Tax Evasion and the Minimum Wage: Evidence from Hungary*

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Abstract

Exploiting a change in reporting defaults and the implied audit threat in Hungary, we demonstrate that a substantial portion of employees and the self-employed reporting to earn the minimum wage have much higher earnings in reality. This can be seen from their sharp but temporary jump to the new reporting default, a twofold increase in reported earnings, which quickly dissipates as enforcement does not follow. Misreporting is also consistent with the response concentrated both spatially and by employer, as well as with the anomalous covariate distributions around the threshold. Requiring these individuals to pay higher taxes or ask for explicit exceptions increases reported earnings for some and decreases formal employment for others, suggesting a trade-off for taxation. We formalize the empirical findings in a model of minimum wage taxation where earnings underreporting around the minimum wage would justify a move towards higher taxation of those earnings, more aligned with a prevalent international practice.

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1 Introduction

Why would we tax the minimum wage? Gross minimum wages can be twice as high as the net in some countries. Even with quite inelastic labor demand, one would think that a lower tax burden could boost employment with the same take-home pay. This paper presents evidence for one potential justification for high and taxed minimum wages: they recover some tax revenue from higher earners who underreport their income.

As long as firms can hire some of their workers informally, the minimum wage is a critical threshold: the least pay registered employees can get away with. Registration lowers the firms' risk of getting caught relative to having unreported employees. 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 be making more.

In this paper, we demonstrate that misreporting is an empirically relevant phenomenon even in a middle-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 ask for an exception. In the latter case, they understood to face higher probabilities of audit from tax authorities. We examine how firms' reporting behavior and the employment of affected workers 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". Using detailed administrative data, we can examine several dimensions of heterogeneity in the response, including by sector, industry, firm size, and productivity.

We find that firms responded to the new threshold in ways that are consistent with substantial underreporting of earnings precisely at the minimum wage. Specifically, we find that 10.2% of the private-sector employees and 19.2% of the self-employed who declared the minimum wage before the reform reported monthly earnings exactly twice the minimum soon after. This phenomenon suggests that they earned extra off the books prior to the reform. In the years after the initial

introduction of the new threshold, the concentration of earnings at the threshold decreases, most likely because of firms' changing perception of the audit threat.

We document other patterns consistent with previous underreporting. First, there is no response to the introduction of the new threshold by public sector employees. Second, the response is more pronounced in the industries most prone to tax evasion. Third, the response is concentrated in small and domestic companies. We also show that there is a negative association between our measure of underreporting and firm productivity. Fourth, we show that individuals who report at the new threshold look very different from individuals who report just below or just above the threshold on a variety of measures. Fifth, the transition from the 2005 minimum wage earnings to twice as much in 2007 is concentrated within firms, and sixth, in specific areas.

After describing changes in wage reporting consistent with previous underreporting, we show that some workers exit formal employment, leading to a loss in tax revenue, in contrast with the higher tax revenue from firms who "comply" by reporting higher earnings than before. Specifically, we find that around 2% of private sector employees exit formal employment as a consequence of the reform. We document substantial heterogeneity in exit rates by worker and firm characteristics. Leaving formal employment was also concentrated in certain firms. 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. This implies a trade-off for governments taxing these low incomes: a broader tax base as some workers and firms formalize more of their income but also a concurrent loss as others go entirely informal or shut down.

In the last part of the paper, we formalize this observed trade-off in a model. Abstracting away from the motivations for full honesty or evasion, we relate the excess masses at earlier and later reporting defaults to the number of underreporting earners. In a monopsonistic labor market, some employment will legitimately bunch at the minimum wage and thus mask misreporting. The government can expect higher net revenues from raising both the gross minimum wage and taxes on it, leaving the net unchanged, as long as enough of those who previously underreported stay employed.[1]

[1]Strictly speaking, governments usually tax annual income and not wages or even earnings, and we do not mean to use these words interchangeably. That said, in countries with individual taxation, stable incomes throughout calendar years, and few deductions or credits, many minimum wage earners pay similar and predictable taxes after their labor

Our finding that reporting defaults and presumptive taxation with audit threats can recover some tax revenue from misreported earnings speaks to the literature on tax compliance and evasion (see Andreoni, Erard and Feinstein, 1998, and Slemrod, 2019, for comprehensive reviews). The documented response to salient audit threats is in line with recent findings (Kleven et al., 2011; De Andrade, Bruhn and McKenzie, 2014; Bérgolo et al., 2017). Declaring the lowest earnings that qualify for some benefits is similar to what Kumler, Verhoogen and Frías (2015) documented in Mexico, where reported wages responded to their link to retirement benefits. Our work on firm compliance is related to de Mel, McKenzie and Woodruff's (2013) findings on the effects of randomly allocated financial incentives on firms to formalize and Di Gregorio and Paradisi (2019) analyzing firm revenue manipulation in response to audit threats. We base our empirical analysis on a quasi-experiment — the introduction of a new audit threshold for individual earnings. We use the effort to avoid audit as evidence for tax evasion. This approach is related to Almunia and Lopez-Rodriguez's (2018) study of a discontinuous increase in enforcement above a revenue threshold for Spanish firms, although with opposite reporting incentives to ours. Choudhary and Gupta (2019) use a similar revenue threshold in India to show that the triggered third-party audits raise taxable income and taxes paid.

We see our work as developing evidence on how to recover some tax revenue lost to misreporting when various considerations limit the set of possible policies and targeting tools. Earlier work has considered a better paper trail on transactions to reduce tax evasion (Pomeranz, 2015; Naritomi, 2019) and auditors targeting likely evaders (Hashimzade, Myles and Rablen, 2016), as well as differentiated reporting standards, thresholds (Tonin, 2013*a*), and even tagging according to personal characteristics (Cremer, Gahvari and Lozachmeur, 2010; Weinzierl, 2014). The policy we evaluate is a mixture of a form of presumptive taxation and a targeted audit threat. We show new evidence on the trade-offs generated by such policies.

We also contribute to the literature on informal employment and taxation. Any economy features labor hired on markets black (unreported or illicit work) and grey (misreported pay). Based on survey data, Williams and Padmore (2013) report that 6 percent of formal employees in the European Union receive part of their pay undeclared. This pattern is even more prevalent

income. Some countries routinely report net minimum wages from these implied taxes, which we also report in our Table 1. We do not observe taxable income in our data.

in Central and Eastern Europe. Williams (2013) reports that informal employment is also more common in this region, amounting to 21.5% of their GDP, based on survey data from 2007. Using public-sector employees as a benchmark in linked tax and survey data, Paulus (2015) finds that 20% of private-sector employees in Estonia underreport income.

Our results on reporting responses to the double minimum wage rule allow us to measure underreporting around the minimum wage. In the Hungarian context, Reizer (2011) used the same policy, and Elek, Köllő, Reizer and Szabó (2012) estimated a double hurdle model, to discuss where tax evasion is concentrated in the economy. Our results indicate that in addition to increases in reported earnings by some workers previously reporting the minimum wage, other workers may opt out of formal employment. This effect of a higher default (or risk of enforcement) relates to earlier work by Kuehn (2014) and Rocha, Ulyssea and Rachter (2018) that shows a positive relationship between tax rates and the size of the informal economy. All this tax evasion has significant welfare consequences. Ulyssea (2018) shows in an equilibrium model of the Brazilian economy that reducing informality among firms and workers can be associated with higher productivity and welfare, but need not be. Also on Brazilian data, Meghir, Narita and Robin (2015) find that informality is a transfer to firms and reduces welfare overall. The extent and nature of informal work can also reveal essential features of the labor market, like market power (Di Gregorio and Paradisi, 2019). It can also impose frictions for policies like unemployment insurance — beneficiaries may collect benefits and work informally at the same time (Gerard and Gonzaga, 2016).

Our results also build towards a pragmatic evaluation of minimum wage levels and the tax treatment of corresponding earnings. Recent evidence on the effects of the minimum wage comes from a massive Hungarian increase in 2001-2002: Harasztosi and Lindner (2019) establish that most of the incidence fell on consumers, with labor and capital responding little. The optimal tax literature has tread more carefully about evaluations of the minimum wage that could be put to the data. Lee and Saez (2012) derived sharp results under perfect competition: Wage floors are only consistent with subsidies, or it would be Pareto improving to let rationed labor work again with a tax cut. This principle is yet to be reconciled with the fact that a substantial tax burden falls on minimum wage earners in many OECD countries (OECD, 2007). We argue that the fiscal externality of this tax on higher earners who misreport their earnings is an essential factor in

countries with lagging tax morale. Tonin (2011, 2013*b*) tied evasion to the minimum wage, both with a positive correlation between the size of the corresponding spike in the wage distribution and that of the informal economy in European cross-country data and with the consumption response to a minimum wage hike in a Hungarian survey.

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 reviews 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 describes our use of the double minimum wage rule and worker and firm responses to document wage underreporting. Section 7 reports our findings on labor leaving formal employment. Section 8 presents a back-of-the-envelope calculation of the fiscal effects of the policy. Section 9 presents a model of taxation of the minimum wage when underreporting is a concern at this point in the wage distribution. Finally, Section 10 concludes.

2 Background

In this section, we introduce the relevant features of the institutional environment in Hungary between 2003 and 2011. We discuss the minimum wage, income taxes, informal employment, industrial relations and market power, and finally the double minimum wage rule that we use in this paper.

Minimum Wage. 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 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 throughout, for singles without dependents and any other tax deduction or credit. Gross and net monthly minimum wages and the Guaranteed Minimum Wage for skilled jobs assumed to

require a high school diploma introduced in 2006 are tabulated in Table 1.

Income Taxes. 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), the average being 35-37% over these years. Labor income taxes include a payroll tax (in 2006, 18% on the first 1,550,000 HUF, 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). In Hungary, the tax wedge on minimum wage earners is high and close to the average tax wedge. Table 2 shows the payroll tax and social security contribution rates by year to compare with the tax wedges listed in Table 1.

Informal Employment. 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. 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. 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).[2]

[2]We discuss some reported audit statistics of the Tax Authority in Appendix A.

Industrial Relations and Market Power. Of course, without legitimate bunching at the minimum wage organically arising in the labor market, underreporting firms could risk exposure by picking this number even if this minimizes their tax bill (for a registered employee). One reason why labor markets can exhibit such bunching is the monopsony power of employers. Hungarian firms are understood to have substantial market power in setting compensation, similar to other countries (Manning, 2011).

Also, we might expect little underreporting if wages were set in collective agreements and not in employee-employer bargaining. Hungary inherited extensive labor unions from Socialist times, and minimum wage increases are often introduced at trilateral meetings with the government and corporatist chambers of commerce (Fazekas, 2007). However, these councils set no binding wage agreements and wage floors are set in law by the government.

Double Minimum Wage Rule. 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 could then increase the probability of a tax audit. If the reported wage was below twice the 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' social security contributions for the difference between the reported wage and twice the amount of the minimum wage. This rule incentivized employers to either request an exemption from the rule or to report at least twice the amount of the minimum wage towards tax authorities. The double minimum wage rule applied to both private sector employees and the self-employed. The rule was in effect between September 1, 2006 and December 31, 2010.

The double minimum wage rule can be considered presumptive taxation (Thuronyi, 1996; Reizer, 2011). According to the definition of Slemrod and Yitzhaki (1994), a presumed tax base is a substitute for a desired tax base, the presumed tax base is derived from items that are easier to monitor. Presumptive taxation exists whenever the legislator is using one tax base in order to approximate another (Yitzhaki, 2007). The double minimum wage rule does not rely on addi-

tional observable items, but it "presumes" that the taxpayer's earning is no less than twice the minimum wage, unless the taxpayer is proves otherwise. 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).

3 Bunching at Enforcement Thresholds

This section overviews the argument why we expect to find a mass of earnings reported at the double minimum wage as long as it is understood that lower amounts are likelier to result in audits and fines for misreported earnings. Thresholds like this are notches in the expected after-fines earnings schedule.

