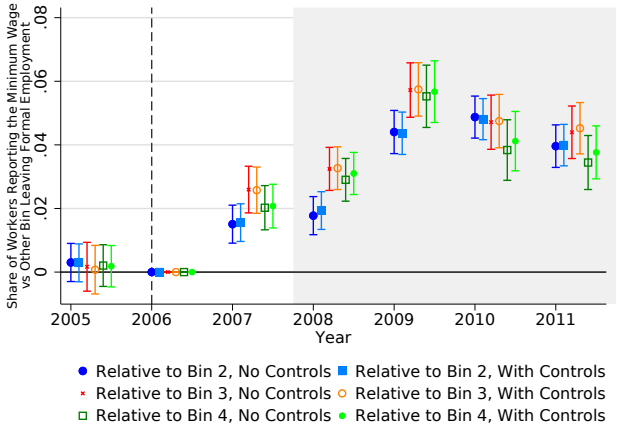
Note: These binned scatter plots relate individual workers' responses to the response of other workers in the same firm. Panel (a) shows the share of private sector employees who report earnings at the minimum wage in March 2005 and report earnings at the new audit threshold in March 2007 against the share of other employees who the same. The binned scatter plots show the average response rates for each decile of the peer response distribution (pooling deciles with ties). The fitted line is the OLS regression line in the original micro data, with the slope and its standard error as shown. Similarly, Panel (b) shows the share of private sector employees who report earnings at the minimum wage in March 2005 and leave formal employment by March 2007 by the difference between the share of other employees in the same firm who do the same and the share of other employees who earn one relative wage bin above the minimum wage in 2005 but still leave formal employment by March 2007. The binned scatter shows the average exit rate for each equal-sized vintile of the difference. Overlaid are two regression lines, separately for firms with more exits among prior minimum wage earners than higher earners and for those with fewer. The figure is limited to firms with at least 10 workers reporting earning the minimum wage in 2005. For more details, see Section 6.3.

Figure 12: Share of Workers Who Leave Formal Employment by Sector, Wage Bin, and Year

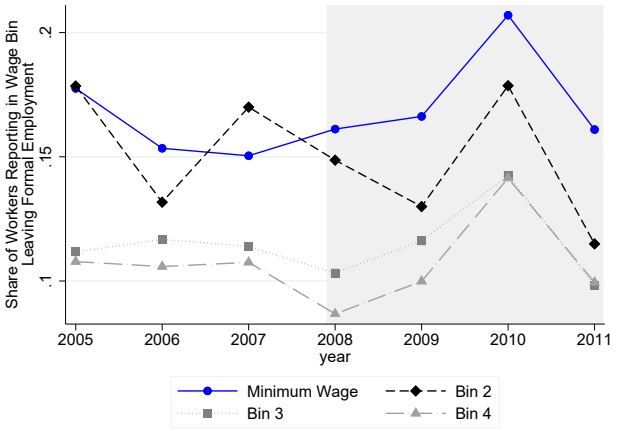
(a) Raw Trends: Private Sector Employees



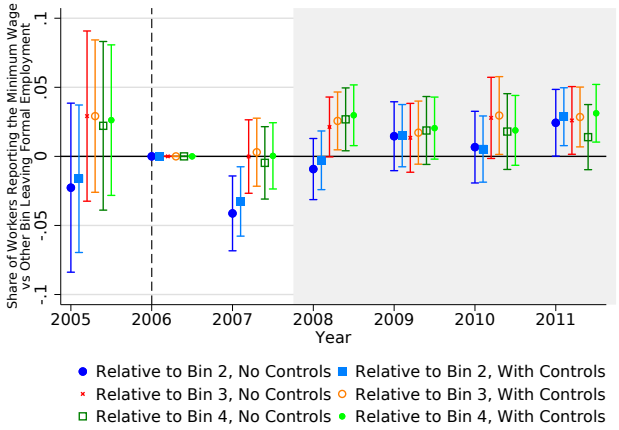
(b) Regression Estimates: Private Sector Employees



(c) Raw Trends: Public Sector Employees



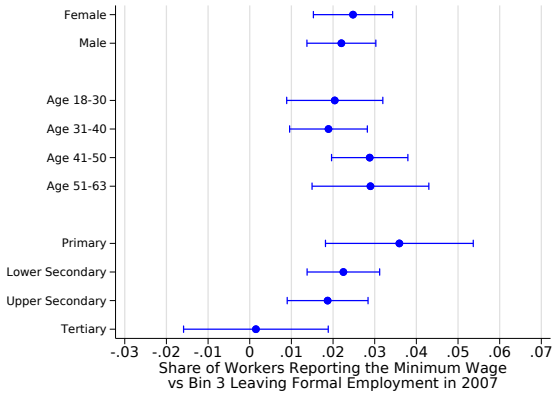
(d) Regression Estimates: Public Sector Employees



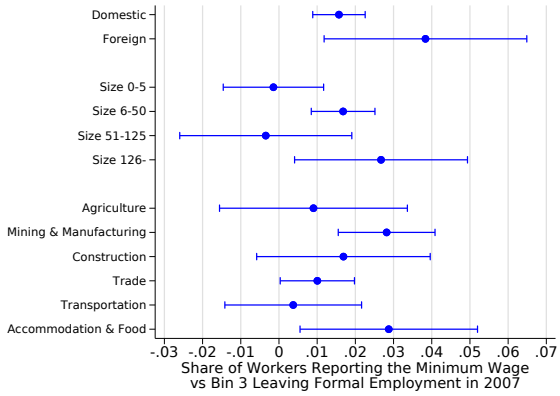
Note: This figure shows the share of workers who leave formal employment by January, by sector and wage bin (in December of two years prior) over time. Panels (a) and (b) show private sector employees, Panels (c) and (d) show public sector employees. Panels (a) and (c) show raw trends for those who report earning the minimum wage in the previous year (in blue), and for those who report in relative wage bins 2, 3, and 4 (in grey). Panels (b) and (d) show event study regression estimates comparing those who report earning the minimum wage to those who report earning in relative wage bin 2 (in blue), those who report earning in relative wage bin 3 (in red), and those who report earning in relative wage bin 4 (in green), based on Equation (12). For each comparison, the first estimate (in a darker color) shows estimates with no additional controls and the second dot (in a lighter color) shows estimates controlling for gender, age group, and location (capital vs not). Standard errors are clustered at the firm level, 95% confidence intervals are displayed. For more details, see Section 5.

Figure 13: Heterogeneity in Probability of Leaving Formal Employment

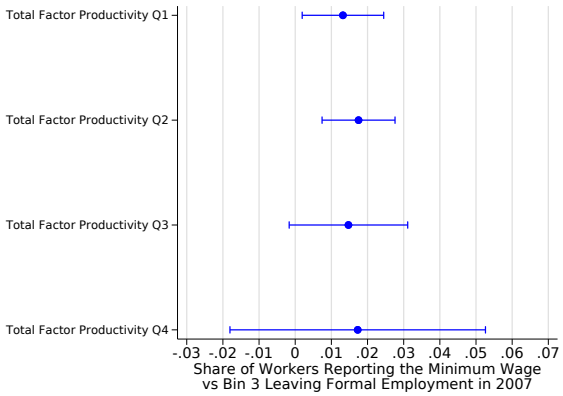
(a) By Worker Characteristics



(b) By Firm Characteristics



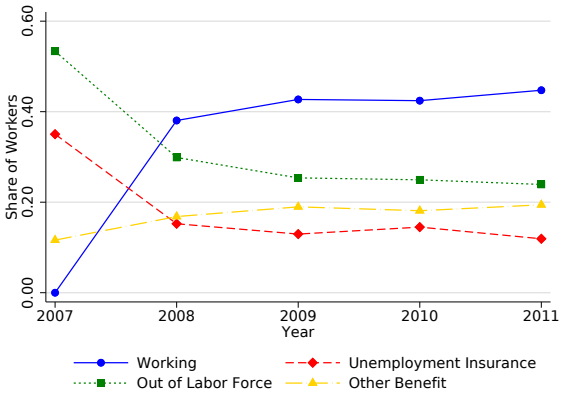
(c) By Firm Quality



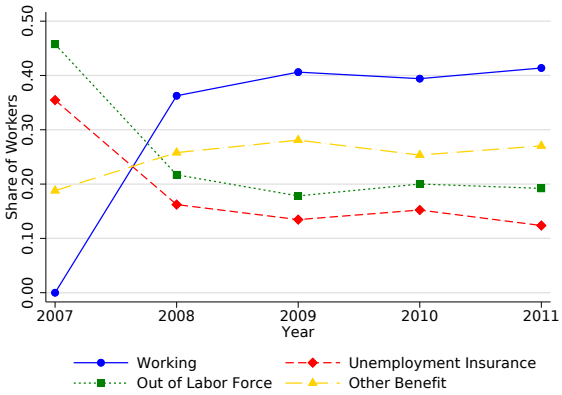
Note: This figure shows the share of private sector employees who leave formal employment in 2007, comparing those who reported earning the minimum wage and those who reported earning in relative wage bin 3 in 2006 by worker characteristics, firm characteristics, and measures of firm quality. Panel (a) shows estimates by worker characteristics, including gender, age, and occupation skill level. Panel (b) shows estimates by firm characteristics, including ownership, observed size, and industry. Panel (c) shows estimates by total factor productivity. The error bars show 95% confidence intervals. For more details, see Section 5.

