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Underreporting of Earnings and the Minimum Wage Spike*

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Abstract

This paper documents a positive correlation within European labour markets between the proportion of full-time employees with earnings on the minimum wage and the extent of underreporting of earnings in the economy. Using a simple model of a competitive labour market, I show how this correlation can emerge as a result of the common dependence of both quantities on the strength of enforcement of fiscal regulation. This suggests that a high spike in the wage distribution at the minimum wage level is, in some contexts, a fiscal issue, more than a labour market issue and this should be taken into consideration when comparing labour market policies or outcomes across countries.

Keywords: Minimum Wage; Spike; Underreporting; Lighthouse effect.
JEL: J38, H26

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1 Introduction

In 2006 the minimum wage was 30% of the average wage in Romania and 38% in the UK. In the same year, more than 8% of Romanian full-time employees earned the minimum wage, while the figure for the UK was a much lower 1.8%.[1] Why such a big difference? Does this imply that the shape of the productivity distribution in the two countries is very different? Or that other institutions, like unemployment benefits, compress the wage distribution much more in the UK than in Romania? What this paper suggests is that the difference in the size of the spike at the minimum wage level between Romania and the UK is actually related to the different incidence of so called "envelope wages", i.e. cash payments unreported to tax or social security authorities. Indeed, in the same period, 23% of Romanian employees admitted having been paid "cash-in-hand" by their employer, while the figure for the UK was just 1%.

Underreporting of earnings is a serious issue in many countries[2]. In 2007 the European Commission conducted a survey on undeclared work using a representative sample of individuals in the European Union (European Commission, 2007). In that survey, 5% of all dependent employees admitted having received all or part of their salary as envelope or cash-in-hand wages within the past 12 months. There is a considerable heterogeneity within the EU, with underreporting of earnings being particularly relevant in Central and Eastern Europe. Romania is the country with the highest incidence of envelope wages, with 23% of employees having received them in the last year. Latvia, Bulgaria, Poland, and Lithuania follow, all with a double digit share, while Estonia and Hungary position themselves just below, with cash-in-hand paid to 8% of employees. On the other hand, the phenomenon is virtually non existent in Germany, France, Luxembourg, Malta and the United Kingdom, with a marginal share of 1% of dependent employees receiving envelope wages. The phenomenon is of course present also outside the EU. For instance, in Ukraine a survey involving 600 households found that 30% of formal employees interviewed received part of their wage cash-in-hand (Williams, 2007), while in Russia, 8% of employees reported that they received part of their income "under the table" (Petrova, 2005). Also regarding Russia, Gorodnichenko, Martinez-Vazquez, and Sabirianova Peter (2009) study the impact of the flat tax reform of 2001 on tax evasion and find a large response by households. They motivate their methodology based on the consumption-income gap by the fact that for Russia "tax evasion was widespread, with employees quite likely practising as much tax evasion as the self-employed." In Turkey, firms belonging to the formal sector are estimated to underreport 28% of their wage bill (World Bank, 2006), and

[1] All data are from Eurostat. Details are provided in the next section.

[2] See Andreoni et al. (1998) or Slemrod and Yitzhaki (2002) for surveys on tax evasion and Schneider and Enste (2000) for a survey on the shadow economy.

in Argentina, "roughly 15 percent of workers receive pay partly on the books and partly off the books" (World Bank, 2007). In its Eastern Europe and Central Asia Enterprise Survey in 2005, the World Bank asked firms to estimate what percentage of the actual wage bill the typical firm in their area of business reports for tax purposes. Private firms estimated underreporting to be above 15% in Albania, Azerbaijan, Georgia, Kyrgyzstan, Macedonia, Russia, and Turkey. More directly linked to the minimum wage, a World Bank study on labour markets in Eastern Europe and the Former Soviet Union (World Bank, 2005) notices how in several countries in the region "disproportionately high shares of workers cluster on declared wages at or just above the minimum wage (with evidence of additional undeclared incomes above the minimum)" and a report to the European Commission (European Commission, 2004) underlines how "[c]haracterising the forms of informal economy in the CEE countries, special attention should be paid to the wide-spread practice of "envelope wages", where only the minimum wage is officially declared and an additional part is paid as cash in an envelope."