Employer Optimization In partial equilibrium of a perfectly competitive labor market, employers will set output (per worker: y) and evasion (e) levels to maximize each employee's value of labor $V(y, e \mid \theta_i)$ (normalizing with total labor cost 1):

$$\max_{y,e} V(y, e \mid \theta_i) = y - \underbrace{c(y, \theta_i)}_{\text{Production Cost}} - \tau \cdot \underbrace{(y - c(y, \theta_i) - e)}_{\text{Declared Earnings}} - \underbrace{\rho \cdot p \cdot \tau \cdot e}_{\text{Expected Audit Cost}} - \underbrace{g(e)}_{\text{Manipulation Cost}}$$

where y is the production level set for worker i, e is amount of manipulation in her earnings, θ_i is her productivity, p is the audit probability they face, τ is the tax wedge on declared earnings, ρ is the recovery rate on misreported earnings if caught.

The labor supply curve that the employer faces defines a cost function with $\partial c/\partial y > 0$. Let us order workers' productivity in a way that $\frac{\partial^2 c}{\partial y \partial \theta} < 0$.

The optimality conditions of this problem are

$$\frac{\partial c(y, \theta)}{\partial y} = MC(y \mid \theta) = 1$$

and

$$\tau - \rho p \tau = g'(e).$$

The supply curves of y and e are the inverse of the (strictly increasing) marginal cost curves, which we denote S and E. Changes in the audit probability only affect the manipulation incentive.

Static Bunching at Enforcement Thresholds. Assume p dropping from p_0 to $p_1 < p_0$ at some declared earnings threshold $y - e = D$ (neglecting the cost shifter from now on). So audit probability p is decreasing, i.e.

$$p = \begin{cases} p_0 & \text{if } y - e < D \\ p_1 & \text{if } y - e \geq D \end{cases}$$

Then for low productivity jobs far from D, $e = E(\tau - \rho p_0 \tau)$ and $y = S(1 \mid \theta)$ as long as

$$S(1 \mid \theta) - E\left(\tau - \rho p_0 \tau\right) \leq D$$

if the marginal cost of unitary production is strictly decreasing in productivity θ (which we can assume without loss of generality), this is satisfied $\forall \theta < \theta_0$ if there is any, where

$$S(1 \mid \theta_0) - E\left(\tau - \rho p_0 \tau\right) = D.$$

For jobs with high enough productivity, $e = E\left(\tau - \rho p_1 \tau\right)$ and $y = S(1 \mid \theta)$ as long as (by the same monotonicity) $\theta_1 < \theta$ where

$$S(1 \mid \theta_1) - E\left(\tau - \rho p_1 \tau\right) = D.$$

In between, for $\theta \in [\theta_0, \theta_1]$ the worker will produce and evade just enough that $y - e = D$. For a continuous distribution of θ with c.d.f. $H(\theta)$, this implies the mass of $H(\theta_1) - H(\theta_0)$ bunching at the enforcement threshold D. This is the mass missing from the left of the threshold D in a world without frictions and noise.

We can check for consistency in $\theta_0 < \theta_1$, which again follows from the fact $\frac{dy}{d\theta} > 0$ at $MC = 1$ (or $\frac{\partial S}{\partial \theta} > 0$ in general) from the implicit function theorem:

$$\frac{dy}{d\theta} = -\frac{\partial MC / \partial \theta}{\partial MC / \partial y} > 0,$$

as $\partial MC/\partial\theta < 0$ but $\partial MC/\partial y > 0$ by assumption.

If one can credibly calibrate parameters like ρ and p_1/p_0 at D, one could recover the elasticity $\frac{d\log g}{d\log e}$ at the point from bunching at this notch using a structural model or the reduced-form approximations of Kleven (2018).

Shifts in bunching. We can easily extend the sitation to two thresholds, an extremely well enforced lower threshold M and an initially ineffective new threshold D.

Initially, $p_0 = p_1$ but for reported earnings below some $M < D$, $p_M \gg p_0$ (and if $p_M \leq 1$ would bind, allow for $\rho_M \gg \rho$ as additional punitive fines). Analogously to the previous argument, only workers with $\theta > \theta_M$ will be reported with earnings above M, where

$$S(1 \mid \theta_M) - E\left(\tau - \rho p_1 \tau\right) = M.$$

If we assume a productivity $\underline{\theta}$ low enough that $MC(M + E(\tau - \rho p_M \tau) \mid \underline{\theta}) > 1$, a mass of $H(\underline{\theta})$ workers will be priced out of the labor market, but $H(\theta_M) - H(\underline{\theta})$ bunch at the minimum wage M.

If p_0 rises for reported earnings in $[M, D]$, the bunch appears as under the previous point and the bunching at M becomes smaller. $\underline{\theta}$ does not change, but some evaders are pushed off M with a new productivity cutoff

$$S(1 \mid \theta'_M) - E\left(\tau - \rho p_0 \tau\right) = M.$$

(Again, for a higher p, the lower implied e necessitates a lower θ'_M for which the marginal cost of a lower $M + e$ equals 1.)

Equilibrium evasion (shading) is lower with a higher probability of getting caught, $E\left(\tau - \rho p_0 \tau\right) = e_0 < E\left(\tau - \rho p_1 \tau\right) = e_1$. Thus the real earnings behind any specific reported earnings $\tilde{y} = y(\theta) - e_0 \in [M, D]$ is higher than before stricter enforcement (with $y(\theta) = \tilde{y} + e_1$ for the same $\tilde{y}$). Thus the density of those observed earnings changes to the density of higher productivity. If M is high enough to leave θ_M to the right of the mode of its unimodal distribution H, then its density is strictly decreasing over $[M, D]$ already, and densities fall after stricter enforcement ($p_0 > p_1$) comes into effect. Also, the observed density of reported earnings will drop to 0 under D, for productivities higher than the new marginal buncher θ_0.

Would the extra mass at D be a lower bound of the prior extra mass at M? Not surprisingly,

this is somewhat ambiguous — with very harsh enforcement ($\rho_0 p_0 \gg \rho_1 p_1$, $e_0 \ll e_1$) and a large $D \gg M$, much of the bunching at D would come from the mass previously spread out between M and D and not necessarily bunching at M.

Combination with segmented labor markets in evasion. In segmented labor markets, the shifts in the segment with evasion would be the only response to a change in the enforcement threshold (new p_0 between M and D). This is equivalent to allowing for an additional dimension of heterogeneity in evasion costs (γ) but restrict the bivariate $\tilde{H}(\theta, \gamma)$ distribution to a mixture of the case discussed previously (with evasion costs g if $\gamma = \gamma_1$ and share α) and complementary one with prohibitive evasion costs ($g_0(e \mid \theta) \gg c(\theta)\ \forall\theta$).

4 Data and Sample

Our data links multiple administrative sources from Hungary. The panel 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. It 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. Since our focus is on the working age population, we restrict the sample to individuals aged 18–65.

The core of the dataset is linked employer-employee data; we observe monthly employment and earnings at the individual-firm level. Administrative data from the Central Administration of National Pension Insurance, the National Health Insurance Fund Administration, the National Tax and Customs Administration, the National Labor Office, and the Pension Payment Directorate of Hungary have been linked to this at the individual level.

Employment and Worker Characteristics. 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 of the 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 Force Survey of the Central Statistical Office of Hungary. Area of residence is observed only in 2003, and not updated.[3] 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.[4] 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 for a firm which has two or more observed workers. Table 3 shows summary statistics for our sample of workers by sector.

Firm Characteristics. Tax authority data on firm-specific indicators are available only for larger firms (with double-entry bookkeeping).[5] Based on this, we see ownership (foreign versus domestic), sector and industry, firm size, domestic and export revenues, net revenues, the total wage bill, gross value added, tangible assets and material costs. The revenue and cost indicators

[3] 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).

[4] These sector definitions are consistent over years 2003-2009, less so for years 2010-2011, due to changes of definitions in the baseline data.

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

are annual measures, corresponding to a calendar year. Using these indicators, we calculate export share of revenues and total factor productivity (TFP). Since these calculated indicators are based on the tax authority's firm-level records, these are 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. Table 4 shows summary statistics for private-sector firm characteristics.[6]

The export share of revenues is the ratio of export revenues and total revenues, both of which are legally required to be reported to the tax authority by firms each year. We calculate TFP as the sum 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.

5 Empirical Framework

In our analyses, we use the introduction of the double minimum wage rule at the end of 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.

Wage Bin Definitions. Throughout our analyses, we use two bin definitions to partition the earnings distribution. Where possible, 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. In order to facilitate cross-year comparison though, we also define relative wage bins. 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 double minimum wage. Thus,

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

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 double minimum wage. 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 cross-year 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% percent higher in 2011 than in 2003.

Treatment of Earnings Below the Monthly Minimum Wage. We do not observe hours worked, therefore part-time workers appear to 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.

5.1 Underreporting of Earnings at the Minimum Wage

Descriptive Evidence. The first set of analyses we present relies on the cross-sectional distribution of earnings before and after the introduction of the double minimum wage. 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 double minimum wage rule, 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 look at transitions of workers between different wage levels. We estimate 2-year transition patterns between each pair of wage bins.

Heterogeneity Analyses. 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 percent of workers who transition by worker characteristics (gender, age, and skill level), firm characteristics (ownership, size, and industry), and measures of firm quality (export share in revenues and total factor productivity). We also report standard errors of the mean for each category.

We also break down these transition rates by 174 districts of Hungary, weighted by population, and analyse 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

$$DMW_{it} = \beta_0 + \sum_{t=2003}^{2011} \beta_{1t} PE_{it} + \sum_{t=2003}^{2011} \beta_{2t} SE_{it} + \alpha_E + \tau_t + \varepsilon_{it} \tag{1}$$

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}, the differential change between private sector employees and public sector employees in the likelihood of reporting earning the double minimum by year and β_{2t} the differential change between the self-employed and public sector employees in the likelihood of reporting earning double the minimum for the year. 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:

$$DMW_{it} = \beta_0 + \beta_1 PE_{it} \times Post_t + \beta_2 SE_{it} \times Post_t + \alpha_E + \tau_t + \varepsilon_{it} \tag{2}$$

where i indexes workers, PE_{it} is an indicator for private sector employees, SE_{it} is an indicator for the self-employed, $Post_t$ is an indicator for the post-period (years 2007-2010), α_E are sector fixed effects (public-sector employee, private-sector employee, or self-employed), and τ_t are year fixed effects. We exclude year 2011 from this regression because the double minimum wage rule was no longer in effect by then. The coefficients of interest are β_1, the differential change between private sector employees and public sector employees in the likelihood of reporting earning double the minimum between the pre and post period and β_2, the differential change between

the self-employed and public sector employees in the likelihood of reporting earning double the minimum between the pre and post period. We cluster standard errors at the firm level.

The advantage of the event study is that we are able to distinguish sharp changes at the introduction of the reform and the later evolution of earnings concentration at the double minimum wage threshold. By contrast, the pooled approach summarizes the longer-term impact of the reform more succinctly.

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, the self-employed, and public sector employees. For this analysis, comparisons across relative wage bins are necessary because macroeconomic trends have a considerable impact on employment as it is apparent during the Great Recession in our figures. Since we are analyzing the probability of a worker leaving formal employment among workers employed in the previous year, we show results for 2004 to 2011, 2003 being the baseline year for 2004.

However, we have to consider the data limitation that our earnings data derives from employment spells cut into calendar years. For instance, if an individual remained in the same job throughout the year, then our monthly earnings measure will be the annual total divided by 12. Because of this smoothing and the double minimum wage rule coming into effect in September, people shifting from the minimum wage to its double are observed to earn between the two (the weighted average) throughout 2006, even in March. Therefore, these shifters are not included among the observed minimum wage earners in March 2006. Of course, long-employed people shifting from the early-2006 minimum wage to its late-2006 double are on a much better track not to leave their steady job by March 2007 either. Therefore, those observed only with the minimum wage for their entire spell in 2006 (whenever it ended) are much more likely to leave formal employment by next spring. Hence, our estimated impact on formal employment among observed minimum wage earners likely overestimates the true effect.