Figure 14: Future Labor Market Status of Workers Leaving Formal Employment Between December 2005 and January 2007

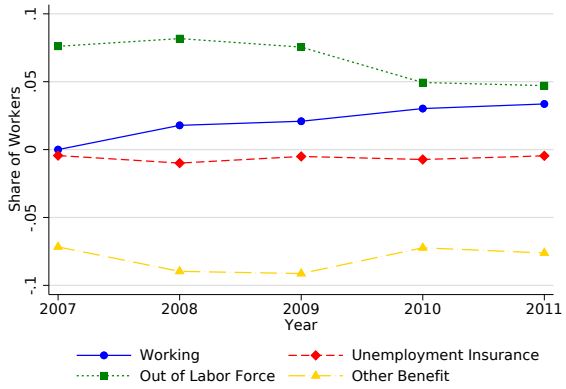
(a) Minimum Wage



(b) Bin 2



(c) Difference



Note: This figure shows the labor market status by year of those private sector employees who leave formal employment by January 2007 (but worked in December 2005). Panel (a) shows workers who reported earning the minimum wage in December 2005, Panel (b) shows workers who reported earning in relative wage bin 2 in December 2005, and Panel (c) shows the difference. We show the share working in blue, the share receiving unemployment payments in red, the share out of the labor force and not observed in our data as green, and the share receiving other benefits (pensions, disability payments, family payments, other transfers) in gold.

Table 1: Summary Statistics of Individual Characteristics

	Private Sector Employees		Self-employed		Public Sector Employees	
	Mean	Std. Dev.	Mean	Std. Dev.	Mean	Std. Dev.
Age	38.45	10.77	41.93	9.71	42.17	10.18
Share Male	0.56	0.50	0.65	0.48	0.27	0.44
Monthly Earnings (HUF)	154,780	313,188	72,932	786,264	191,774	172,654
Skill Level						
Primary	0.13				0.14	
Lower Secondary	0.49				0.12	
Upper Secondary	0.26				0.33	
Tertiary	0.12				0.41	
Person-Year Observations	8,946,562		960,638		2,496,331	
Unique Individuals	1,867,828		273,879		506,534	

Note: This table shows summary statistics by sector. The sample pools years 2003-2011. Skill level is missing for the self-employed because we are unable to impute it based on occupation characteristics.

Table 2: Share of Workers Reporting Earning Twice Minimum Wage Before and After the Reform

	(1)	(2)
Post × Private Sector Employee	0.023***	0.023***
	[0.001]	[0.001]
Post × Self-Employed	0.114***	0.115***
	[0.001]	[0.001]
Post × Workers of Public Firms	0.017**	0.017**
	[0.008]	[0.008]
Controls		×
N	12,385,920	12,328,514

Robust standard errors clustered at the firm level in brackets
*** p<0.01, ** p<0.05, * p<0.1

Note: This table shows difference-in-differences regression estimates of the change between the period before the introduction of the audit policy (2004-2006) and the period after the introduction of the policy (2007-2010) in the probability of reporting at twice the minimum wage for private sector employees and the self-employed vs public sector employees, based on Equation (11). In column (1) we show estimates with no additional controls. In column (2) we show estimates controlling for gender, age group, and location (capital vs not). Standard errors are clustered at the firm level.

Table 3: Share of Workers Who Leave Formal Employment in 2007

(a) Private Sector Employees

Reference bin:	(1) Bin 2	(2) Bin 2	(3) Bin 3	(4) Bin 3	(5) Bin 4	(6) Bin 4
2007 × Minimum Wage	0.032***	0.032***	0.040***	0.041***	0.034***	0.036***
	[0.002]	[0.002]	[0.003]	[0.003]	[0.003]	[0.003]
Controls		×		×		×
N	2,003,193	1,990,559	1,712,067	1,701,136	1,593,756	1,583,331

(b) Public Sector Employees

Reference bin:	(1) Bin 2	(2) Bin 2	(3) Bin 3	(4) Bin 3	(5) Bin 4	(6) Bin 4
2007 × Minimum Wage	0.014	0.015	0.007	0.010	0.006	0.010
	[0.015]	[0.014]	[0.014]	[0.013]	[0.014]	[0.013]
Controls		×		×		×
N	108,341	107,919	154,190	153,693	164,824	164,381

Robust standard errors, clustered at the firm level in brackets
*** p<0.01, ** p<0.05, * p<0.1

Note: This table shows regression estimates of the probability of leaving formal employment in 2007 among those reporting at the minimum wage in the previous year relative to those reporting in one of the relative wage bins above the minimum wage, based on Equation (12). Panel (a) shows estimates for private sector employees, Panel (b) shows estimates for public sector employees. In columns (1) and (2), the comparison group for workers reporting at the minimum wage in the prior year are workers reporting in relative wage Bin 2. In columns (3) and (4) , the comparison group for workers reporting at the minimum wage in the prior year are workers reporting in relative wage Bin 3. In columns (5) and (6) , the comparison group for workers reporting at the minimum wage in the prior year are workers reporting in relative wage Bin 4. For more details on our relative wage definitions see Section 5. In columns (1), (3), and (5) we show estimates with no additional controls. In columns (2), (4), and (6), we show estimates controlling for gender, age group, and location (capital vs not). Standard errors are clustered at the firm level.

Appendix

A Proofs and Derivations

A.1 Characterizing Bunching at the Minimum Wage

The Karush-Kuhn-Tucker conditions are the following, with corresponding complementary slackness for the nonnegative multipliers and the respective nonnegativity constraints.

$$\max_{w,e} V = f(w \mid \theta) - w - \tau \cdot (w - e) - \rho p \tau e - g(e) \tag{14}$$

$$w - e - M \geq 0, \ (\lambda) \tag{15}$$

$$e \geq 0, \ (\mu) \tag{16}$$

$$V \geq 0 \ (\nu). \tag{17}$$

The first-order conditions are:

$$\lambda + (1 + \nu) \left(f_w(w \mid \theta) - (1 + \tau) \right) = 0, \tag{18}$$

$$-\lambda + \mu + (1 + \nu) \left(\tau(1 - \rho p) - g'(e) \right) = 0. \tag{19}$$

.

The following cases characterize the solutions:

Case 1: no constraint binding ($\lambda = \mu = \nu = 0$). These are firms (with $\theta \in \Theta_3$) operating profitably with pay and reported pay over the minimum. With all multipliers equal to zero, we can show their productivity is higher than any of the other groups.

The first-order conditions in this case are:

$$f_w(w_1 \mid \theta \in \Theta_3) = (1 + \tau) \tag{20}$$

$$\tau(1 - \rho p) = g'(e_1). \tag{21}$$

Case 2: reporting constraint binds only ($\mu = \nu = 0$, $w - e = M$). This is similar to the case of Subsection 3.1.

The first-order conditions in this case are:

$$f_w(w_2 \mid \theta \in \Theta_2) + \lambda_2 = (1 + \tau) \tag{22}$$

$$\tau(1 - \rho p) = \lambda_2 + g'(e_2). \tag{23}$$

Lemma 1. $\theta \leq \theta'$, $\forall \theta \in \Theta_2, \theta' \in \Theta_3$.

Proof. From $g'(e_2) \leq g'(e_1)$, it follows that $e_2 \leq e_1$. Thus, $w_2 = M + e_2 \leq M + e_1 \leq w_1$. Also, $f_w(w_1 \mid \theta) \leq f_w(w_2 \mid \theta) \leq f_w(w_1 \mid \theta')$, therefore, $\theta \leq \theta'$. □

Case 3a: evasion constraint binds only ($\lambda = \nu = 0$, $e = 0$). This implies that $g'(0) = \tau(1 - \rho p) + \mu$. The assumption of $g'(0) = 0$ renders this case moot.