In this paper, I first present a novel empirical observation: controlling for the minimum wage level, there is a positive correlation within European labour markets between the proportion of full-time employees with earnings on the minimum wage and various measures of informality, like the percentage of employees receiving envelope wages. I propose a rationale for this positive correlation on the basis of a labour market model with underreporting of earnings, where a spike at the minimum wage level emerges as a result of the optimal reporting behaviour by firms and workers. In particular, I show that for a given level of the minimum wage, a looser enforcement of fiscal regulation is associated with a bigger spike and, quite naturally, with higher underreporting of earnings. Thus, the prediction is of a positive correlation between the spike at the minimum wage level and the extent of underreporting in the economy.

The literature on minimum wage and informality has focused mostly on Latin America. The main issue in Latin America is the existence of a large informal sector where employees generally lack basic social or legal protections or employment benefits and the minimum wage legislation is not implemented. The literature usually looks at the impact of the minimum wage on the informal sector. For instance, Maloney and Nunez (2004) find that the minimum wage has an influence in the informal sector wage distribution in virtually all the countries they examine and, in some countries (Brazil, Mexico, Argentina, and Uruguay), the influence of the minimum wage seems far stronger on the informal sector than the formal. More recently, Lemos (2009) uses Brazilian data and finds a wage compression effect for both the formal and informal sectors, but no evidence of employment effects in either sector. However, Bosch and Manacorda (2010) find no significant effect of the

minimum wage on informal workers' earnings in Mexico. To identify evasion costs associated with non-wage compensation and minimum wages, McIntyre (2009) develops and estimates on Brazilian data a model where workers can choose between legal or illegal employment, where legality is defined as abiding by the minimum wage and participating in a set of payroll taxes and mandated non-wage benefits. He shows how enforcement of a minimum wage law creates a clump of illegal workers at the minimum wage. The view of informality that I use here, and that better fits the European experience, is instead one where there is also an "intensive margin" to the compliance decision, where firms and workers operating in the formal economy may decide to partially underreport earnings to avoid paying taxes and social security contributions.

The rest of the paper is organized as follows. Next section makes some empirical observations regarding European labour markets, while section 3 presents the model. The last section concludes.

2 Some Empirical Observations

In 2007 the European Commission conducted a survey about undeclared work (European Commission, 2007). The survey interviewed almost 27,000 individuals from the 27 member states and asked specific questions about cash-in-hand payments by employers. For instance, the following question was asked to dependent employees:

"Sometimes employers prefer to pay all or part of the regular salary or the remuneration for extra work or overtime hours cash-in-hand and without declaring it to tax or social security authorities. Did your employer pay you all or part of your income in the last 12 months in this way?"

In case of a positive answer, the survey asked whether the cash-in-hand payment was part of the remuneration for regular work or for overtime hours or both[3], and which percentage share of gross yearly income in the main job was received cash-in-hand[4]. In what follows, I use these questions to build different measures of underreporting of earnings by employees in EU countries.

This survey is unique in measuring undeclared work, and in particular envelope wages, on an EU wide basis and in a cross-nationally comparable way, even if the limitations of measuring sensitive issues like undeclared work through a direct survey should be acknowledged. Getting cross-country data on the size of the spike at the minimum wage level is also challenging. Until the end of 2008, Eurostat has asked member countries to report the proportion of full-time employees with earnings

[3] "Was this income part of the remuneration for your regular work, was it payment for overtime hours or was it both?"

[4] "Approximately which percentage share of your gross yearly income in your main job did you get this way?"

on the minimum wage and this measure will be used to measure the size of the spike at the minimum wage level. Also these data on the spike are unique, even if it should be noticed how they were not fully harmonized between the countries (Eurostat, personal communication). Given that the survey on undeclared work took place in May-June 2007 and that the question on underreporting of earnings referred to the last 12 months, I will use spike data for 2006. I will also use Eurostat data on the minimum monthly wage as a proportion of average monthly earnings in industry and services and I will refer to this measure as the Kaitz index.

Among the 27 countries that are members of the European Union, seven (the three Nordic countries, plus Austria, Cyprus, Germany, and Italy) do not have anything resembling a national minimum wage (see Eurostat, 2007a, for the methodology used to calculate the minimum wage), while Eurostat does not report the proportion of full-time employees with earnings on the minimum wage for Belgium and Greece (Eurostat, 2007b). Therefore, the analysis is conducted on the remaining 18 countries. This is clearly a small sample size and the results should be interpreted accordingly. However, despite their limitations, these are, to the best of my knowledge, the best available data to assess the relationship between the spike at the minimum wage and underreporting of earnings.