Thus for exits, we estimate the impact 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. formal employment 13 months later). Thus, we avoid the mismeasurement of earnings in 2006, since we look at the probability of leaving formal employment between December 2005 and January 2007 by earnings categories of 2005. We have to extend the time horizon to 13 months because in our data, a disproportionately high fraction of exits are observed between December and January, and much of the response of the DMW regulation in the fall is realistically registered only as a job lost by the following January. This approach likely underestimates the true annual effect because we miss more responses on newer spells starting in 2006. Our approach can be consistent over the years, including placebo or control years before the reform, but we can only use one year less of these.

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 very low number of self-employed reporting earnings above the minimum wage bin. Our estimating equation is

$$Exit_{it} = \beta_0 + \sum_{t=2004}^{2011} \beta_t MW_{i,t-1} + \alpha_B + \tau_t + \varepsilon_{it}, \tag{3}$$

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 minimum wage earners and workers earnings just above the minimum wage in the likelihood of exiting formal employment by year.

In addition, we also estimate a pooled version of this regression, comparing years before and after 2007:

$$Exit_{it} = \beta_0 + \beta MW_{i,t-1} \times Post_t + \alpha_B + \tau_t + \varepsilon_{it}, \tag{4}$$

where i indexes workers, $MW_{i,t-1}$ is an indicator for being in the minimum wage bin the year

before, α_B are wage bin fixed effects (minimum wage vs. bin 2), and τ_t are year fixed effects. The coefficient of interest is β, the differential change between minimum wage earners and workers earnings just above the minimum wage in the likelihood of exiting formal employment between the pre and post period.

The event study and the pooled regression have similar appeal as before. For formal employment responses though, long-term responses are influenced by the Great Recession, which likely had disparate impacts on workers in different parts of the wage distribution and in different sectors.

Heterogeneity Analyses. Further on, to analyse heterogeneities in exit responses, we re-estimate equation (3) by splitting the sample by worker characteristics (gender, age, and skill level), firm characteristics (ownership, size, and industry), and a measure of firm quality (total factor productivity).

6 Results: Underreporting of Earnings at the Minimum Wage

In this section, we use the introduction of the double minimum wage rule at the end of 2006 to provide evidence on the underreporting of earnings at the minimum wage. We start by providing cross-sectional evidence on the distribution of earnings prior to the introduction of the double minimum wage rule (in 2005) and after the introduction of the double minimum wage rule (2007). A spike appears in the distribution at double the minimum wage in 2007. We then exploit the panel structure of our data to provide evidence on transitions between different wage levels over time and show that a substantial fraction of workers report to have doubled their earnings after earning 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 observables 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 double minimum wage rule 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 double minimum wage rule had different salience in different areas. Finally, we describe the dynamics of earnings concentration at the double minimum wage threshold.

6.1 Main Results

Cross-Sectional Evidence. Figure 1 shows the distribution of monthly earnings in 2005 and 2007 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 some excess mass at the amount of 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. 18.3% 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 double minimum wage rule, in 2007, the amount of excess mass at the minimum wage decreases for private sector employees and the self-employed, though it is still substantial in these sectors. The amount of excess 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 excess mass point appears in the distribution of earnings for private sector employees and the self-employed, but not for public sector employees. In 2007, 5.1% (up from 2.1% in 2005, a 2.5-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 double 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.

Evidence on Transitions. Making use of the panel structure of our data, Figure 2 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 1) 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 double minimum wage rule 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 10.2% of private sector employees reporting the minimum wage in 2005 report at the double minimum wage in 2007. This means that around 2% of all workers in the private sector report at the minimum wage in 2005 and at the double minimum wage 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 double minimum wage in 2007. This means that 10% of all the self-employed report at the minimum wage in 2005 and at the double minimum wage in 2007, suggesting a large fraction of prior minimum wage earners falsely reporting the lowest possible earnings and paying the corresponding taxes.

Event Study Estimates. To estimate changes in reported earnings in a formal regression, Figure 3(b) and 3(c) 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. These are based on Equation (1). 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 double minimum wage rule, the share of workers reporting earning at the double minimum wage was stable among public sector employees and private sector employees. Among private sector employees, the share of workers reporting earning at the double minimum wage increased by 3.3 percentage points relative to public sector employees in 2007. Panel (c) shows that prior to the introduction of the double minimum wage rule, the share of workers reporting double the minimum wage

was stable among public sector employees and the self-employed. Among the self-employed, the share of workers reporting this amount increased by 16 percentage points relative to public sector employees in 2007.

Table 5 shows our estimates after pooling the years prior to the reform (2003-2006) and after (2007-2010), based on Equation (2). We estimate that relative to public sector employees, the share of private sector employees reporting double the minimum wage was 2.2% higher and and the share of the self-employed reporting double the minimum wage was 11.4% higher after the introduction of the double minimum wage rule. 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.

6.2 Heterogeneous Effects

Heterogeneity by Worker Characteristics. Not every worker benefits from tax evasion equally. We examine heterogeneous responses along various characteristics of private-sector employees who remain formally employed in 2007. Figure 6(a) shows the share of minimum wage earners in 2005 who transition to the double minimum wage in 2007 by gender, age, and skill level. Men who earned at the minimum in 2005 are 3 percentage points (40%) 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. 4.2% 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 more high-skilled jobs: 14.9% 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.

Heterogeneity by Firm Characteristics. Tax evasion might not be feasible in more prominent businesses. Figure 6(b) shows the share of minimum wage earners in 2005 who transition to the double minimum wage in 2007 by ownership, firm size, and industry. It is apparent that the overall 10.3% 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 4.8 percentage point (73%) 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 1–5 have a transition rate of 13.8%, while firms of observed size 6–50 have 8.1%, and those of 51–125 have 3.5%. Among the largest firms, with observed size above 125, only around 2.8% 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 (13.0%, 11.4%, and 11.3%, respectively) than Agriculture, Mining and Manufacturing, and Accommodation and Food (7.1%, 7.2%, 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).

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 two dimensions that proxy for "firm quality": export share in revenues and total factor productivity. Figure 6(c) shows transitions by quartiles of each measure. There is a negative association between export share and transitions from the minimum wage to the double minimum wage and between total factor productivity and transitions. We interpret these findings to suggest that firms that are more connected to foreign companies and productive are less likely to underreport worker earnings.

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 4 demonstrates this phenomenon for four covariates: gender, skill level, residing in the capital (in 2003), and utilizing any outpatient care in a year. All four variables have smooth distributions among public sector employees both before and after the introduction of the double minimum wage threshold, but show a spike among private sector employees at the double minimum wage threshold after the introduction of the threshold.[7]

Geographic Concentration. We also find the transition rates from the minimum wage to its double between 2005 and 2007 by districts of Hungary closely move together for private sector employees and the self-employed. Figure 7 shows this rate to vary between 1% and 22% among private sector employees, with a wider dispersion (3-28%) for the self-employed. We also see a strong positive association in the district-specific transition rates between the two sectors. This suggests strong spatial clustering of tax evasion or in the perception of the double minimum wage

[7] Choudhary and Gupta (2019) analyze other outcomes in the context of a more conventional bunching response.

rule. 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 of prior evasion (Chetty, Friedman and Saez, 2013). It is reassuring to see that in areas where the self-employed found no reason to report earning double the minimum wage, there is no bunching for private sector employees either; this suggests that there are no confounding reasons for bunching in 2007 if people are not aware of the new rule and the vague audit threat or did not previously underreport their earnings.

Cross-Firm Concentration. An important conceptual question for understanding tax evasion around the minimum wage is whether this is primarily a firm-side or 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 double minimum wage rule measured at the level of individual workers to responses measured for other employees of the same private-sector employer. Figure 5 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 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 others respond, individual responses are less closely associated to peers', 70-80% of workers respond on average. Panel (b) shows something similar for exits (foreshadowing Section 7), 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 continue working but completely undocumented, as we discuss in Section 7.

Dynamics of Concentration at the Threshold. Our analyses above rely on the 2007 introduction of the double minimum wage threshold 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. Figure 3(a) shows the evolution of the share of workers by sector who earn at the double minimum wage threshold. Prior to the 2007 introduction of the double minimum wage threshold, the share of workers at this wage level was stable among private employees (at 2.3 %), 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 5.1 %) 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 3.8 % in 2010) and the self-employed (14.0 % in 2008, 9.8 % in 2009, and 5.5 % in 2010). Recall that after 2010, the double minimum wage audit threshold is no longer in effect. Our panel only runs to 2011 and then the share of workers at the double minimum wage is the same as prior to the 2007 introduction of the double minimum wage rule. We view the post-2007 gradual decrease in the share of workers at the audit threshold as evidence of dissipating perceptions of the audit threat.

By 2010, around 50% of those that initially moved from the minimum wage to its double move to wages that are lower than twice the minimum wage, both among private sector employees

and the self-employed. By 2011, the same ratios are around 70%. The complete dissipation of the excess mass of workers at the double minimum wage threshold after the threshold was no longer in effect is consistent with the concentration at the threshold 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 report the double minimum wage threshold by worker characteristics, firm characteristics, and measures of firm quality, respectively. They are analogous to those in Figure 6 extending the results to our entire time period. They show that in each subgroup, the share of workers earning at 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 reform is no longer in effect, the share of workers reporting double the minimum wage is the same in each subgroup as their pre-reform level. Appendix Figure A1 corresponds to Figure 6(a) and shows results by worker characteristics, including by gender in panel (a), by age group in panel (b), and by skill level in panel (c). It confirms that the reporting response is much large for men, is similar by age group, and is decreasing in skill level. Pre-reform and post-reform trends appear roughly parallel by subgroup. Appendix Figure A2 corresponds to Figure 6(b) and shows results by firm characteristics, including by ownership in panel (a), by size in panel (b), and industry in panel (c). It confirms that the reporting response is concentrated in domestic and small firms and certain industries (construction and trade show the largest response). Appendix Figure A3 corresponds to Figure 6(c) and shows results by measures of firm quality, including by export share in revenues in panel (a) and by total factor productivity in panel (b). It confirms that the reporting response is larger for firms with low export shares in the revenues and low total factor productivity.

7 Results: The Impact of the Double Minimum Wage Rule 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, in this section we examine whether the introduction of the double minimum wage rule 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 that 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 double minimum wage rule is introduced. We then turn to examining which worker and firm characteristics are associated with an increased probability of leaving formal employment.

Overall Impact on Formal Employment. Figure 8 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 the private sector employees. Prior to the introduction of the double minimum wage rule, the probability of leaving formal employment was relatively stable for each wage level among the private sector employees. When the double minimum wage rule is introduced in September 2006, the probability of leaving formal employment remains stable only among those earning the minimum wage, it decreases for the higher earners. 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 the public sector employees. Among the private sector employees, the probability of leaving formal employment increases by around 2% when the double minimum wage rule is introduced. Table 6 shows pooled estimates comparing years prior to the introduction of the double minimum wage rule (2004–2006) to years following the reform (2007–2010). The pooled estimates also show a similar picture: the probability of leaving formal employment increases by 3.6 to 4.8 percentage points among private sector employees. The results are close to zero and statistically insignificant among the public sector employees. 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 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. In Section 9 we formalize this intuition.

Heterogeneity by Worker and Firm Characteristics. Figures 9, 10 and 11 show the the evolution of the exit probability over time by gender, age, 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 heterogeneities in exit responses. The strongest finding is that exit response is more pronounced among the low-skilled.

8 Fiscal Effects of the Double Minimum Wage Rule

We provide a back-of-the-envelope calculation of how minimum wage filers' responses to presumptive taxation impacted the public budget.

Private Sector Employees. In 2005, there were 399,382 minimum wage earners in the private sector (based on data from March). Approximately 7.8% (31,100) of them earned twice the minimum wage in 2007. Had they stayed at the minimum wage, they would have earned around 2,100 million HUF in March 2007. Since in fact, they shifted up to the double minimum wage, they earned 4,162 million. The additional 2,062 million HUF of declared income meant roughly 1,383 million HUF additional tax and social security income for the government, including employer-paid taxes on the gross minimum wage. This makes up approximately 0.4% of government revenue from personal income tax (around 109 billion HUF per month) and social security contributions (around 240 billion HUF per month).

On the other hand, due to the double minimum wage rule, around 2% (7,988) of the minimum wage filers left formal employment over a 13-month horizon. Due to their exits, the net government revenue from the double minimum wage rule among private-sector employees shrinks to around 0.3% of the personal income tax and social security contributions.