Case 3b: evasion and minimum wage constraints both bind for profitable firms ($\nu = 0$). This is a case with $e = 0$ but $w = M$, for $\theta \in \Theta_1$.

The first-order conditions are now:

$$f_w(M \mid \theta \in \Theta_1) + \lambda_3 = (1 + \tau) \tag{24}$$

$$\tau(1 - \rho p) = \lambda_3 + g'(0) - \mu_3 = \lambda_3 - \mu_3. \tag{25}$$

Lemma 2. $\theta \leq \theta'$, $\forall \theta \in \Theta_1, \theta' \in \Theta_2$.

Proof. From the first-order conditions, $\lambda_3 \geq \lambda_2$. Thus, $f_w(w_2 \mid \theta \in \Theta_1) \leq f_w(M \mid \theta \in \Theta_1) \leq f_w(w_2 \mid \theta' \in \Theta_2)$. Therefore, $\theta \leq \theta'$. □

The remaining cases cover the firm (job) barely breaking even. Depending on costs and technology, this could arise at any of the three cases discussed so far — and by monotonicity, it would render all other cases with lower productivity moot.

Case 4: all constraints bind. The firm barely breaks even with $w = M$ and $e = 0$. As $g(0) = 0$, this pins down a single θ_0 for which $f(M \mid \theta_0) - M - \tau M = 0$.

Lemma 3. $\theta_0 \leq \theta \; \forall \theta \in \Theta_1$.

Proof. $f(M \mid \theta \in \Theta_1) \geq 0 = f(M \mid \theta_0)$, therefore, $\theta_0 \leq \theta$ for all $\theta \in \Theta_1$. □

From the above lemmas it follows that $\theta_0 \leq \theta \leq \theta' \leq \theta''$ for all $\theta \in \Theta_1$, $\theta' \in \Theta_2$, and $\theta'' \in \Theta_3$. We demarcate the three relevant intervals of $\Theta_1, \Theta_2, \Theta_3$ by points θ_0, θ_1, and θ_2. (Θ_1 is open from above.) Panel (b) of Figure 2 illustrates the productivity categories.

A.2 The First Derivative of Welfare with Respect to the Minimum Wage

Proof. Proof of Proposition 1. Raising the minimum wage affects the three groups characterized at the end of Section 3 and the previous Appendix Section A.1 as follows:

1. Where the constraint is ineffective, lax ($\lambda = 0$), behavior does not change.

$$\frac{\mathrm{d}}{\mathrm{d}M}\int_{\theta_2}^{\infty} \alpha(\theta)V(\theta) + \beta(\theta)w(\theta) + \gamma(\theta)(\tau(w(\theta) - e(\theta)) + \rho p\tau e(\theta))\,\mathrm{d}\theta = \int_{\theta_2}^{\infty} 0\,\mathrm{d}\theta - \frac{\mathrm{d}\theta_2}{\mathrm{d}M}\left(\alpha(\theta_2)V(\theta_2) + \beta(\theta_2)w(\theta_2) + \gamma(\theta_2)(\tau(w(\theta_2) - e(\theta_2)) + \rho p\tau e(\theta_2))\right)$$

2. For evaders bunching at the minimum wage,

$$\begin{aligned}\frac{\mathrm{d}}{\mathrm{d}M}\int_{\theta_1}^{\theta_2} \alpha(\theta)V(\theta) + \beta(\theta)w(\theta) + \gamma(\theta)(\tau M + \rho p\tau e(\theta))\,\mathrm{d}\theta = &\int_{\theta_1}^{\theta_2}\left(-\alpha(\theta)\lambda(\theta) + \beta(\theta)\frac{\mathrm{d}w(\theta)}{\mathrm{d}M} + \gamma(\theta)\tau + \gamma(\theta)\rho p\tau\frac{\mathrm{d}e(\theta)}{\mathrm{d}M}\right)\mathrm{d}\theta + \\ &+ \frac{\mathrm{d}\theta_2}{\mathrm{d}M}\left(\alpha(\theta_2)V(\theta_2) + \beta(\theta_2)w(\theta_2) + \gamma(\theta_2)(\tau M + \rho p\tau e(\theta_2))\right) \\ &- \frac{\mathrm{d}\theta_1}{\mathrm{d}M}\left(\alpha(\theta_1)V(\theta_1) + \beta(\theta_1)w(\theta_1) + \gamma(\theta_1)(\tau M + \rho p\tau e(\theta_1))\right),\end{aligned}$$

   where we use the envelope theorem for $\frac{\mathrm{d}V(\theta)}{\mathrm{d}M} = -\lambda(\theta)$.

3. For true minimum wage jobs,

$$\begin{aligned}\frac{\mathrm{d}}{\mathrm{d}M}\int_{\theta_0}^{\theta_1} \alpha(\theta)V(\theta) + \beta(\theta)M + \gamma(\theta)\tau M\,\mathrm{d}\theta = &\int_{\theta_0}^{\theta_1}\left(-\alpha(\theta)\lambda(\theta) + \beta(\theta) + \gamma(\theta)\tau\right)\mathrm{d}\theta + \\ &+ \frac{\mathrm{d}\theta_1}{\mathrm{d}M}\left(\alpha(\theta_1)V(\theta_1) + \beta(\theta_1)M + \gamma(\theta_1)\tau M\right) - \frac{\mathrm{d}\theta_0}{\mathrm{d}M}\left(\beta(\theta_0)M + \gamma(\theta_0)\tau M\right)\end{aligned}$$

Notice that because welfare is a continuous function of productivity even at the thresholds of different cases, the sum of these terms are not affected by the changes in the thresholds. Formally:

$$\begin{aligned}\alpha(\theta_2)V(\theta_2) + \beta(\theta_2)w(\theta_2) + \gamma(\theta_2)(\tau(w(\theta_2) - e(\theta_2)) + \rho p\tau e(\theta_2)) = \\ = \alpha(\theta_2)V(\theta_2) + \beta(\theta_2)w(\theta_2) + \gamma(\theta_2)(\tau M + \rho p\tau e(\theta_2))\end{aligned} \quad (26)$$

as $w - e = M$ at θ_2 and the wage and evasion schedules (not distinguished here) also solve the same problem at this point as this is the point with a zero multiplier even though its constraint still binds ($\lambda = 0$), as complementary slackness allows. Similarly,

$$\alpha(\theta_1)V(\theta_1) + \beta(\theta_1)w(\theta_1) + \gamma(\theta_1)(\tau M + \rho p \tau e(\theta_1)) = \\ = \alpha(\theta_1)V(\theta_1) + \beta(\theta_1)M + \gamma(\theta_1)\tau M \quad (27)$$

as $w = M$ and $e = 0$ at θ_1 and everything equals because the two cases coincide with $\mu = 0$ (even though its constraint is not lax).

Using that for evaders bunching at the minimum wage, $\beta(\theta)\frac{\mathrm{d}w(\theta)}{\mathrm{d}M} = \beta(\theta) + \beta(\theta)\frac{\mathrm{d}e(\theta)}{\mathrm{d}M}$, in total, the welfare changes from a marginal increase of the minimum wage add up to

$$\frac{\mathrm{d}W}{\mathrm{d}M} = \int_{\theta_0}^{\theta_2} \left(-\alpha(\theta)\lambda(\theta) + \beta(\theta) + \gamma(\theta)\tau\right) \mathrm{d}\theta + \int_{\theta_1}^{\theta_2} \left(\beta(\theta) + \gamma(\theta)\rho p \tau\right) \frac{\mathrm{d}e(\theta)}{\mathrm{d}M}\, \mathrm{d}\theta \\ - \frac{\mathrm{d}\theta_0}{\mathrm{d}M}\left(\beta(\theta_0)M + \gamma(\theta_0)\tau M\right). \quad (28)$$

□

A.3 The Cross-Derivative of Welfare with Respect to the Minimum Wage and Audit Probabilities