Table 1 reports some summary statistics for the main variables of interest. In table 2, I present some simple regression results, considering only informality and the Kaitz index (top half) or adding, as a control variable, GDP per capita expressed in Purchasing Power Standard (bottom half)[5]. Starting with the top half of table 2, it emerges how, when considered in isolation, both the informal economy as proxied by the percentage of employees being paid cash-in-hand and the ratio of the minimum to average wage have an insignificant relationship with the size of the spike (columns 1 and 2). The Kaitz index and the spike in the wage distribution corresponding to the minimum wage are the two measures most commonly used to assess how binding the minimum wage is and one would expect to see a positive correlation between the two, even if they do not necessarily always move together (see Dolado et al., 1998, for a formal argument). However, this does not appear to be the case in the European context, unless one controls for informality. Indeed, when informality and the Kaitz index are considered together, the coefficients are statistically significant (column 3).[6] Eyeballing the graphs plotting the size of the spike against the size of the informal economy (left-hand side of figure 1) and the size of the spike against the Kaitz index (right-hand side) gives indeed the impression of a positive correlation, with some notable outliers.

[5] Using GDP per capita expressed in EUR gives very similar results (not reported).

[6] Notice that the model that will be presented in section 3 predicts a positive correlation between the spike at the minimum wage and the size of the informal economy *for a given productivity distribution and minimum wage*. Thus, the inclusion of the Kaitz index in the regressions is theoretically justified.

In particular, looking at the relationship between the spike and the Kaitz index, countries like Romania and Latvia appear as outliers, with a big spike despite a low minimum wage relative to the average, while at the same time underreporting of earnings is widespread in these two countries. Looking at the relationship between the spike and the informal economy, France and Luxembourg are characterized by a very small informal economy and a big spike, but a minimum wage that is high relative to the average wage.

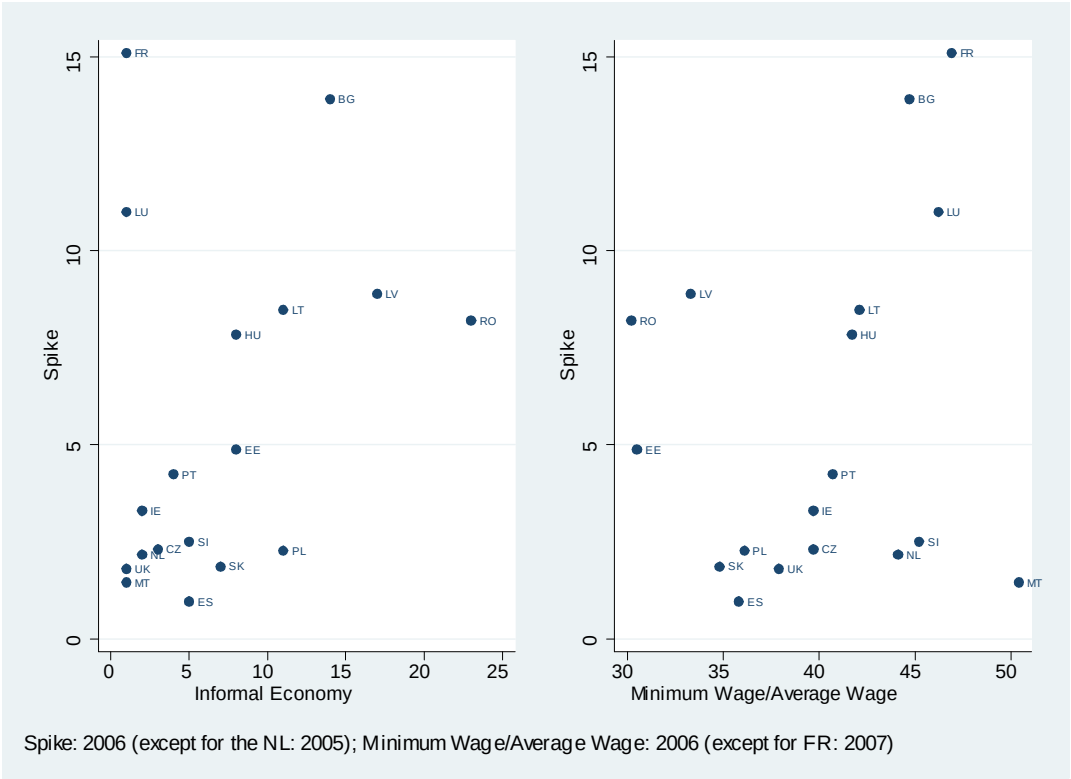
Table 1: Summary Statistics

	Mean	Std. Dev.	Min	Max
Spike	5.62	4.46	0.96	15.10
Informality Definition 1	6.89	6.26	1.00	23.00
Informality Definition 2	2.96	4.09	0.01	16.19
Informality Definition 3	2.54	3.17	0.00	11.04
Informality Definition 4	4.94	5.78	0.00	20.47
Informality Definition 5	9.61	7.83	1.00	30.00
Kaitz Index	40.00	5.76	30.20	50.40
GDP pc PPS	21.46	12.94	9.00	64.00