Moreover, 1.5% (i.e. roughly two-third 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 double the minimum wage by March 2007. As a result of presumptive taxation, an additional 1,592 million HUF of income was declared, which meant roughly 581 million HUF additional personal income tax and social security income for the government. This makes up approximately 0.17% of the revenue of the public sector from personal income tax and social security contributions.

We do not have evidence for an effect of the double minimum wage rule on the probability of self-employed minimum wage earners leaving the formal labor market. As a consequence, the overall public net revenue from the double minimum wage rule among the self-employed is around 0.17% of the total revenue from personal income tax and social security contributions.

Note some limitations of our calculations here. We focused only on minimum wage filers and did not consider that the rule's impact on other low earners. We neglected all other types of 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 first-order effect of the double minimum wage rule was small on the public budget.

9 Theory

We now present a more formal argument why underreporting at the minimum wage (with no presumptive taxation) would justify higher taxation of those earnings than otherwise would be optimal. The model builds towards a characterization of how the optimal tax rate at the minimum wage depends on the presence of underreporting at the minimum wage. After incorporating the minimum wage in a model of monopsonistic labor markets (as in Butcher, Dickens and Manning, 2012), we turn to a simple evaluation of a tax increase while keeping net minimum wages constant, and then discuss how this evaluation would change with some underreporting of earnings. The model is related to Tonin (2013*a*), however, while Tonin (2013*a*) focuses on the impact of minimum income thresholds and audit threats on income declaration, our focus is on the impact of minimum wage on the optimal tax rate, taking wage underreporting as exogenously given. Our model is also close in spirit to Tonin (2011) — the main deviations are that in our

model, there is bunching at the minimum wage even in the absence of underreporting of earnings, which we consider crucial to go beyond a simple policy recommendation to audit all minimum wage filers. We evaluate the consequences of taxing the minimum wage when both legitimate bunching at the minimum wage and earnings underreporting are present.

Wage Setting by Monopsonists. We assume wages are set by employers with some market power, who differ in their marginal product of labor, denoted by A_i. Abstracting away from labor supply decisions, firms compete over a fixed supply of workers L. Each employer's optimal wage is

$$W_i^* = \frac{\varepsilon}{1+\varepsilon} A_i < A_i, \tag{5}$$

where ε is the (uniform) wage elasticity of labor supply to each firm.

Minimum Wage. When the government introduces a gross minimum wage W^{m0} in this environment, it will have three consequences:

1. Firms with $A_i < W^{m0}$ exit the market;
2. Firms with $W_i^* > W^{m0}$ continue to pay the same wage as before;
3. Firms with $A_i > W^{m0} > W_i^*$ will pay the minimum wage, creating a spike at the minimum wage.

Figure 12 illustrates the earnings distribution under this policy, with excess mass M_0 at earnings corresponding to the minimum wage.

Tax Increase. Assume there is an income tax with initial rate τ_0, which applies to earnings in some $\left(W^{m0}, W^{max}\right)$ neighborhood of the minimum wage. τ_0 can be negative, incorporating the possibility of policies such as the Earned Income Tax Credit (EITC). τ_0 is assumed to be the optimal tax rate if everyone reports their true earnings. The initial (gross) minimum wage of W^{m0} corresponds to the net minimum wage of $W^{m,net} = W^{m0}(1-\tau_0)$.

Imagine that the government raises the tax rate to τ_1, with $\tau_1 > \tau_0$, while keeping the net

minimum wage unchanged. The new gross minimum wage would become

$$W^{m1} = \frac{W^{m,net}}{1-\tau_1} > W^{m0}.$$

This reform would increase the gross minimum wage, without any effect on the net minimum wage. This implies that only labor demand is affected, leaving labor supply unchanged.

Figure 12 illustrates the following three implications of the proposed tax reform:

1. Firms with $A_i < W^{m1}$ exit the market;
2. Firms with $W_i^* > W^{m1}$ continue to pay the same wage as before;
3. Firms with $A_i > W^{m1} > W_i^*$ will pay the new minimum wage, creating a new spike, denoted by M_1.

Under reasonable assumptions about the elasticity of labor supply (Bargain, Orsini and Peichl, 2011; Ransom and Sims, 2010; Hirsch, Schank and Schnabel, 2010), only those firms which paid the minimum wage W^{m0} before the tax increase (i.e. inframarginal firms with employees in excess mass M_0) exit the market after. To see how mild this assumption is, consider the case with $\varepsilon = 3$ (as in Hirsch, Schank and Schnabel, 2010). Then Equation (5) gives us the markup for each firm as $W_i^* = 3/4A_i$. For firms paying more than W^{m0} to exit the labor market due to the tax increase, their productivity would need to be $A_i > 4/3W^{m0}$. At the same time, they would need to be constrained and ultimately priced out by the new gross minimum wage, $A_i < W^{m1}$, implying $W^{m1} > 4/3W^{m0}$. This is only possible if the gross minimum wage increased by more than 33%. For any increase smaller than that, only a subset of firms who paid the original gross minimum wage exits the market.

Based on these considerations, the excess mass at the new spike will be $M_1 = M_{[0,1]} + (1-\beta)M_0$, where β is the fraction of group M_0 workers who work at firms with $W^{m0} < A_i < W^{m1}$ and are thus priced out by the tax increase, and $M_{[0,1]}$ is the mass of workers at firms with $W^{m0} < W_i^* < W^{m1}$, thus bunching at the new kink even though they paid their marginal revenue product for labor before the tax hike. The value of β depends on the magnitude of the tax increase and the (here unrestricted) productivity distribution.

Due to mass βM_0 leaving the labor market, L amount of tax revenue is lost to the government (abstracting away from unemployment insurance and its fiscal externality). On the other hand, due to the higher tax rate, G extra tax revenue is gained, where:

$$L = \tau_0 W^{m0} \cdot \beta M_0 \tag{6}$$

and

$$G = \tau_1 W^{m0} \cdot (1-\beta) M_0 + \int_{W^{m0}}^{W^{max}} (\tau_1 - \tau_0) w f(w) dw, \tag{7}$$

where W^{max} is the highest gross wage to which the analyzed tax applies.

If the government's aim is to maximize tax revenue and τ_0 is the optimal tax rate without evasion, then $G \leq L$. This is the case because, by definition, if $G > L$ then τ_0 would not have been optimal.

Underreporting of Earnings. Let's turn our attention to the possibility that some workers are reported to earn less than their true wages (but for unmodeled reasons, they still prefer reporting the least possible earnings to not reporting any). This is depicted in Figure 13, with $f(w)$ denoting the true distribution of earnings paid and $g(w)$ is the observed one reported. Since the minimum wage is binding, those who underreport earnings are at W^{m0} (mass M_0^e on Figure 13). They are the ones who would like to report lower than W^{m0} wages, but cannot do so due to the binding minimum wage. Those who underreport thus increase the observed spike at the minimum wage.

We denote with α the fraction of underreporting workers whose productivity is at or above W^{m1} (with $0 \leq \alpha \leq 1$). This implies that as a consequence of the tax increase, the reported gross wage of αM_0^e of those who underreport shifts up to W^{m1}. Thus, there is a new extra $M_1^e = \alpha M_0^e$ mass of workers at gross wage W^{m1}. A mass of $(1-\alpha)M_0^e$ those who underreport have to exit the market due to the tax increase.

Due to underreporting, the government realises an additional net gain (NG) as a result of the

tax increase:

$$NG = M_1^e \cdot \tau_1 W^{m1} - M_0^e \cdot \tau_0 W^{m0} =$$
$$= M_0^e \cdot (\alpha \tau_1 W^{m1} - \tau_0 W^{m0}).$$

This is positive if:

$$\frac{W^{m1}}{W^{m0}} = \frac{1-\tau_0}{1-\tau_1} > \frac{\tau_0}{\alpha \tau_1}.$$

This inequality is more likely to hold the closer is α to one. If $\alpha = 1$ (no cheaters exit the market) then the inequality always holds, thus the additional net gain due to the tax increase is always positive.

Implications. This model implies that the optimal tax rate is higher in the presence of underreporting. As a consequence, a positive tax on the minimum wage can be optimal if the recovered tax revenue from evaders outweighs the losses from those priced out of the labor market. A corresponding increase in the gross minimum wage increase can also be optimal in such a case — this ensures that cheaters report higher earnings and pay more income tax.

10 Conclusion

This paper demonstrates that even in a middle-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 twice the minimum wage, we document significant shifts in the earnings distribution consistent with previous underreporting. We show that 10.2% of private 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

on several dimensions, such as export share or total factor productivity. 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.

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, in some sense making some employment more formal and extracting more taxes from it. On the other hand, an unintended consequence of such policies may be the loss of formal employment, decreasing tax revenue.

We believe that our findings are pertinent for tax and minimum wage policy and the taxation of potentially informal work in particular. Policymakers should be cognizant of misreporting and the corresponding potential to boost tax revenues at the cost of some informality 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.

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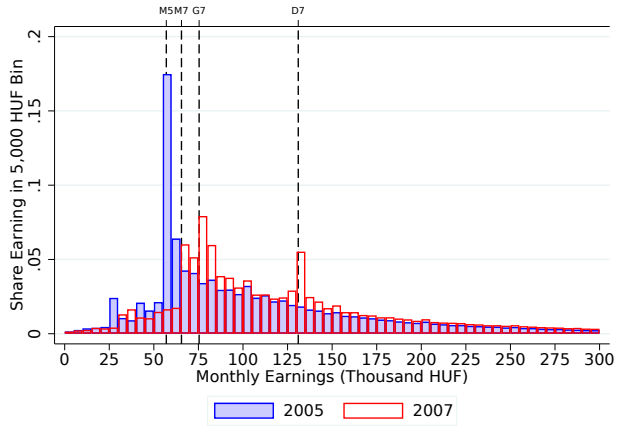
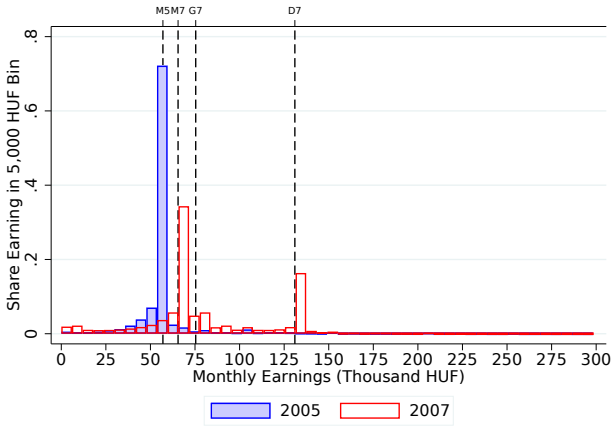
Figure 1: Distribution of Earnings by Sector in 2005 and 2007

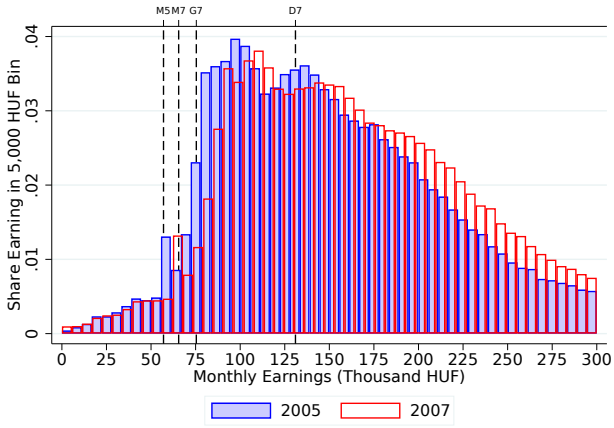
(a) Private Sector Employees



(b) Self-Employed



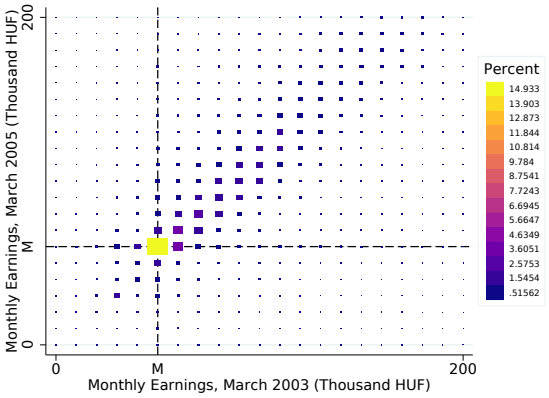
(c) Public Sector Employees



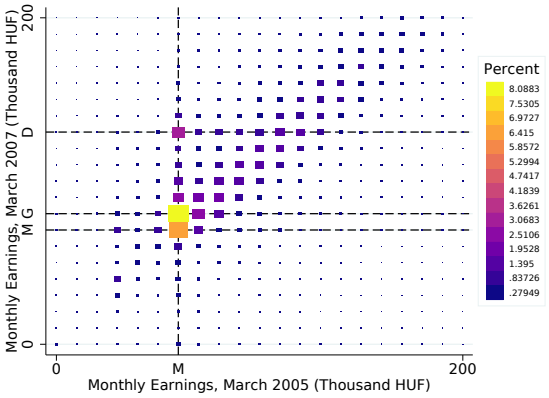
Note: Figure shows the distribution of earnings in March 2005 and March 2007 by sector in 5,000 HUF (≈$17) bins. Panel (a) shows private sector employees, panel (b) shows the self-employed, and panel (c) shows public sector employees. The vertical lines show the 2005 and 2007 levels of the minimum wage (M5 and M7, respectively), the 2007 level of the guaranteed wage minimum (G7), and the 2007 level of the double minimum wage (D7). For more details, see Section 5.