Proof. Proof of Theorem 1. First, ponder the cross partial derivative:

$$\frac{\mathrm{d}^2 W}{\mathrm{d}M\,\mathrm{d}p} = \int_{\theta_0}^{\theta_2} \left(-\alpha(\theta)\frac{\mathrm{d}\lambda}{\mathrm{d}p}\right) \mathrm{d}\theta + \\ + \frac{\mathrm{d}\theta_2}{\mathrm{d}p}\left(-\alpha(\theta_2)\lambda(\theta_2) + \beta(\theta_2) + \gamma(\theta_2)\tau\right) - \frac{\mathrm{d}\theta_0}{\mathrm{d}p}\left(-\alpha(\theta_0)\lambda(\theta_0) + \beta(\theta_0) + \gamma(\theta_0)\tau\right) + \\ + \int_{\theta_1}^{\theta_2} \left(\beta(\theta) + \gamma(\theta)\rho p\tau\right) \frac{\mathrm{d}^2 e}{\mathrm{d}M\,\mathrm{d}p} + \gamma(\theta)\rho\tau\frac{\mathrm{d}e}{\mathrm{d}M}\,\mathrm{d}\theta + \frac{\mathrm{d}\theta_2}{\mathrm{d}p}\left(\beta(\theta_2) + \gamma(\theta_2)\rho p\tau\right)\frac{\mathrm{d}e}{\mathrm{d}M} - \\ - \frac{\mathrm{d}\theta_1}{\mathrm{d}p}\left(\beta(\theta_1) + \gamma(\theta_1)\rho p\tau\right)\frac{\mathrm{d}e}{\mathrm{d}M} - \frac{\mathrm{d}^2\theta_0}{\mathrm{d}M\,\mathrm{d}p}\left(\beta(\theta_0)M + \gamma(\theta_0)\tau M\right). \quad (29)$$

This simplifies, because $\frac{\mathrm{d}^2\theta_0}{\mathrm{d}M\,\mathrm{d}p} = 0$ with the break-even firm conducting no evasion (and

dropping the notation for θ-specific weights, as for derivatives before):

$$\frac{\mathrm{d}^2 W}{\mathrm{d}M\,\mathrm{d}p} = \int_{\theta_0}^{\theta_2} \left(-\alpha \frac{\mathrm{d}\lambda}{\mathrm{d}p}\right) \mathrm{d}\theta + \frac{\mathrm{d}\theta_2}{\mathrm{d}p}\left(-\alpha\lambda + \beta + \gamma\tau\right) - \frac{\mathrm{d}\theta_0}{\mathrm{d}p}\left(-\alpha\lambda + \beta + \gamma\tau\right) + \\ + \int_{\theta_1}^{\theta_2} \left(\beta + \gamma\rho p\tau\right) \frac{\mathrm{d}^2 e}{\mathrm{d}M\,\mathrm{d}p} + \gamma\rho\tau \frac{\mathrm{d}e}{\mathrm{d}M}\,\mathrm{d}\theta + \frac{\mathrm{d}\theta_2}{\mathrm{d}p}\left(\beta + \gamma\rho p\tau\right) \frac{\mathrm{d}e}{\mathrm{d}M} - \frac{\mathrm{d}\theta_1}{\mathrm{d}p}\left(\beta + \gamma\rho p\tau\right) \frac{\mathrm{d}e}{\mathrm{d}M}. \quad (30)$$

This simplifies further as $\frac{\mathrm{d}e(\theta)}{\mathrm{d}M}\Big|_{\theta=\theta_1} = 0$ for zero evasion with marginal cost of zero. Also, $\lambda(\theta_2) = 0$ by definition. The shadow price of the minimum wage does not change for firms with no evasion, so $\frac{\mathrm{d}\lambda}{\mathrm{d}p} = 0; \forall\theta \in [\theta_0, \theta_1]$. $\frac{\mathrm{d}\theta_0}{\mathrm{d}p} = 0$ as evasion (and detection, and fines) do not enter the calculus for the marginal firm breaking even, as we assumed that some firms still operate truly paying the minimum wage (and they must be less productive than evaders). Also, $\mathrm{d}^2 e/\,\mathrm{d}M\,\mathrm{d}p = 0$.

The cross-partial reads thus:

$$\frac{\mathrm{d}^2 W}{\mathrm{d}M\,\mathrm{d}p} = \int_{\theta_1}^{\theta_2} \left(-\alpha \frac{\mathrm{d}\lambda}{\mathrm{d}p}\right) \mathrm{d}\theta + \frac{\mathrm{d}\theta_2}{\mathrm{d}p}\left(\beta + \gamma\tau\right) + \int_{\theta_1}^{\theta_2} \gamma\rho\tau \frac{\mathrm{d}e}{\mathrm{d}M}\,\mathrm{d}\theta + \frac{\mathrm{d}\theta_2}{\mathrm{d}p}\left(\beta + \gamma\rho p\tau\right) \frac{\mathrm{d}e}{\mathrm{d}M}. \quad (31)$$

$\frac{\mathrm{d}\theta_2}{\mathrm{d}p} < 0$, as more firms (jobs) operate with smaller, non-binding evasion when enforcement is stricter (e_1 is lower when p is higher). Formally, from the optimality conditions under Case 2, a lower p implies a higher $g'(w(\theta_2) - M)$ and thus higher $w(\theta_2)$ and lower $f_w(w \mid \theta_2)$. θ_2 has to increase to still satisfy the equality with $(1 + \tau)$.

Yet evasion and the minimum wage move in opposite direction, but not one-to-one, thus at θ_2:

$$\frac{\mathrm{d}\theta}{\mathrm{d}p}\left(\beta + \gamma\tau\right) + \frac{\mathrm{d}\theta}{\mathrm{d}p}\left(\beta + \gamma\rho p\tau\right) \frac{\mathrm{d}e}{\mathrm{d}M} < \frac{\mathrm{d}\theta}{\mathrm{d}p}\left(\beta + \gamma\tau\right) + \frac{\mathrm{d}\theta}{\mathrm{d}p}\left(\beta + \gamma\rho p\tau\right)(-1) < \\ < \frac{\mathrm{d}\theta}{\mathrm{d}p}\left(\beta + \gamma\tau\right) - \frac{\mathrm{d}\theta}{\mathrm{d}p}\left(\beta + \gamma \cdot 1 \cdot 1 \cdot \tau\right) = 0, \quad (32)$$

where we used that at θ_2, $-1 < \frac{\mathrm{d}e(\theta)}{\mathrm{d}M} < 0$. To see this, first note that if $M = w - e$ rises, then e and w cannot both rise along, because the first would imply a lower λ, the second a higher, a contradiction. Similarly, e and w both falling is a contradiction as well. Thus, e falls and w rises if M increases. From this, using that $\frac{\mathrm{d}w(\theta)}{\mathrm{d}M} = 1 + \frac{\mathrm{d}e(\theta)}{\mathrm{d}M} > 0$, it follows that $-1 < \frac{\mathrm{d}e(\theta)}{\mathrm{d}M} < 0$.

For the remaining terms, first see that $\mathrm{d}e/\,\mathrm{d}M < 0$.

All that remains to show that the cross-partial is negative is that the integral in the first term of equation (31) is negative. As $\alpha(\theta) \geq 0$, this is guaranteed if $\mathrm{d}\lambda/\,\mathrm{d}p > 0$ for the cases

we numbered as Case 2 before, the bunching evaders. For them, $\mathrm{d}w = \mathrm{d}e$ which we can use to rearrange the differential of both equations as

$$\frac{\mathrm{d}\lambda}{\mathrm{d}p} = \tau\rho\frac{f_{ww}(w \mid \theta)/g''(e)}{f_{ww}(w \mid \theta)/g''(e) - 1}, \tag{33}$$

which is clearly positive as $f_{ww}(w \mid \theta) < 0$ and $g''(e) > 0$. □

B Audit Statistics

The Hungarian Tax Authority reported aggregate annual audit statistics by some grouping of taxpayers until 2006. Audit levels are defined as the ratio of the number of completed tax audits in a tax year (which corresponds to a calendar year in Hungary) to the number of taxpayers at the end of the previous year. In 2006, the agency reported high audit levels (Tax and Financial Control Administration of Hungary, 2007): 41.6% among private business entities with legal personality (partnerships, LLCs, private and public companies) and 15.5% among those without, but only 5.9% among government and other organizations and 4.3% among the self-employed and private persons. These levels were relatively stable throughout 2003-2006. These numbers mean that on average, in 2006, firms with legal personality had an audit every 2.5 years, those without every 6.5 years, government and other organizations every 17 years, and self-employed and private persons every 23 years.