"Spike" is spike at minimum wage level in 2006 (except for the Netherlands: 2005) in %.
"Informality" refers to the period 2006/2007 and is given by:
Def 1: % of YES on question about employer paying cash-in-hand in the last 12 months;
Def 2: as in Def 1 multiplied by % of gross yearly income in the main job paid cash-in-hand;
Def 3: as in Def 1 multiplied by % of employees receiving cash-in-hand as part of remuneration for regular job;
Def 4: as in Def 3 including also employees receiving cash-in-hand for both regular job and overtime hours;
Def 5: as in Def 1 including also those refusing to answer the question;
"Kaitz Index" is given by the minimum monthly wage as a % of average monthly earnings in industry and services for 2006 (except for France: 2007);
"GDPpc PPS" is GDP per capita expressed in Purchasing Power Standard for 2006, in 1000s.

The size of the coefficient for the informal economy in column 3 implies that, when controlling for the size of the minimum wage relative to the average wage, an increase by 1% in the proportion of dependent employees answering affirmatively to the question on whether they have been paid cash-in-hand in the last 12 months is related to a 0.5% increase in the proportion of full-time employees with earnings on the minimum wage. I also use different measures of the informal economy, based on the additional survey questions administered to those receiving unreported earnings. In column 4, I use the product between the proportion of dependent employees receiving cash-in-hand and the proportion of gross yearly income paid cash-in-hand in the main job to these employees. This represents a measure of the proportion of the total wage bill that goes unreported in the economy, thus capturing both the "extensive" and "intensive" margins of underreporting. In column 5, I

Figure 1: Scatter Plot



Spike: 2006 (except for the NL: 2005); Minimum Wage/Average Wage: 2006 (except for FR: 2007)

consider the proportion of dependent employees receiving cash-in-hand as part of remuneration for their regular job only, as opposed to overtime hours, while in column 6 I include also those receiving cash-in-hand for both their regular job and overtime. In some countries, for instance in Hungary, the statutory minimum wage relates to gross monthly earnings net of overtime pay. In these cases, the minimum wage is not likely to represent a constraint to those underreporting remuneration only for overtime hours. The measures reported in columns 5 and 6 exclude them. Finally, considering the fact that undeclared work is a sensitive issue and people may be reluctant to admit it in a direct survey, in column 7 I also consider as receiving unreported pay those refusing to answer the question. Regardless of the specification, there appear to be a positive correlation between the size of the spike at the minimum wage level and the prevalence of underreporting of earnings in the economy, after controlling for the size of the minimum wage relative to the average.[7] The correlation is even stronger when controlling for GDP per capita. Next section will show how this correlation may emerge in a stylized model of the labour market with underreporting of earnings.

[7] For specifications 3 to 7, a Shapiro-Wilk test fails to reject the null that the distribution of residuals is normal (p-value for specification 3: 0.605; 4: 0.386; 5: 0.588; 6: 0.735; 7: 0.801), while this is not the case for specifications 1 (p-value 0.006) and 2 (p-value 0.073). This provides some reassurance about the validity of the test statistics on which the claim of a significant correlation is based.

Table 2: Regression Results

	1	2	3	4	5	6	7
Informality	0.23	–	0.48**	0.67**	0.93**	0.50**	0.36**
	(0.17)		(0.18)	(0.27)	(0.34)	(0.19)	(0.15)
MW / AW	–	0.17	0.47**	0.42**	0.44**	0.44**	0.45**
		(0.19)	(0.20)	(0.20)	(0.19)	(0.19)	(0.20)
Constant	4.05**	−1.09	−16.56*	−13.17	−14.42*	−14.48*	−15.71*
	(1.55)	(7.63)	(8.76)	(8.32)	(8.08)	(8.28)	(8.92)
R^2	0.10	0.05	0.35	0.32	0.36	0.35	0.32
Informality	0.41*	–	0.65***	0.78**	1.19***	0.66***	0.50**
	(0.21)		(0.21)	(0.30)	(0.38)	(0.22)	(0.17)
MW / AW	–	0.18	0.47**	0.40*	0.42**	0.42**	0.44**
		(0.21)	(0.19)	(0.20)	(0.18)	(0.19)	(0.19)
GDPpc PPS	0.14	−0.01	0.14	0.08	0.12	0.12	0.13
	(0.10)	(0.09)	(0.09)	(0.09)	(0.09)	(0.09)	(0.09)
Constant	−0.23	−1.27	−20.41**	−14.21	−16.63*	−17.12*	−19.48**
	(3.44)	(7.96)	(8.75)	(8.45)	(8.02)	(8.24)	(9.00)
R^2	0.20	0.05	0.44	0.35	0.44	0.43	0.41
Obs.				18			