Figure 2: 2-Year Earnings Dynamics by Sector

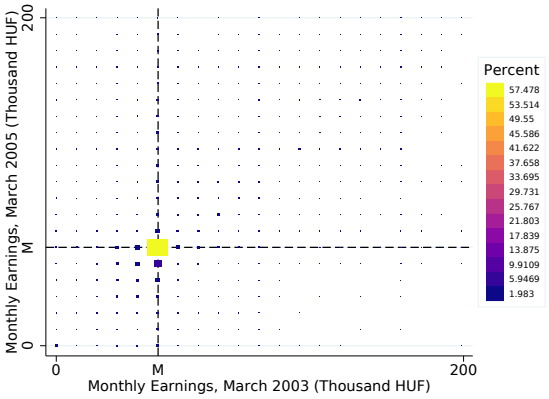
(a) Private Sector Employees, 2003 to 2005



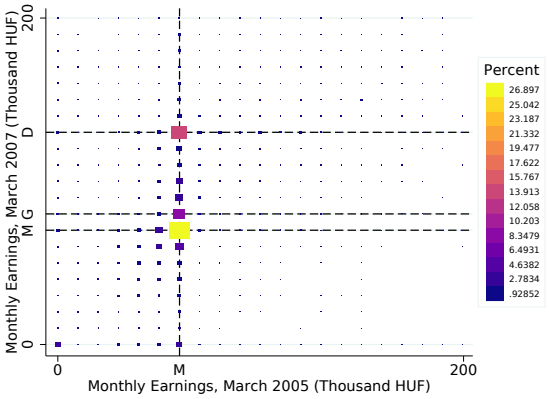
(b) Private Sector Employees, 2005 to 2007



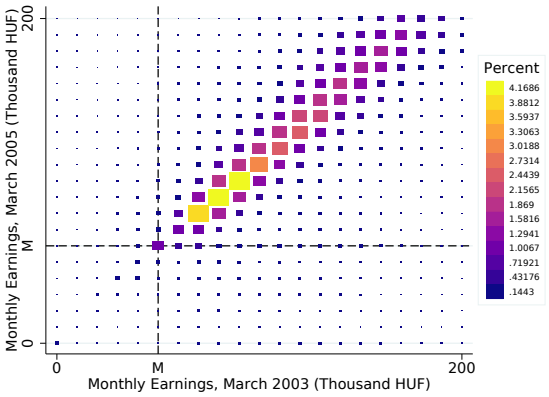
(c) Self-Employed, 2003 to 2005



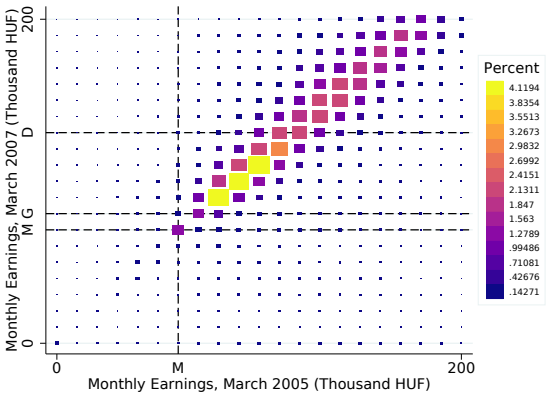
(d) Self-Employed, 2005 to 2007



(e) Public Sector Employees, 2003 to 2005



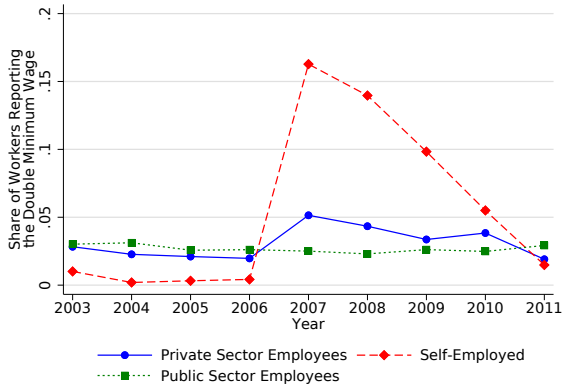
(f) Public Sector Employees, 2005 to 2007



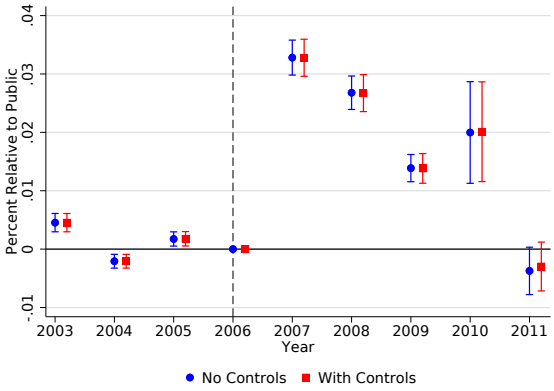
Note: Figure shows 2-year transition probabilities of earnings between March 2003 and March 2005 and between March 2005 and March 2007 by sector. For each pair (w_1, w_2) of year t and year $t+2$ earnings, we show what percentage of all workers in the sector who earned w_1 in year t and w_2 in year $t+2$. 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 minimum wage (G), and the year-specific level of the double minimum wage (D). For more details, see Section 5.

Figure 3: Share of Workers Reporting Earnings at the Double Minimum Wage Over Time

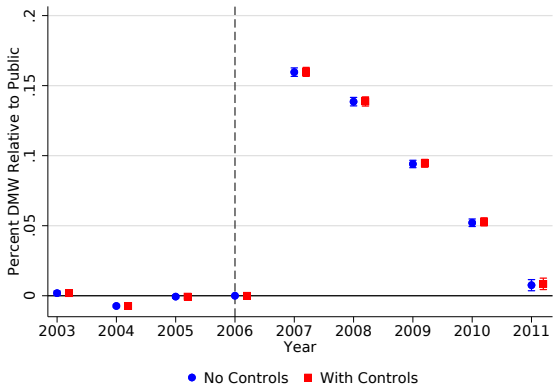
(a) Raw Trends



(b) Regression Estimates: Private Sector Employees

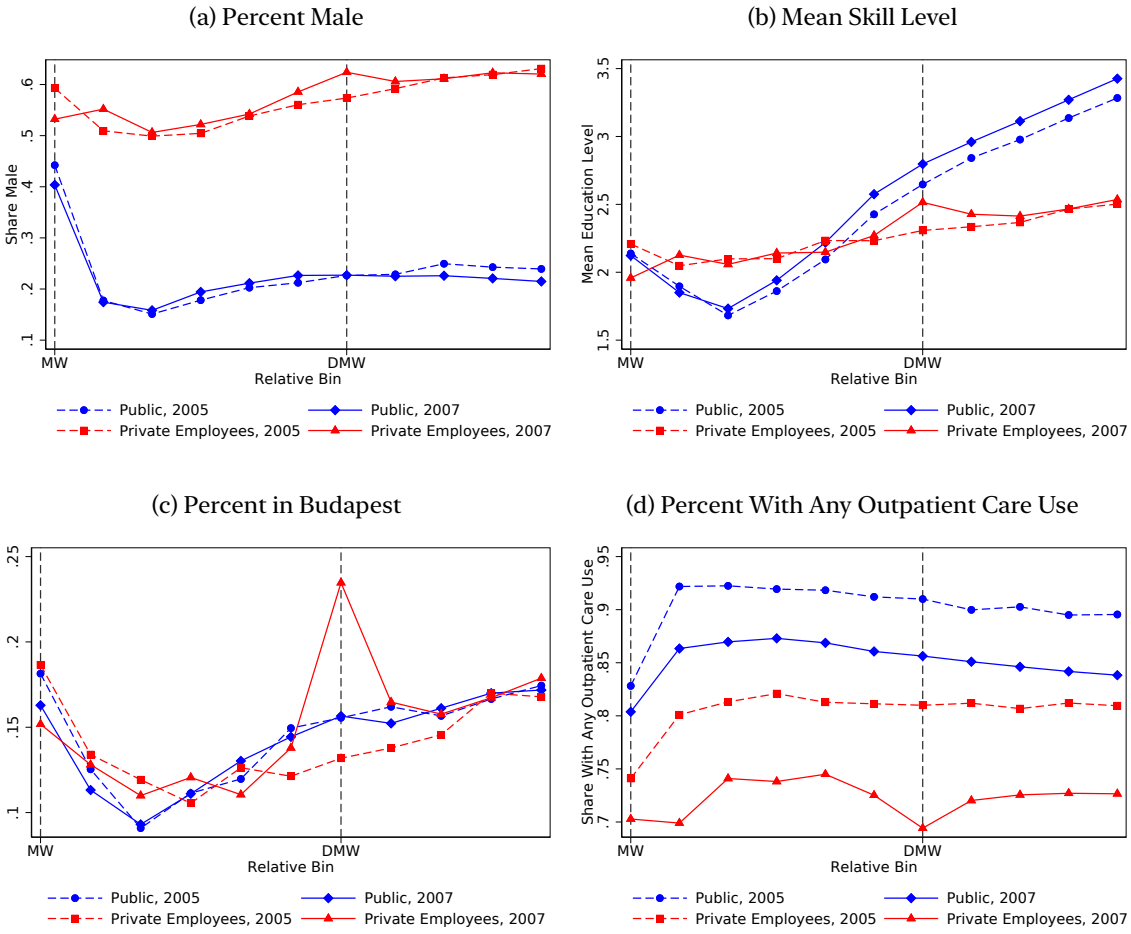


(c) Regression Estimates: Self-Employed



Note: 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 (1). Panel (c) shows shows event study regression estimates comparing the self-employed to public sector employees, based on Equation (1). 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.