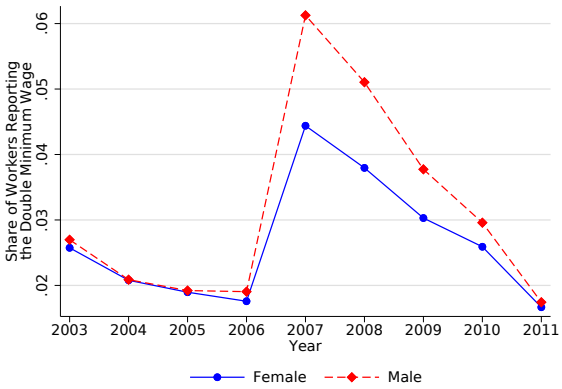
Based on later annual reports, the total number of audits decreased gradually between 2003 and 2007 (from 376 thousand in 2004 to 236 thousand in 2007). Then, there was a marked increase in the number of audits in 2008 (up to 317 thousand), with a decrease afterwards (down to 266 thousand in 2010). (Tax and Financial Control Administration of Hungary, 2019)

It is important to keep in mind that the above audit statistics cover all types of audits the Tax Authority conducts, such as audits to control fulfillment of certain tax obligations, audits of transforming and dissolving entities, net wealth growth audits, etc. Not all audits have the purpose or capacity to reveal underreporting of earnings. In fact, the vast majority (around 80%) of findings of net tax owed was in the value added tax during the analysed period.

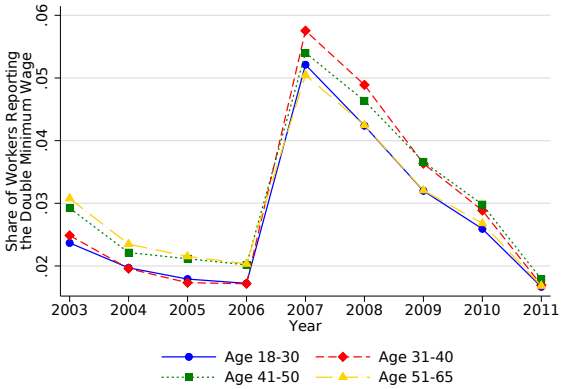
C Appendix Figures and Tables

Appendix Figure A1: Share of Private Sector Employees Reporting Earnings at Twice the Minimum Wage Over Time by Worker Characteristics

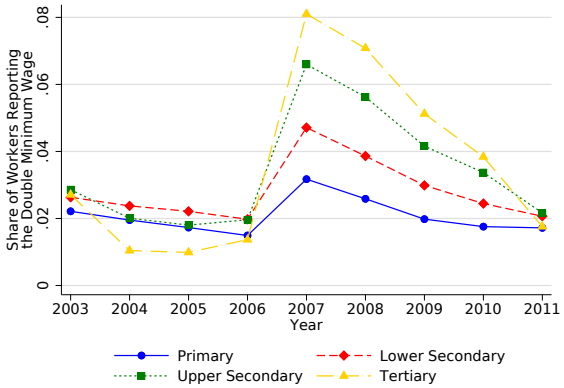
(a) By Gender



(b) By Age



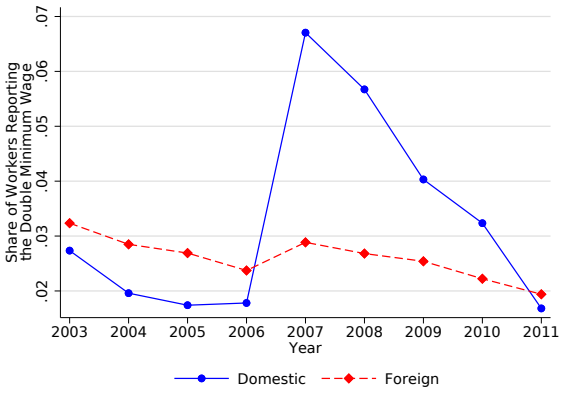
(c) By Skill Level



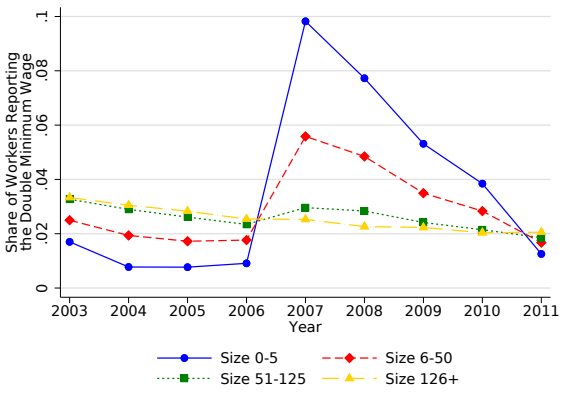
Note: This figure shows the share of private sector employees who report earning twice the minimum wage over time by gender, age group, and occupation skill level. Panel (a) shows the share of private sector employees who report earning twice the minimum wage for each year by gender (female in blue and male in red). Panel (b) shows the share of private sector employees who report earning twice the minimum wage for each year by age group (age 18-30 in blue, age 31-40 in red, age 41-50 in green, and age 51-65 in yellow). Panel (c) shows the share of private sector employees who report earning twice the minimum wage for each year by occupation skill level (primary in blue, lower secondary in red, upper secondary in green, and tertiary in yellow). For more details, see Section 5.

Appendix Figure A2: Share of Private Sector Employees Reporting Earnings at Twice the Minimum Wage Over Time by Firm Characteristics

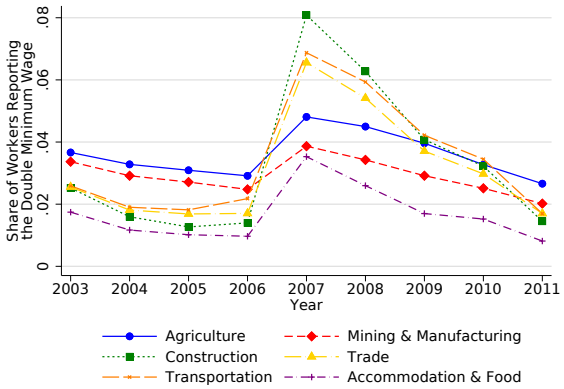
(a) By Ownership



(b) By Size

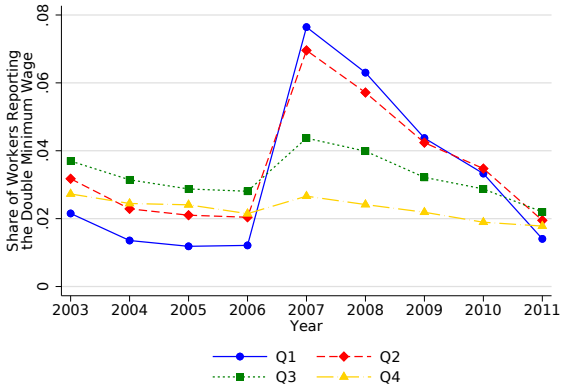


(c) By Industry



Note: This figure shows the share of private sector employees who report earning twice the minimum wage over time by ownership, observed size, and industry. Panel (a) shows the share of private sector employees who report earning twice the minimum wage for each year by ownership (domestic in blue and foreign in red). Panel (b) shows the share of private sector employees who report earning twice the minimum wage for each year by observed size (0-5 in blue, 6-50 in red, 51-125 in green, and more than 126 in yellow). Panel (c) shows the share of private sector employees who report earning twice the minimum wage for each year by industry (Agriculture in blue, Mining & Manufacturing in red, Construction in green, Trade in yellow, Transportation in orange, and Accommodation & Food in purple). For more details, see Section 5.

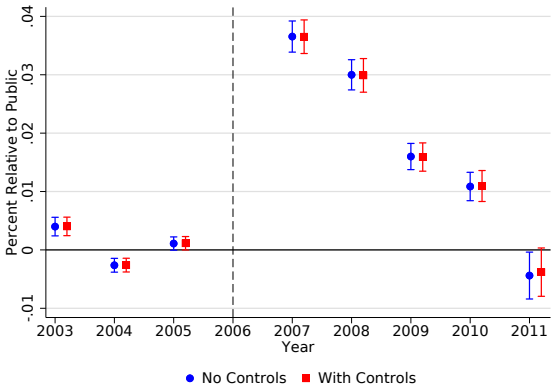
Appendix Figure A3: Share of Workers Reporting Earnings at Twice the Minimum Wage Over Time by Total Factor Productivity



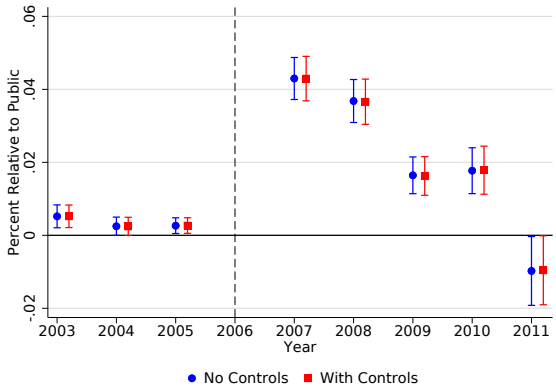
Note: This figure shows the share of workers who report earning double the minimum wage over time by total factor productivity. We show estimates for workers of firms that fall in quartile 1 of TFP in blue, estimates for workers of firms that fall in quartile 2 of TFP in red, estimates for workers of firms that fall in quartile 3 of TFP in green, and estimates for workers of firms that fall in quartile 4 of TFP in yellow. For more details, see Section 5.