a. Dependent variable is spike at minimum wage level in 2006 (except for the Netherlands: 2005).

b. The variable "Informality" refers to the period 2006/2007 and is given by:

1) and 3) % of YES on question about employer paying cash-in-hand in the last 12 months;

4) as in 1) multiplied by % of gross yearly income in the main job paid cash-in-hand;

5) as in 1) multiplied by % of employees receiving cash-in-hand as part of remuneration for regular job;

6) as in 5) including also employees receiving cash-in-hand for both regular job and overtime hours;

7) as in 1) including also those refusing to answer the question;

c. The variable "MW/AW" is given by the minimum monthly wage as a proportion of average monthly earnings in industry and services for 2006 (except for France: 2007). The variable "GDPpc PPS" is GDP per capita expressed in Purchasing Power Standard for 2006, in 1000s.

d. OLS estimation. Standard errors in parenthesis.

e. *** [**] (*) denote significance at 1, [5], and (10) percent level.

3 The model

Here, I use the model of a perfectly competitive labour market with underreporting of earnings developed in Tonin (2011) to study the relationship between the spike and underreporting. At the end of this section, I will also highlight the implications of the model for the average wage in the informal sector after a minimum wage hike, showing that the model is consistent with the so-called "lighthouse effect".[8]

The purpose of the model is to illustrate in a simple and tractable way the mechanism behind the correlation between the size of the spike at the minimum wage level and the prevalence of underreporting of earnings in the economy. As such, I will greatly simplify the fiscal environment, assuming for instance proportional taxation and random audits by the tax authority, and the labour market, assuming no frictions and no choice about hours of work. However, the intuition behind the proposed mechanism is likely to hold more generally. Namely, the idea is that firms and workers base their decision on how much to report on the likelihood of being detected and fined in case of evasion. The minimum wage represents an additional constraint for firms' and workers' reporting decision, because if they wish to remain in the formal economy they need to declare at least the minimum. More firms and workers will find the minimum wage constraint to be actually binding as fiscal enforcement gets weaker, thus increasing the size of the spike and inducing its positive correlation with the prevalence of underreporting.

Assume that, in a population of size 1, every individual is characterized by a productivity y_i, distributed in the population according to pdf $g(y)$ and cdf $G(y)$ on the support $[\underline{y}, \bar{y}]$, where $\underline{y} \geq 0$. Firms are risk-neutral and maximize expected profits. Given that each firm employs one worker, there is no capital, and production is equal to labour input, profits are given by $\pi_i = y_i - w_i$, where w_i is the gross wage. Firms have an obligation to withhold taxes and social security contributions at the proportional rate $t \in (0, 1)$ and transfer them to the authorities. Workers' (indirect) utility is an increasing function of net income, given by $I_i = w_i(1-t)$. Without underreporting of earnings, a worker with productivity y_i would receive a gross wage y_i, from which the firm would deduct taxes ty_i, thereby leaving the worker a net wage $(1-t)y_i$.

In this economy, however, it is possible to underreport earnings, so that a firm can deduct taxes from any tax base $x_i \in [0, y_i]$. The fiscal enforcement technology is such that with an exogenously given probability $\gamma \in [0, 1]$, the tax authority inspects firms. The detection technology is imperfect, so that during an audit the tax authority may find evidence to impute an income $\hat{y}_i \in [0, y_i]$, where

[8] Notice that Tonin (2011) does not look at these implications of the model.