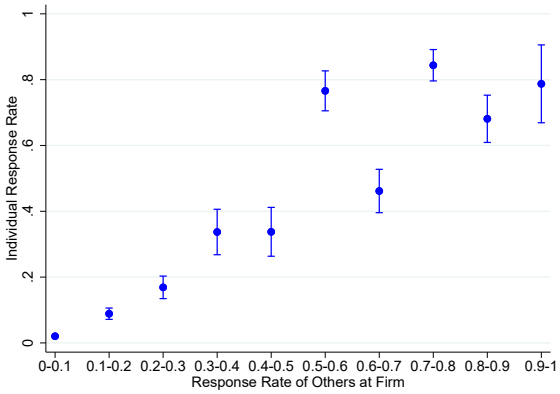
Figure 4: Distribution of Observable Characteristics Over the Wage Distribution



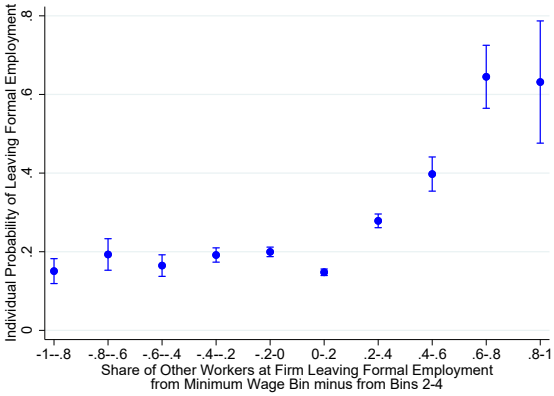
Note: Figure shows the distribution of four observable variables over the wage distribution for public sector employees (blue lines) and private sector employees (red lines) in 2005 (dashed lines) and in 2007 (solid lines). For each relative wage bin, panel (a) shows the percent of workers who are male, 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 5: Response of Workers and Other Workers at the Same Firm

(a) Share of Minimum 2005 Minimum Wage Earners Moving to Double Minimum Wage in 2007



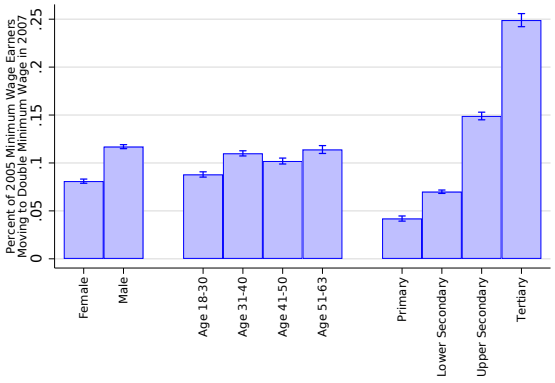
(b) Share of Minimum 2005 Minimum Wage Earners Leaving Formal Employment in 2007



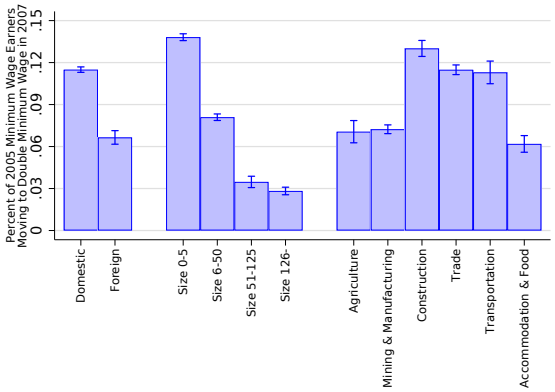
Note: Figure relates individual workers' response to the response of other workers in the same firm. Panel (a) shows the share of private sector employees who report earnings at the minimum wage in March 2005 and report earnings at the double minimum wage in March 2007 by the share of other employees in the same firm who report earnings at the minimum wage in March 2005 and report earnings at the double minimum wage in March 2007. 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 report earning the minimum wage in March 2005 and leave formal employment by March 2007 and the share of other employees in the same firm who report earning in one of the relative wage bins above the minimum wage and leave formal employment by March 2007. Figure is limited to firms with at least 10 workers reporting earning the minimum wage. For more details, see Section 6.3.

Figure 6: Heterogeneity in Reporting Response

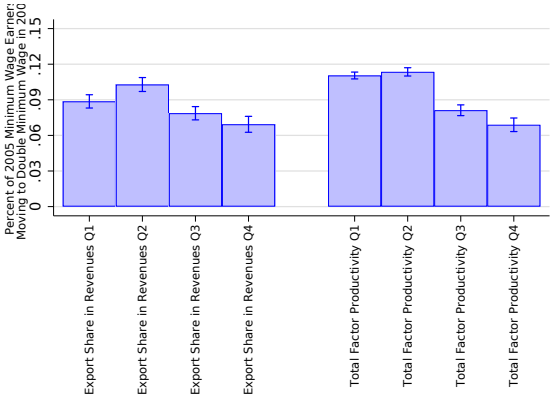
(a) By Worker Characteristics



(b) By Firm Characteristics

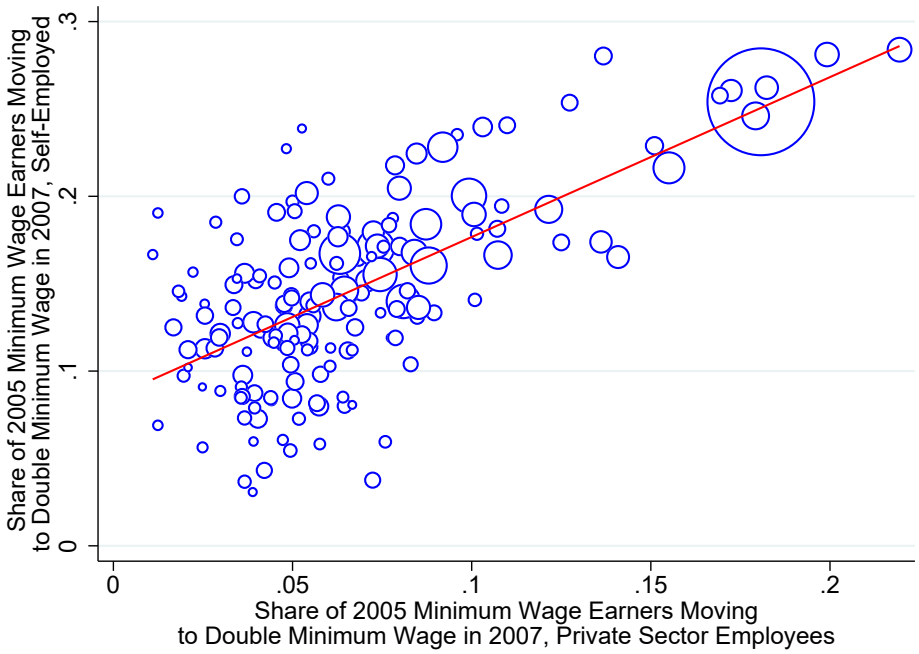


(c) By Firm Quality



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

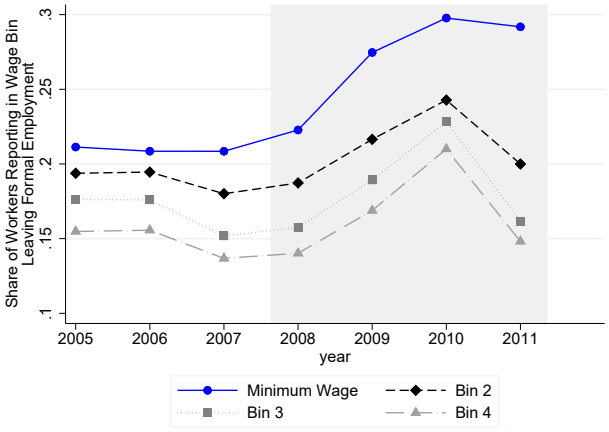
Figure 7: Reporting Response by Districts and Sector



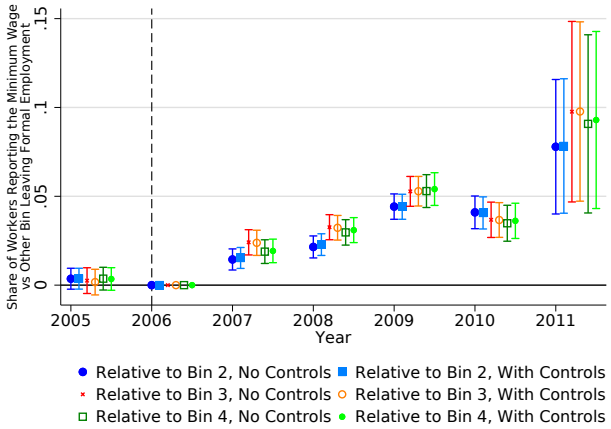
Note: Figure shows the share of private sector employees (x-axis) and self-employed (y-axis) who report earnings at the minimum wage in March 2005 and report earnings at the double minimum wage in March 2007 by districts. The size of the circles reflect the relative population size of a district. The red line is the linear fitted line (slope = 0.92).

Figure 8: Share of Workers Who Leave Formal Employment by Sector, Wage Bin, and Year

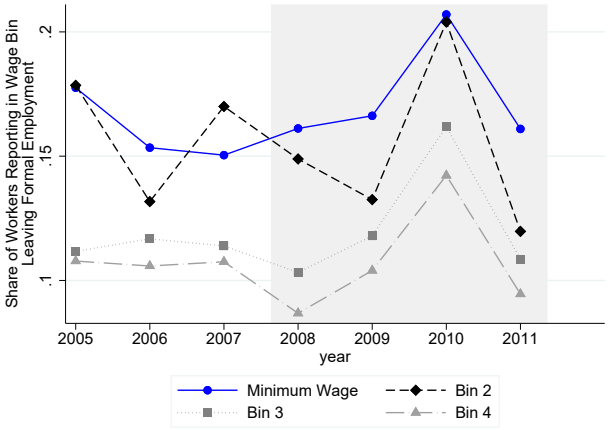
(a) Raw Trends: Private Sector Employees



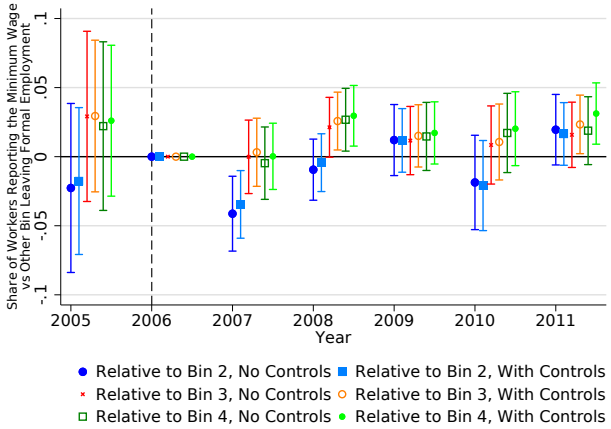
(b) Regression Estimates: Private Sector Employees