Appendix Figure A4: Share of Workers Reporting Earnings at Twice the Minimum Wage Over Time

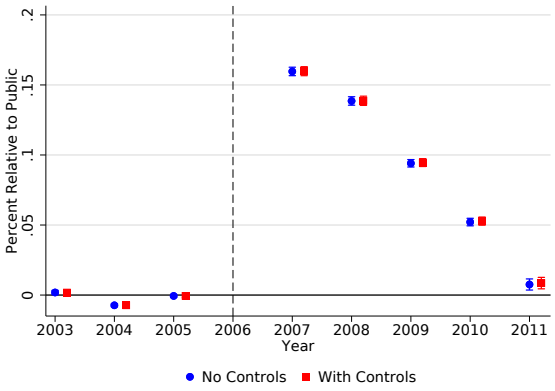
(a) Regression Estimates: Private Sector Employees, 5,000 HUF Wage Bin Definition



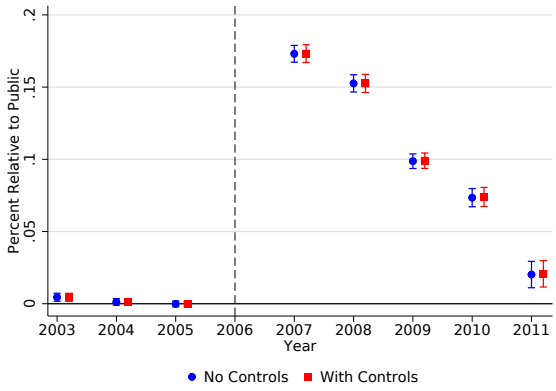
(b) Regression Estimates: Private Sector Employees, 95-105% Wage Bin Definition



(c) Regression Estimates: Self-Employed, 5,000 HUF Wage Bin Definition



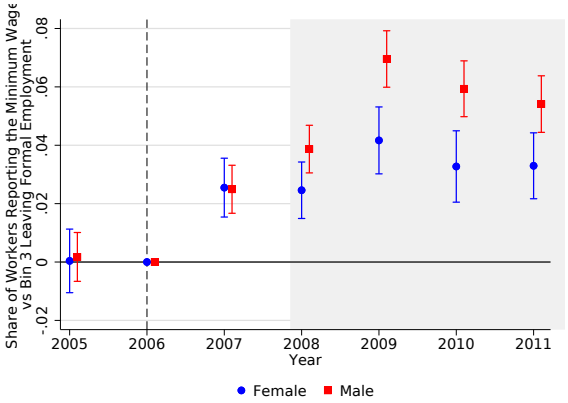
(d) Regression Estimates: Self-Employed, 95-105% Wage Bin Definition



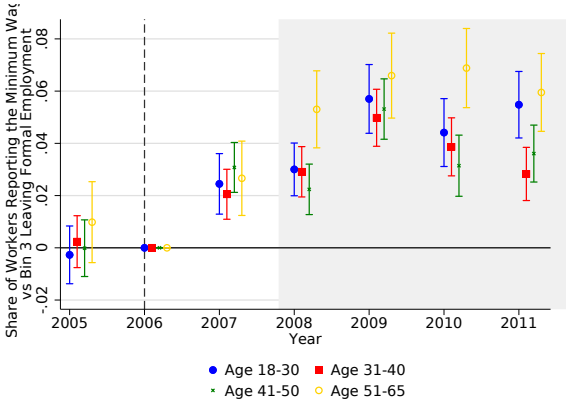
Note: This figure shows the share of workers who report earning double the minimum wage over time by sector. Panels (a) and (b) show event study regression estimates comparing private sector employees to public sector employees, based on Equation (10). Panels (c) and (d) show event study regression estimates comparing the self-employed to public sector employees, based on Equation (10). Panels (a) and (c) repeat results from Panels (b) and (c) of Figure 7, using our standard 5,000 HUF wage bin definition. Panels (b) and (d) show the same results using an alternative wage bin definition, based on annually updated 95-105% interval around the level of the post-2006 audit threshold. In each panel, the blue dots show estimates with no additional controls and the red dots show estimates controlling for gender, age group, and location (capital vs not). Standard errors are clustered at the firm level, 95% confidence intervals are displayed. For more details, see Section 5.

Appendix Figure A5: Heterogeneity by Worker Characteristics in Probability of Leaving Formal Employment Over Time