$\hat{y}_i$ has an uniform distribution over the support $[0, y_i]$. In case tax evasion is detected, i.e. when $\hat{y}_i > x_i$, the tax authority imposes the payment of due taxes plus an additional fine proportional to the assessed tax evasion $\theta t\left(\hat{y}_i - x_i\right)$, with $\theta > 1$. Thus, for a worker-firm pair characterized by a productivity y_i and declaring x_i, the expected fine in case of auditing, f_i, is

$$f_i = t\theta \int_{x_i}^{y_i} \left(\hat{y}_i - x_i\right)/y_i \; d\hat{y}_i = t\theta (y_i - x_i)^2 / \left(2y_i\right). \tag{1}$$

With the assumption that fines are imposed on firms[9], expected profits are given by $E\left(\pi_i\right) = y_i - w_i - \gamma f_i$, and the worker's net income is $I_i = w_i - t x_i$. The firm and the worker agree to choose x_i so as to maximize the expected total surplus available to them, or, equivalently, to minimize expected payments to the tax authority, so the optimal declaration is

$$x_i^* \quad s.t. \quad \max_{x_i \in [0, y_i]} y_i - \gamma f_i - t x_i. \tag{2}$$

Substituting (1) into (2) and taking the first order condition, the optimal reporting behaviour is given by

$$x_i^* = \begin{cases} \left(1 - \alpha\right) y_i & \text{if} \quad 0 < \alpha < 1 \\ 0 & \text{if} \quad \alpha \geq 1 \end{cases}, \tag{3}$$

where, to simplify the notation, the two enforcement parameters are summarized by $\alpha \equiv 1/\left(\gamma\theta\right)$. In what follows, I will assume that enforcement is strong enough that there is partial evasion, i.e. $\alpha \in (0, 1)$.

What are the effects of introducing a minimum monthly wage[10] ϖ, with universal coverage, in the economy described above? Workers cannot be legally employed at a wage below the minimum, in the sense that their reported gross wage cannot be below the minimum. Therefore, the choice set in (2) shrinks from $[0, y]$ to $\{0\} \cup [\varpi, y]$.

Worker-firm pairs characterized by high productivity ($y_i > \varpi/\left(1 - \alpha\right)$), would have declared more than the minimum wage anyway, so they are unaffected by it. Worker-firm pairs with low productivity ($y_i < \varpi$) can only work in the black market, by declaring nothing, or be inactive[11]. If

[9] Who pays the fine is immaterial as far as also workers are risk-neutral.

[10] The assumption is that the minimum wage is fixed on a monthly basis for full-time work and that no alternative working-time arrangements are available. In Tonin (2007), the model is extended to the case where the minimum wage is fixed on an hourly basis, labour supply can vary across workers and underreporting can involve both hours of work and hourly wage. The results remain qualitatively unchanged.

[11] The possibility of a worker paying back part of his or her wage to the firm is thus excluded. The results are

enforcement is weak enough ($\alpha > t/2$), they choose to be active in the black market, otherwise they withdraw from the labour market (see the Appendix for proof). Worker-firm pairs characterized by intermediate productivity ($\varpi \leq y_i \leq \varpi/(1-\alpha)$), also have the possibility of declaring the minimum wage and thus participating in the formal labour market. If enforcement is strong enough ($\alpha \leq 1/2$), all these workers will increase their compliance and declare the minimum, otherwise workers with productivity below a certain threshold ($\varpi/(2-2\alpha)$) will instead move to the black market (see the Appendix for proof). Thus, reported earnings bunch at the minimum wage level, creating a spike whose size is given by

$$S = \int_{\varpi \max\{1/(2-2\alpha),1\}}^{\varpi/(1-a)} g(y)dy. \tag{4}$$

In what follows, I will study the link between the size of the spike and the amount of underreporting of earnings in the economy.

3.1 The Spike and Underreporting

A decrease in enforcement parameters, i.e. an increase in α, induces the minimum wage to be declared by some workers previously declaring more, thereby increasing the size of the spike. If enforcement is sufficiently weak, i.e. if $1/2 < \alpha < 1$, an additional effect plays a role, as some workers previously declaring the minimum wage prefer to go into the black economy, thus reducing the size of the spike. In this case

$$\frac{\partial S}{\partial \alpha} > 0 \Leftrightarrow g\left(\frac{\varpi}{1-a}\right) > \frac{1}{2} g\left(\frac{\varpi}{2(1-a)}\right). \tag{5}$$

Assuming that the distribution of productivity is single peaked, the above condition is satisfied if the minimum wage is binding for workers with productivity lower than the mode. The analysis can also be conducted in terms of the size of the spike relative to the size of the officially employed workforce, where the latter is given by:

$$L = \int_{\varpi \max\{1/(2-2\alpha),1\}}^{\bar{y}} g(y)dy. \tag{6}$$

The condition for the spike relative to the officially employed workforce, S/L, to increase with α is looser than (5), as the size of the officially employed workforce is not increasing with α. I can then

qualitatively unaffected by this modelling choice.