(c) Raw Trends: Public Sector Employees

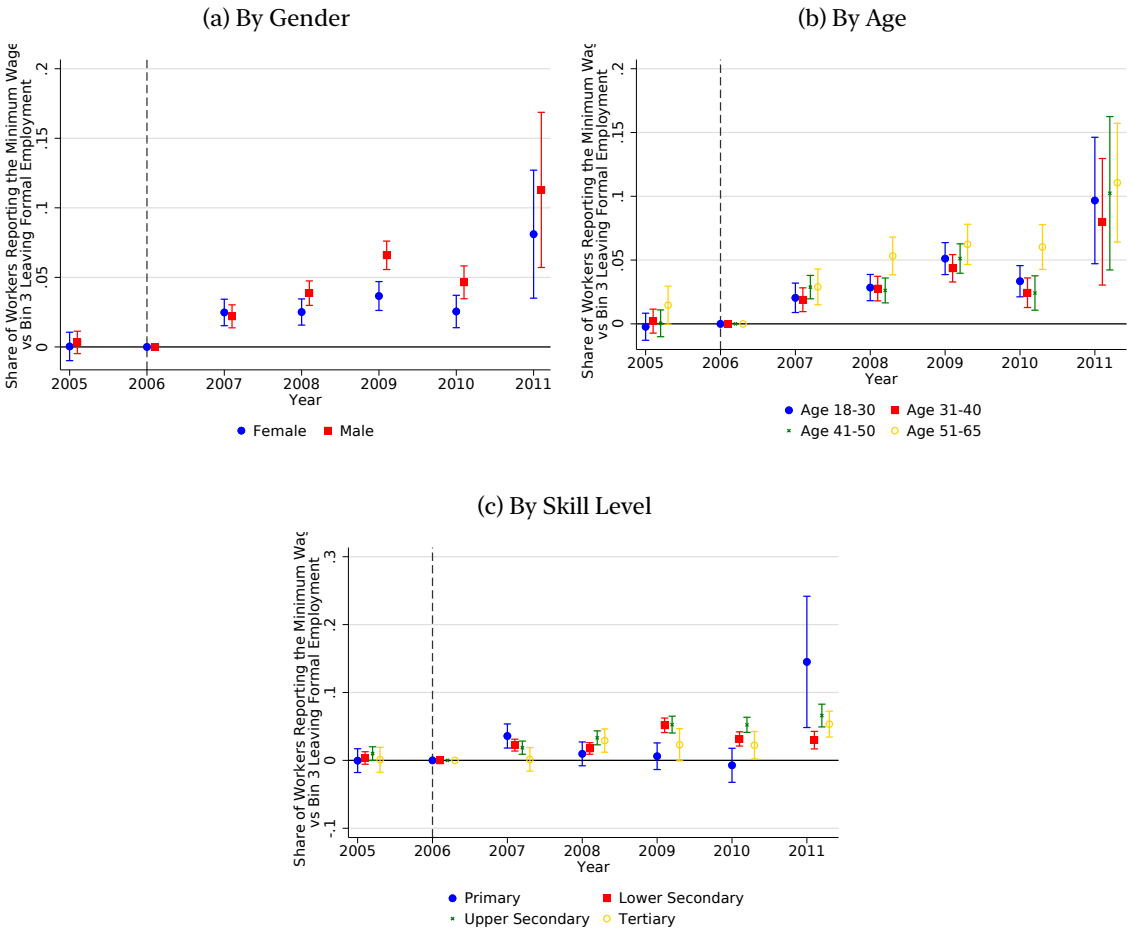


(d) Regression Estimates: Public Sector Employees



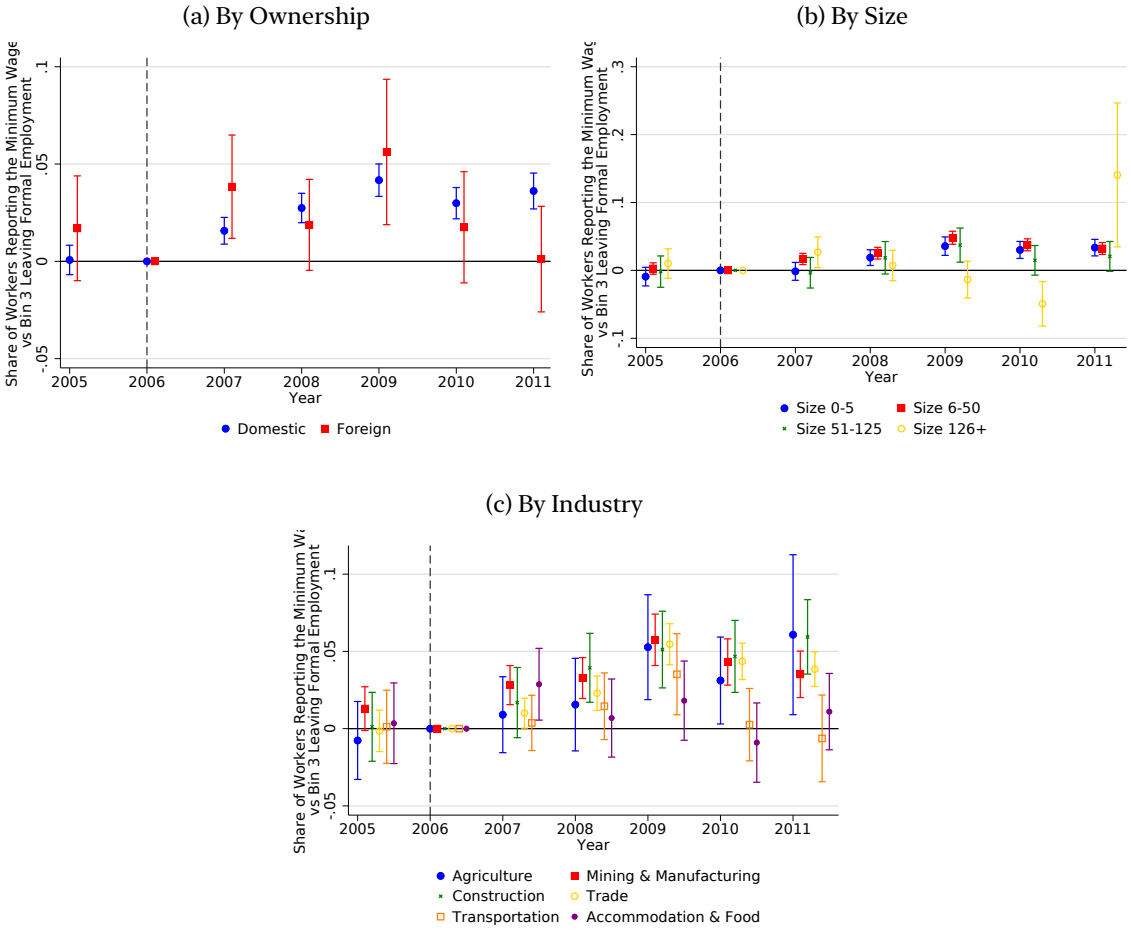
Note: Figure shows the share of workers who leave formal employment by January, by sector and wage bin (in December of two years prior) over time. Panels (a) and (b) show private sector employees, panels (c) and (d) show public sector employees. Panels (a) and (c) show raw trends for those who report 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 (3). 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 9: Heterogeneity by Worker Characteristics in Probability of Leaving Formal Employment Over Time



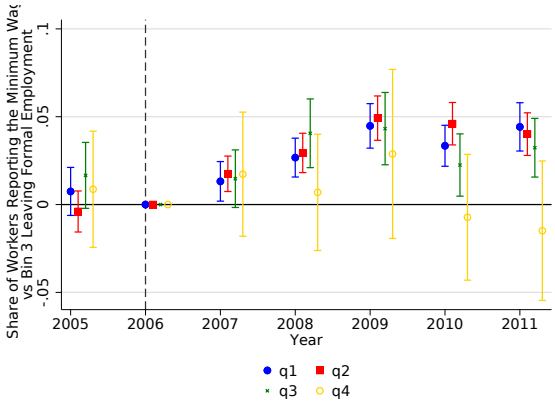
Note: Figure shows the share of private sector employees who leave formal employment over time by worker characteristics, comparing those who reported earning the minimum wage and those who reported earning in relative wage bin 3 in the previous year in event study regression estimates, based on Equation (3). 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.

Figure 10: Heterogeneity by Firm Characteristics in Probability of Leaving Formal Employment Over Time



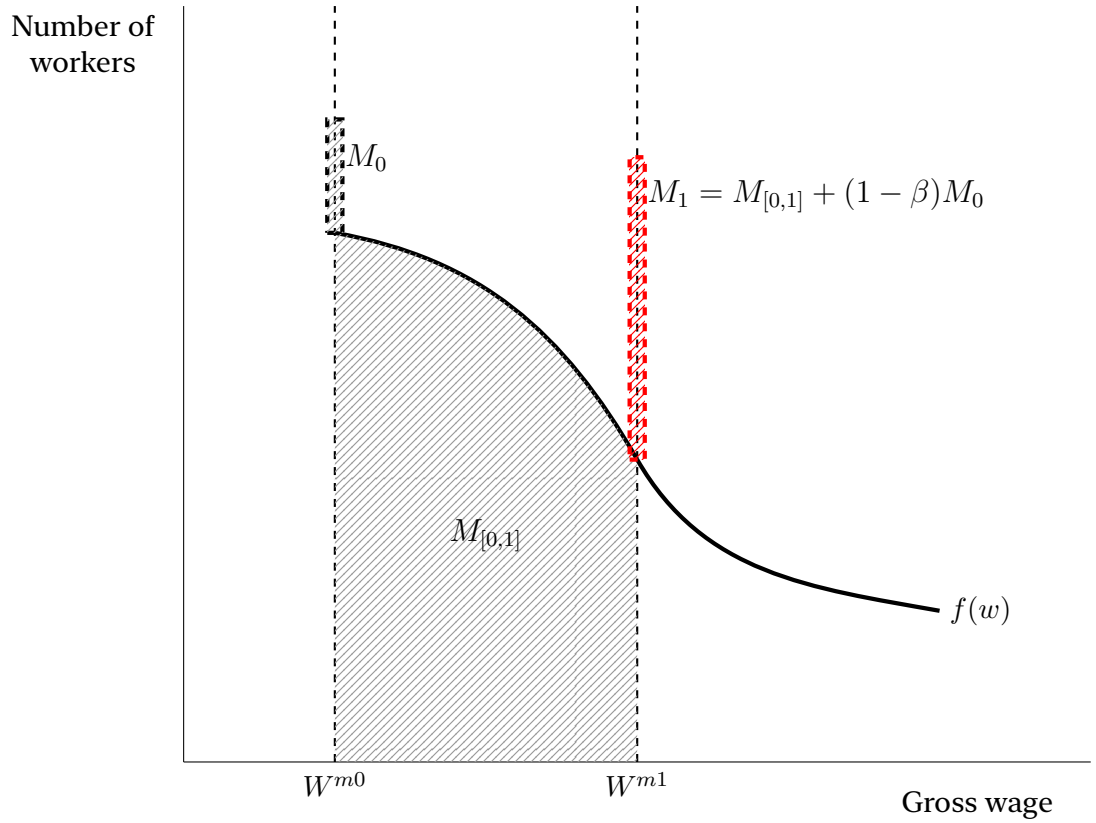
Note: Figure shows the share of private sector employees who leave formal employment over time by firm characteristics, comparing those who reported earning the minimum wage and those who reported earning in relative wage bin 3 in the previous year in event study regression estimates, based on Equation (3). 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.

Figure 11: Heterogeneity by Firm Total Factor Productivity in Probability of Leaving Formal Employment Over Time



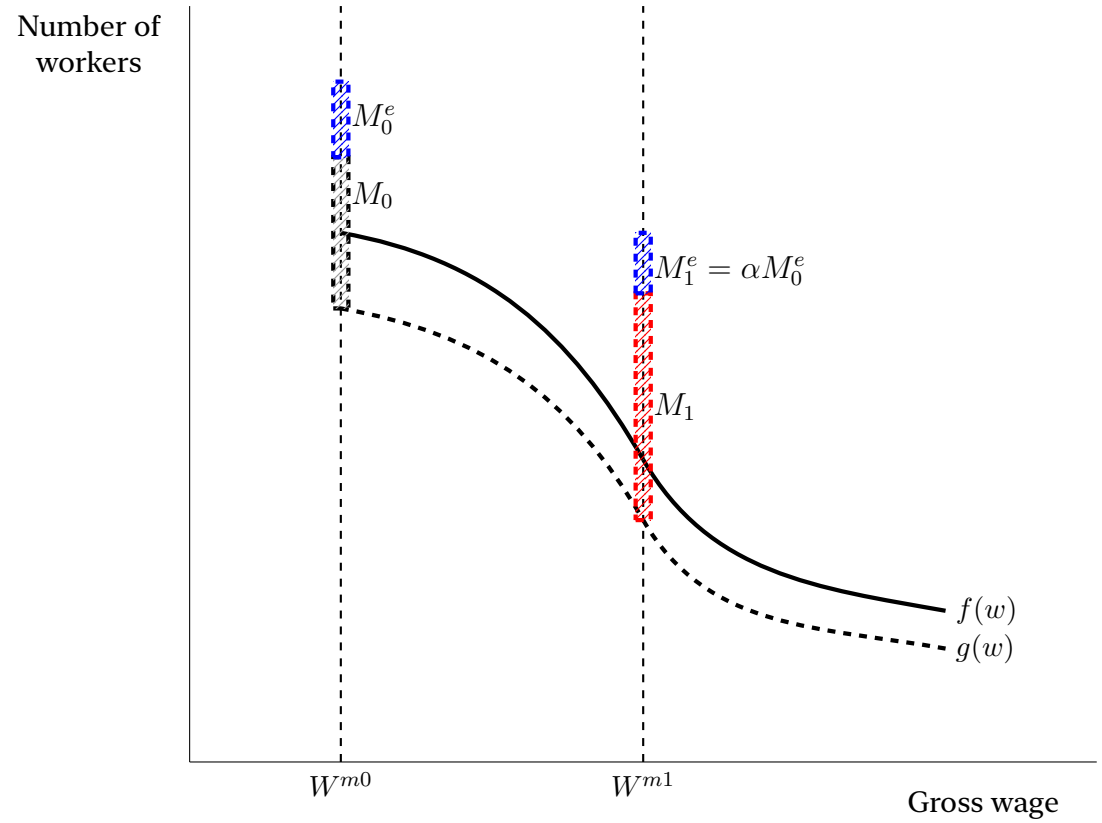
Note: Figure shows the share of private sector employees who leave formal employment over time by total factor productivity, comparing those who reported earning the minimum wage and those who reported earning in relative wage bin 3 in the previous year in event study regression estimates, based on Equation (3). 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.