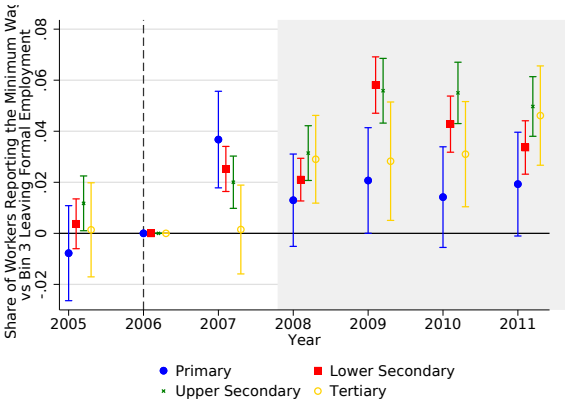
(a) By Gender



(b) By Age

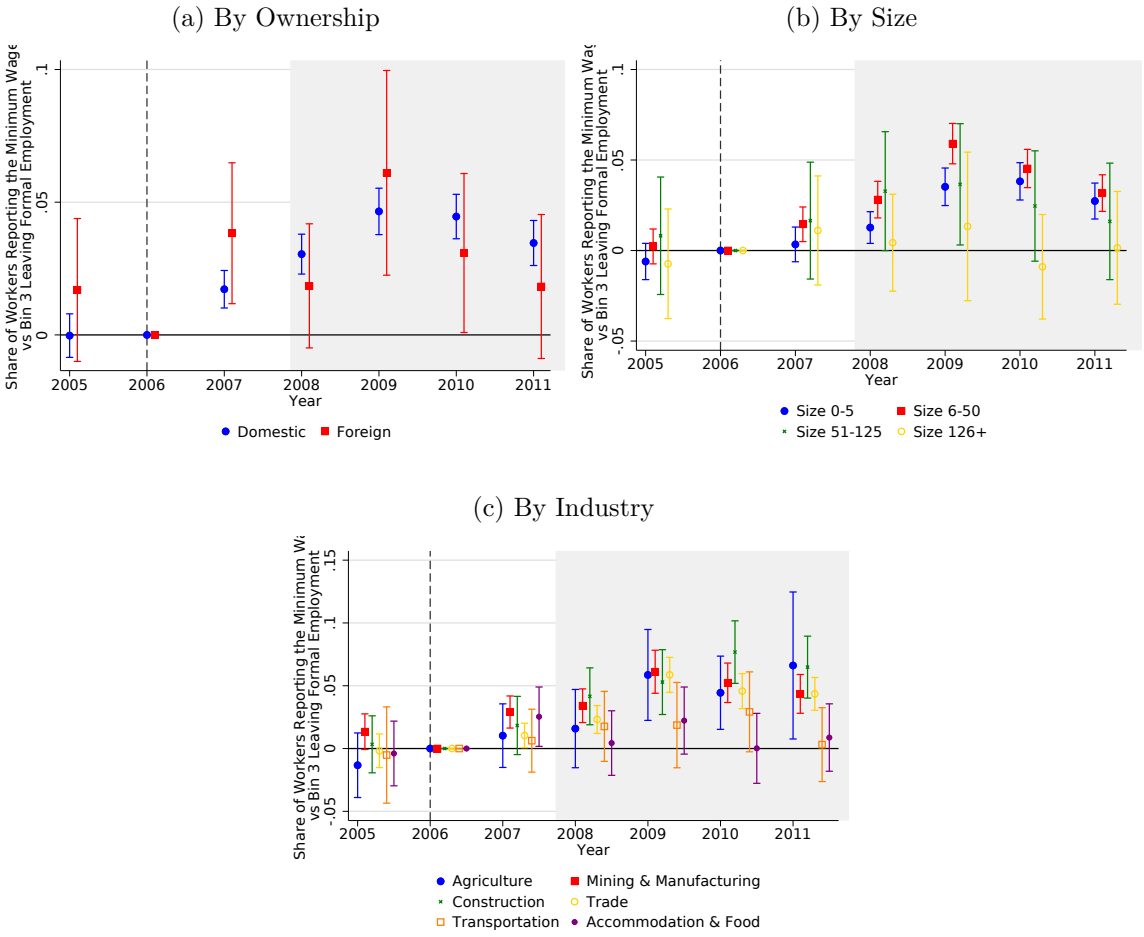


(c) By Skill Level



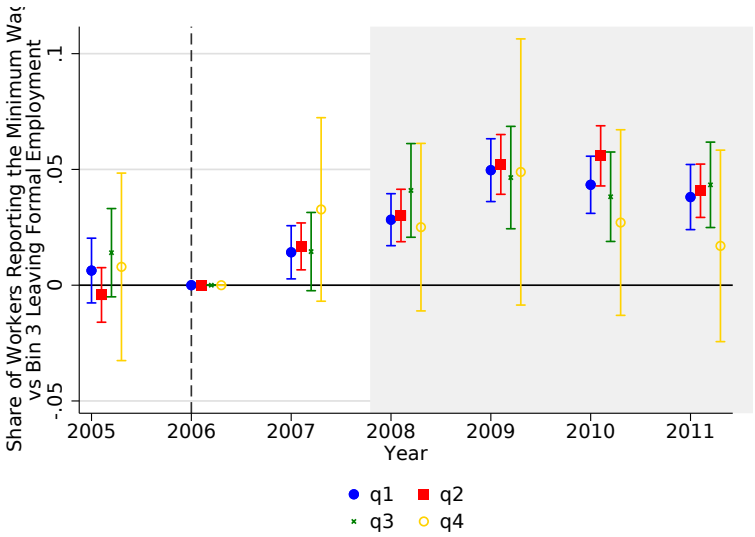
Note: This figure shows the share of private sector employees who leave formal employment over time by worker characteristics, comparing those who reported earning the minimum wage and those who reported earning in relative wage bin 3 in the previous year in event study regression estimates, based on Equation (12). Panel (a) shows estimates by gender (female in blue and male in red). Panel (b) shows estimates by age group (age 18-30 in blue, age 31-40 in red, age 41-50 in green, and age 51-65 in yellow). Panel (c) shows estimates by skill level (primary in blue, lower secondary in red, upper secondary in green, and tertiary in yellow). Standard errors are clustered at the firm level, 95% confidence intervals are displayed. For more details, see Section 5.

Appendix Figure A6: Heterogeneity by Firm Characteristics in Probability of Leaving Formal Employment Over Time



Note: This figure shows the share of private sector employees who leave formal employment over time by firm characteristics, comparing those who reported earning the minimum wage and those who reported earning in relative wage bin 3 in the previous year in event study regression estimates, based on Equation (12). Panel (a) shows estimates by ownership (domestic in blue and foreign in red). Panel (b) shows estimates by observed size (0-5 in blue, 6-50 in red, 51-125 in green, and more than 126 in yellow). Panel (c) shows estimates by industry (Agriculture in blue, Mining & Manufacturing in red, Construction in green, Trade in yellow, Transportation in orange, and Accommodation & Food in purple). Standard errors are clustered at the firm level, 95% confidence intervals are displayed. For more details, see Section 5.

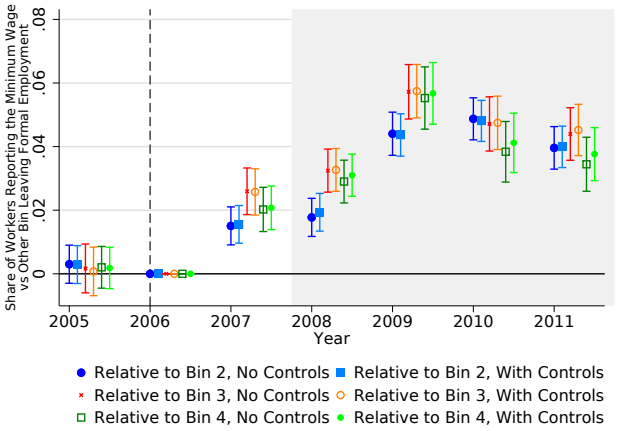
Appendix Figure A7: Heterogeneity by Firm Total Factor Productivity in Probability of Leaving Formal Employment Over Time



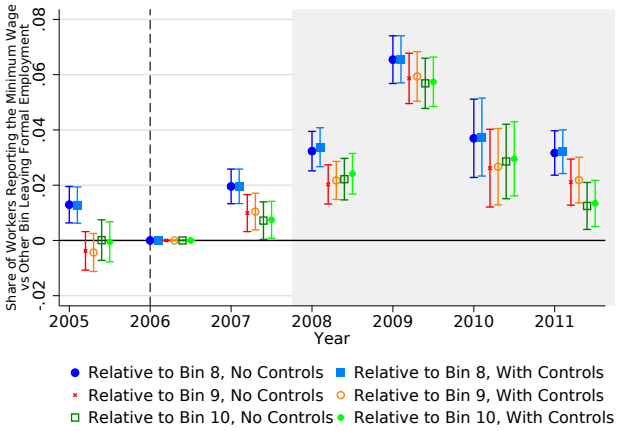
Note: This figure shows the share of private sector employees who leave formal employment over time by total factor productivity, comparing those who reported earning the minimum wage and those who reported earning in relative wage bin 3 in the previous year in event study regression estimates, based on Equation (12). We show estimates for workers of firms that fall in quartile 1 of the measure in blue, estimates for workers of firms that fall in quartile 2 of the measure in red, estimates for workers of firms that fall in quartile 3 of the measure in green, and estimates for workers of firms that fall in quartile 4 of the measure in yellow. Standard errors are clustered at the firm level, 95% confidence intervals are displayed. For more details, see Section 5.

Appendix Figure A8: Share of Workers Who Leave Formal Employment by Sector, Wage Bin, and Year

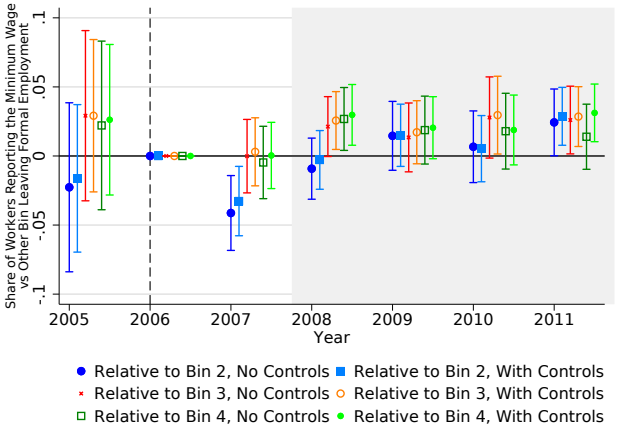
(a) Regression Estimates: Private Sector Employees, Using Wage Bins 2-4 as Reference



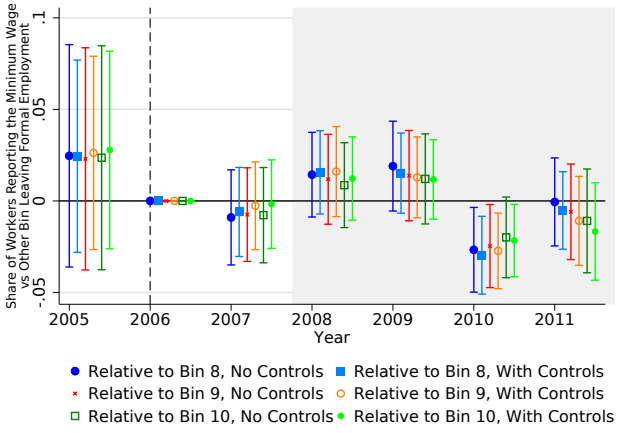
(b) Regression Estimates: Private Sector Employees, Using Wage Bins 8-10 as Reference



(c) Regression Estimates: Public Sector Employees, Using Wage Bins 2-4 as Reference



(d) Regression Estimates: Public Sector Employees, Using Wage Bins 8-10 as Reference



Note: This figure shows the share of workers who leave formal employment by January, by sector and wage bin (in December of two years prior) over time. Panels (a) and (b) show private sector employees, Panels (c) and (d) show public sector employees. Repeating our results from Figure 12, Panels (a) and (c) show event study regression estimates comparing those who report earning the minimum wage to those who report earning in relative wage bin 2 (in blue), those who report earning in relative wage bin 3 (in red), and those who report earning in relative wage bin 4 (in green), based on Equation (12). Panels (b) and (d) show event study regression estimates comparing those who report earning the minimum wage to those who report earning in relative wage bin 8 (in blue), those who report earning in relative wage bin 9 (in red), and those who report earning in relative wage bin 10 (in green), based on Equation (12). For each comparison, the first estimate (in a darker color) shows estimates with no additional controls and the second dot (in a lighter color) shows estimates controlling for gender, age group, and location (capital vs not). Standard errors are clustered at the firm level, 95% confidence intervals are displayed. For more details, see Section 5.