state the following (see the Appendix for proof):

Proposition 1 *When enforcement is not too weak, a decrease in enforcement increases the size of the spike at the minimum wage, both in absolute terms or relative to the officially employed workforce. When enforcement is weak, a sufficient condition for this to happen is a single peaked productivity distribution combined with a minimum wage binding for workers with productivity lower than the mode.*

When workers with a productivity below the minimum wage work in the black market, i.e. when $\alpha \geq t/2$, the size of the informal economy is given by:

$$U = \underbrace{\int_{\underline{y}}^{\varpi \max\{1/(2-2\alpha),1\}} yg(y)dy}_{\text{black economy}} + \underbrace{\int_{\varpi \max\{1/(2-2\alpha),1\}}^{\varpi/(1-a)} (y-\varpi)g(y)dy + \alpha \int_{\varpi/(1-a)}^{\bar{y}} yg(y)dy}_{\text{underreporting}}. \tag{7}$$

A decrease in enforcement, i.e. an increase in α, increases the size of the informal economy as workers unaffected by the minimum wage evade more. Moreover, when enforcement is already low, i.e. $1/2 < \alpha < 1$, some workers previously declaring the minimum wage go into the black economy, thereby further increasing informality. The size of the informal economy relative to the economy as a whole, U/Y, or relative to the size of the formal economy, $U/(Y-U)$, is also of interest. When $\alpha \geq t/2$, the size of the economy is given by $Y = \int_{\underline{y}}^{\bar{y}} yg(y)dy$ and does not depend on α. Thus, the derivatives of U, U/Y, $U/(Y-U)$ w.r.t. α all have the same sign.

When workers with productivity below the minimum wage withdraw from the labour market; i.e. when $\alpha < t/2$, there is no black market, thus the size of the underground economy is given by the last two terms in expression (7). Also in this case does a decrease in enforcement, i.e. an increase in α, increase the size of the informal economy as workers unaffected by the minimum wage evade more. Notice that there is a discontinuity in the size of the informal economy at $\alpha = t/2$. When enforcement parameters decrease (i.e. α increases), the size of the informal economy jumps up discretely as workers previously withdrawn from the labour market enter into the black market. This jump goes in the same direction as the derivative, so it is possible to state that the size of the informal economy always increases as enforcement decreases. The same is true if I consider the size of the informal economy relative to the whole economy, U/Y, or relative to the formal economy, $U/(Y-U)$.

To summarize (see Appendix for proof):

Proposition 2 *When enforcement decreases, the size of the informal economy increases, both in absolute terms, relative to the formal economy, or relative to the economy as a whole.*

Thus, under mild conditions, the common dependence on α induces a positive correlation between the spike at the minimum wage and the size of the informal economy for a given productivity distribution and minimum wage.

3.2 Lighthouse effect

The model is also consistent with the increase in the informal sector average wage after a minimum wage hike, the so-called "lighthouse effect" of the minimum wage that has been observed extensively in Latin America (Maloney and Mendez, 2004). The mechanism usually proposed is that the minimum wage acts as a signal of what represents a fair wage. However, in a recent contribution, Boeri, Garibaldi, and Ribeiro (2011) have shown the importance of sorting and composition effects within a matching model. They use data on Brazil and find that sorting accounts for at least one third of the increase in average wages in the informal sector after a minimum wage hike. Sorting is also what induces an increase in the average wage paid in the black economy in the current model. The wage paid in the black economy is linked to productivity. As the minimum wage increases, higher productivity workers go completely underground. Therefore, a minimum wage hike increases the average wage paid in the black economy. Indeed, the average wage in the black economy is given by

$$A = \frac{\int_{\underline{y}}^{\varpi \max\{1/(2-2\alpha),1\}} y\left[1 - t/\left(2\alpha\right)\right] g(y)dy}{G\left(\varpi \max\left\{1/(2-2\alpha),1\right\}\right)}$$

and it is increasing in ϖ (see Appendix for proof).

4 Conclusions

In this paper, I have shown how, within European labour market, there is a positive correlation between the size of the spike at the minimum wage level and the relevance of underreporting of earnings in the economy, and I have proposed a simple model that explains this correlation through a common dependence of both quantities on the strength of fiscal enforcement. One could argue that, rather than enforcement, it could be the case that it is the tax rate that is driving this correlation, with countries with higher tax rates on labour earnings having both a higher degrees of informality and higher spikes. This, however, appears not to be the case. I have added a measure

of the tax rate[12] as a control variable beside the size of the informal economy and the Kaitz index. While the tax rate is not significant, the other two variables maintain their statistical significance.