Figure 12: Conceptual Framework With No Underreporting



Note: Figure shows the wage distribution in our model with no underreporting of earnings. $W^{m0} stands$ for the original gross minimum wage. W^{m1} stands for the increased gross minimum wage. M_0 is the excess mass at the original gross minimum wage caused by some firms having lower labor productivity than the minimum wage. M_1 is the excess mass after the increase in the gross minimum wage.

Figure 13: Conceptual Framework With Underreporting



Note: Figure shows the wage distribution in our model when there is underreporting of earnings. $f(w)$ is the true wage distribution and $g(w)$ is the observed wage distribution. $W^{m0} stands$ for the original gross minimum wage. W^{m1} stands for the increased gross minimum wage. M_0 is the excess mass at the original gross minimum wage caused by some firms having lower labor productivity than the minimum wage. M_1 is the excess mass after the increase in the gross minimum wage. M_0^e is the additional excess mass at the original gross minimum wage caused by some firms underreporting their earnings. $M_1^e = \alpha M_0^e$ is the share of this excess mass that stays formally employed after the gross minimum wage is increased and reports earnings at the new gross minimum wage.

Table 1: 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: 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.

Table 2: 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: Table shows tax and social security contribution rates by year.

Table 3: Summary Statistics of Individual Characteristics

	Private Sector Employees		Self-employed		Public Sector Employees	
	Mean	Std. Dev.	Mean	Std. Dev.	Mean	Std. Dev.
Age	38.89	10.78	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)	155,165	297,603	72,932	786,264	191,774	172,654
Skill Level						
Primary	0.14				0.14	
Lower Secondary	0.48				0.12	
Upper Secondary	0.27				0.33	
Tertiary	0.11				0.41	
Person-Year Observations	10,221,529		960,638		2,496,331	
Unique Individuals	2,119,527		273,879		506,534	

Note: 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 4: Summary Statistics of Firm Indicators

	Weighted by Firm Size			Unweighted		
	Mean	Std. Dev.	Median	Mean	Std. Dev.	Median
Observed Firm Size	1,417	4,471	43	8.04	155.77	2
Foreign Ownership	0.29	0.45	0	0.07	0.26	0
Export Share of Revenue	0.3	0.38	0.05	0.13	0.27	0
Total Factor Productivity	0.86	1.04	0.86	0.03	0.90	0.10

Note: Table collects summary statistics on firms in the pooled sample of years 2003–2011. There are 401,162 firms in that sample.

Table 5: Share of Workers Reporting Earning at the Double Minimum Wage Before and After the Reform

	(1)	(2)
Post × Private Sector Employee	0.022***	0.022***
	[0.002]	[0.002]
Post × Self-Employed	0.114***	0.115***
	[0.001]	[0.001]
Controls		×
N	12,333,359	12,276,191

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

Note: Table shows difference-in-differences regression estimates of the change between the period before the introduction of the double minimum wage rule (2004-2006) and the period after the introduction of the double minimum wage rule (2007-2010) in the probability of reporting at the double minimum wage for private sector employees and the self-employed vs public sector employees, based on Equation (2). 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 6: Share of Workers Who Leave Formal Employment Before and After the Reform

(a) Private Sector Employees

Reference bin:	(1) Bin 2	(2) Bin 2	(3) Bin 3	(4) Bin 3	(5) Bin 4	(6) Bin 4
Post × Minimum Wage	0.036***	0.036***	0.048***	0.048***	0.043***	0.044***
	[0.004]	[0.004]	[0.007]	[0.006]	[0.006]	[0.006]
Controls		×		×		×
N	1,951,472	1,938,761	1,908,523	1,896,472	1,777,545	1,766,099

(b) Public Sector Employees

Reference bin:	(1) Bin 2	(2) Bin 2	(3) Bin 3	(4) Bin 3	(5) Bin 4	(6) Bin 4
Post × Minimum Wage	0.005	0.004	-0.001	0.004	0.006	0.010
	[0.016]	[0.014]	[0.014]	[0.012]	[0.014]	[0.013]
Controls		×		×		×
N	85,102	84,741	156,028	155,521	172,715	172,245

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

Note: Table shows difference-in-differences regression estimates of the change between the period before the introduction of the double minimum wage rule (2004-2006) and the period after the introduction of the double minimum wage rule (2007-2010) in the probability of leaving formal employment 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 (4). 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 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 very 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.

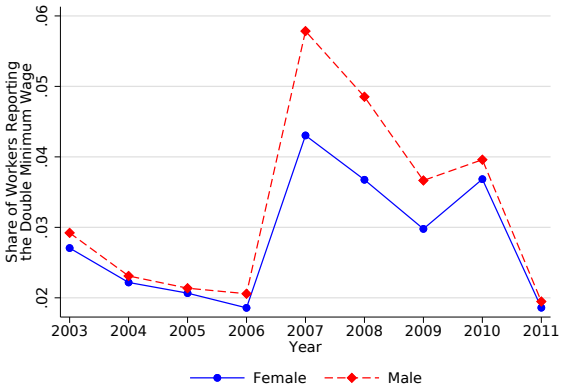
Based on later annual reports, the total number of audits decreased gradually between 2003 and 2007 (from 376 thousand in 2004 to 236 thousand in 2007). Then, there was a marked increase in the number of audits in 2008 (up to 317 thousand), with a decrease afterwards (down to 266 thousand in 2010). (Tax 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 taxed owed was in the value added tax during the analysed period.

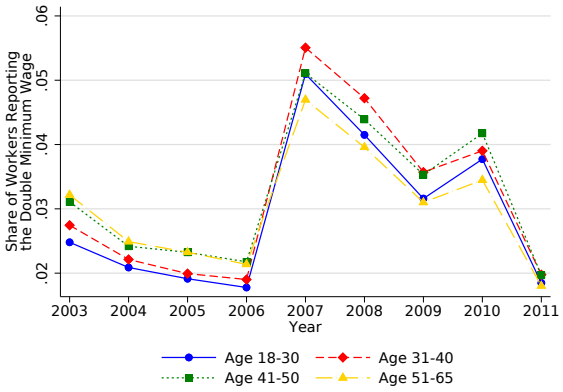
B Appendix Figures

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

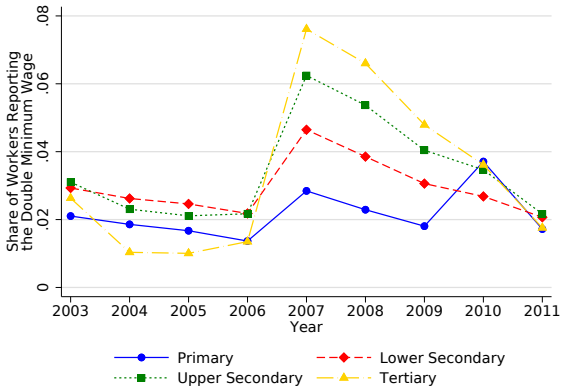
(a) By Gender



(b) By Age



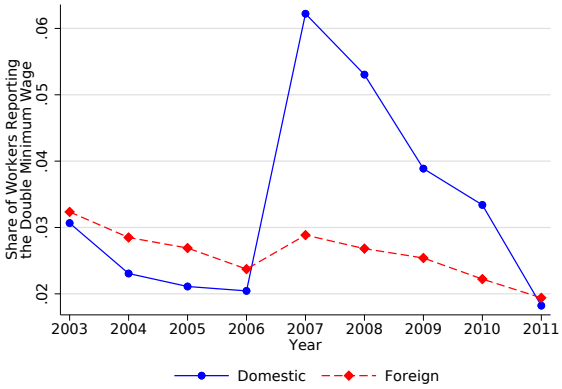
(c) By Skill Level



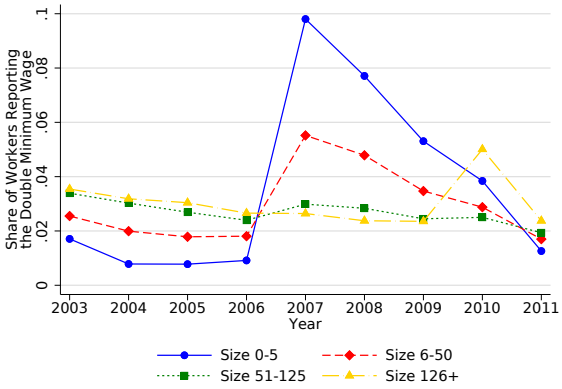
Note: Figure shows the share of private sector employees who report earning the double minimum wage over time by gender, age group, and skill level. Panel (a) shows the share of private sector employees who report earning the double minimum wage for each year by gender (female in blue and male in red). Panel (b) shows the share of private sector employees who report earning the double 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 the double minimum wage for each year by 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 the Double Minimum Wage Over Time by Firm Characteristics

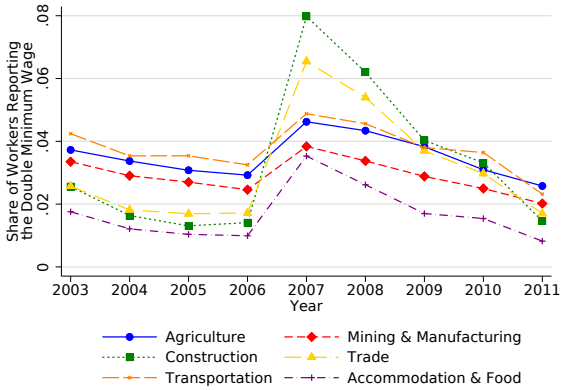
(a) By Ownership



(b) By Size

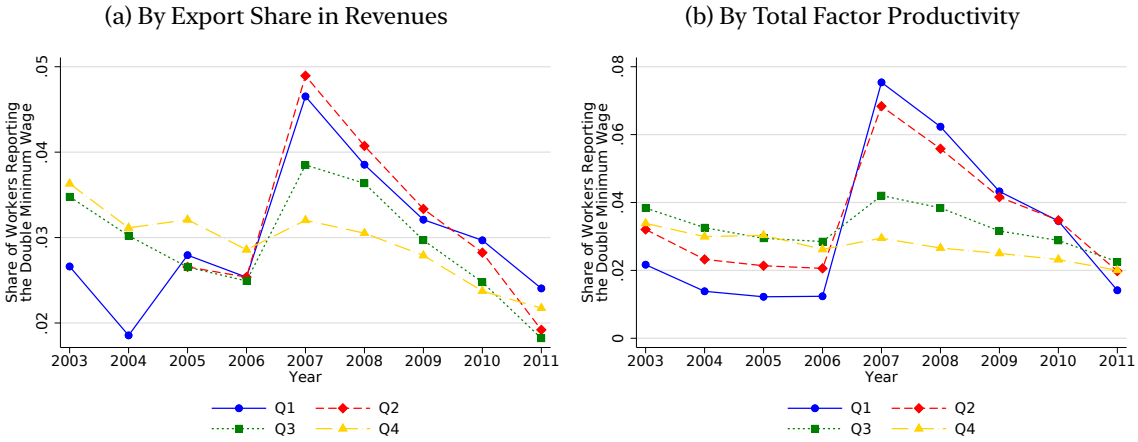


(c) By Industry



Note: Figure shows the share of private sector employees who report earning the double minimum wage over time by ownership, observed size, and industry. Panel (a) shows the share of private sector employees who report earning the double 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 the double 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 the double 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 the Double Minimum Wage Over Time by Firm Quality



Note: Figure shows the share of workers who report earning double the minimum wage over time by export share in revenues and total factor productivity. Panel (a) shows the share of private sector employees who report earning the double minimum wage for each year by export share in revenues. Panel (b) shows the share of private sector employees who report earning the double minimum wage for each year by total factor productivity. In each panel, 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. For more details, see Section 5.