Appendix Table A1: Monthly Minimum Wages and Guaranteed Wage Minima by Year

Year	Minimum Wage				GMW	PPP
	Gross	Net	TLC	Tax Wedge (%)	Gross	
	(1)	(2)	(3)	(4)	(5)	(6)
1997	17,000	15,045	26,450	43.1		77.5
1998	19,500	17,258	30,297	43.0		88.4
1999	22,500	18,188	34,538	47.3		95.1
2000	25,500	20,213	38,963	48.1		97.6
2001	40,000	30,000	58,400	48.6		103.6
2002	50,000	36,750	71,250	48.4		104.7
2003	50,000	42,750	70,200	39.1		112.4
2004	53,000	45,845	74,205	38.2		117.3
2005	57,000	49,305	79,295	37.8		122.2
2006	62,500	54,063	85,388	36.7	68,000	124.5
2007	65,500	53,915	89,393	39.7	75,400	129.0
2008	69,000	56,190	94,065	40.3	86,300	128.9
2009	71,500	57,815	97 403	40.6	87,500	127.7
2010	73,500	60,236	94,448	36.2	89,500	122.9
2011	78,000	60,600	100,230	39.5	94,000	122.0
2012	93,000	60,915	119,505	49.0	108,000	122.6
2013	98,000	64,190	125,930	49.0	114,000	121.8
2014	101,500	66,483	130,428	49.0	118,000	125.7
2015	105,000	68,775	134,925	49.0	122,000	128.7
2016	111,000	73,815	142,635	48.2	129,000	131.2
2017	127,500	84,788	157,463	46.2	161,000	135.1
2018	138,000	91,770	167,670	45.3	180,500	138.6

Note: This table collects nominal monthly minimum wages in column (1) and guaranteed wage minima (column 5) in Hungarian forints. For the minimum wage, it also tabulates the net amount (column 2) assuming a single full-time full-year worker earning the minimum wage throughout and not taking advantage of other income tax deductions or credits. The total labor cost towards the employer is listed in column (3), and column (4) tabulates the corresponding tax wedge between columns 2 and 3. Source: page 285 of Fazekas (2019), using calculations of Ágota Scharle. Column (6) lists the Purchasing Power Parity between 1 USD and Hungarian forints for actual individual consumption, as reported by the OECD. Our analysis covers 2003-2011.

Appendix Table A2: Tax and Social Security Contribution Rates by Year

		Employee			Employer		
Year	Tax	Pension Fund	Health Insurance	Labor Market Fund	Pension Fund	Health Insurance	Unemployment Insurance
2003	0-650,000: 20% 650,000-1,350,000: 30% 1,350,000-: 40%	8.5%	3%	3%	18%	11%	1%
2004	0-800,000: 18% 800,000-1,500,000: 26% 1,500,000-: 38%	8.5%	4%	3%	18%	11%	1%
2005	0-1,500,000: 18% 1,500,000: 38%	8.5%	4%	3%	18%	11%	1%
2006	0-1,550,000: 18% 1,550,000-: 36%	8.5%	4%	3%	18%	11%	1%
2007	0-1,700,000: 18% 1,700,000-: 36%	8.5%	7%	3%	21%	8%	1.5%
2008	0-1,700,000: 18% 1,700,000-: 36%	9.5%	6%	3%	24%	5%	1.5%
2009	0-1,900,000: 18% 1,900,000-: 36%	9.5%	6%	3%	24%	5%	1.5%
2010	0-5,000,000: 17% 5,000,000-: 32%	9.5%	6%	1%	24%	2%	1.5%
2011	16%	10%	6%	1%	24%	2%	1.5%

Note: This table shows tax and social security contribution rates by year.

Appendix Table A3: Summary Statistics of Firm Indicators

	Weighted by Firm Size			Unweighted		
	Mean	Std. Dev.	Median	Mean	Std. Dev.	Median
Observed Firm Size	427	1,382	28	6.00	49.22	2
Foreign Ownership	0.33	0.47	0	0.07	0.26	0
Total Factor Productivity	0.77	1.03	0.77	0.03	0.90	0.09

Note: This table collects summary statistics on private sector firms in the pooled sample of years 2003–2011. There are 398,906 firms in that sample.

Appendix Table A4: Share of Workers Reporting Earning at Twice the Minimum Wage Before and After the Reform, 95-105% Definition of the Threshold

	(1)	(2)
Post × Private Sector Employee	0.026***	0.026***
	[0.003]	[0.003]
Post × Self-Employed	0.124***	0.125***
	[0.003]	[0.003]
Controls		×
N	12,385,920	12,328,514

Robust standard errors clustered at the firm level in brackets
*** p<0.01, ** p<0.05, * p<0.1

Note: This table shows difference-in-differences regression estimates of the change between the period before the introduction of the audit policy (2004-2006) and the period after the introduction of the audit policy (2007-2010) in the probability of reporting twice the minimum wage for private sector employees and the self-employed vs public sector employees, based on Equation (11). This table is analogous to Table 2, but we apply an alternative definition of wage bins. Instead of defining 5,000 HUF wage bins, we create a 95-105% interval around the post-2006 audit threshold. In column (1) we show estimates with no additional controls. In column (2) we show estimates controlling for gender, age group, and location (capital vs not). Standard errors are clustered at the firm level.

Appendix Table A5: Share of Workers Who Leave Formal Employment in 2007

(a) Private Sector Employees

Reference bin:	(1) Bin 8	(2) Bin 8	(3) Bin 9	(4) Bin 9	(5) Bin 10	(6) Bin 10
2007 × Minimum Wage	0.031***	0.032***	0.029***	0.030***	0.025**	0.026**
	[0.003]	[0.003]	[0.003]	[0.003]	[0.003]	[0.003]
Controls		×		×		×
N	1,397,225	1,387,777	1,351,921	1,342,823	1,322,537	1,313,606

(b) Public Sector Employees

Reference bin:	(1) Bin 8	(2) Bin 8	(3) Bin 9	(4) Bin 9	(5) Bin 10	(6) Bin 10
2007 × Minimum Wage	-0.013	-0.015	-0.014	-0.016	-0.016	-0.018
	[0.014]	[0.012]	[0.014]	[0.012]	[0.014]	[0.012]
Controls		×		×		×
N	157,904	157,425	151,468	151,061	142,247	141,871

Robust standard errors, clustered at the firm level in brackets
*** p<0.01, ** p<0.05, * p<0.1

Note: This table shows regression estimates of the probability of leaving formal employment in 2007 among those reporting at the minimum wage in the previous year relative to those reporting in one of the relative wage bins above the minimum wage, based on Equation (12). Panel (a) shows estimates for private sector employees, Panel (b) shows estimates for public sector employees. In columns (1) and (2), the comparison group for workers reporting at the minimum wage in the prior year are workers reporting in relative wage Bin 8. In columns (3) and (4) , the comparison group for workers reporting at the minimum wage in the prior year are workers reporting in relative wage Bin 9. In columns (5) and (6) , the comparison group for workers reporting at the minimum wage in the prior year are workers reporting in relative wage Bin 10. For more details on our relative wage definitions see Section 5. In columns (1), (3), and (5) we show estimates with no additional controls. In columns (2), (4), and (6), we show estimates controlling for gender, age group, and location (capital vs not). Standard errors are clustered at the firm level.