Beside the fiscal one, other mechanisms could of course be proposed to explain this correlation. One obvious candidate involves the importance of small firms in the economy. Namely, small firms may be more likely to pay the minimum wage, because their productivity is generally lower and they are less unionized, and also more likely to underreport to fiscal authorities, because they are less subject to audits. Thus, countries with more small firms will tend to have both a higher spike and a bigger informal economy. This, however, turns out not to be the case when looking at the European labour markets considered here. The share of micro enterprises (defined as those with less than 10 employees) in the total population of enterprises or their relative share of the workforce are uncorrelated with the proportion of dependent employees receiving cash-in-hand or with the proportion of full-time employees with earnings on the minimum wage[13].

The mechanism proposed in this paper is supported by the presence, in the policy discussions briefly reviewed in the introduction, of many references to the practice of officially paying the minimum wage, while supplementing it with some cash-in-hand, and in Tonin (2011) this mechanism has been shown to be at work in the Hungarian context. The implication of the proposed mechanism is that, in some contexts, a high proportion of the workforce earning the minimum wage is a fiscal issue more than a labour market issue, and this should be taken into consideration when analysing and formulating labour market policy or when comparing labour market outcomes across countries.

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[12] In particular I have used one of the following measures (results not reported):
1) the tax wedge for single persons without children earning 67% of the average wage;
2) the tax rate for single persons without children, earning 50% of the average wage;
3) the tax rate for two-earner married couple, one at 100%, the other at 33% of the average wage, with no children;
4) the tax rate for two-earner married couple, one at 100%, the other at 100% of the average wage, with no children;

[13] In particular, regressing the proportion of full-time employees with earnings on the minimum wage on a constant and the share of micro enterprises in the total population of enterprises active in the non-financial business economy gives a coefficient of -0.066 (s.e. 0.173), while using the micro enterprises relative share of the non-financial business economy workforce gives a coefficient of -0.068 (s.e. 0.155). The same figures when having the proportion of dependent employees receiving cash-in-hand as the dependent variable are -0.116 (s.e. 0.277) and -0.055 (s.e. 0.250). I have also repeated the analysis in table 2 including either of the two micro enterprises measures. The coefficients on these two measures are insignificant, while, when included together, the kaitz index and informality are strongly significant. Data on the importance of micro enterprises are for 2008. Data on France and Malta are not available. The source is Eurostat.

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APPENDIX - Proofs

Proofs related to Section 3 Replacing $x_i = 0$ in the maximand in (2), income in case of work in the black market, i.e. full evasion, is given by

$$I_{bm} \equiv y_i \left[1 - t/\left(2\alpha\right)\right]. \tag{8}$$

Income in case of declaring ϖ is given by substituting $x = \varpi$ in the same expression

$$I_{mw} \equiv y_i(1-t) + \left(y_i - \varpi\right) t - t\left(y_i - \varpi\right)^2 / \left(2\alpha y_i\right). \tag{9}$$

Comparing black market income to inactivity, where income is assumed to be 0, gives the following condition:

$$I_{bm} > 0 \Leftrightarrow \alpha > t/2.$$

The comparison between income in case of declaring the minimum wage and income in the black market gives the following condition

$$I_{mw} \geq I_{bm} \Leftrightarrow y_i \geq \varpi/\left[2(1-\alpha)\right] \equiv y_{mw}. \tag{10}$$

As the choice between employment at the minimum wage and employment in the black market is only relevant for workers satisfying $\varpi \leq y_i \leq \varpi/(1-\alpha)$, it is necessary to position y_{mw} in the interval $[\varpi, \varpi/(1-\alpha)]$ to determine the behavior once a minimum wage is introduced. The threshold y_{mw} is greater than the minimum wage if and only if $\alpha > 1/2$, while it is always the case that $y_{mw} < \varpi/(1-\alpha)$. Thus, if the degree of underreporting is high, i.e. $\alpha > 1/2$, the threshold y_{mw} is internal to the interval. This implies that some of the workers affected by the minimum wage and with a productivity higher than the minimum wage prefer to decrease evasion and declare the minimum, while others prefer to go into the black market. If the degree of underreporting is instead low, i.e. $\alpha \leq 1/2$, all workers affected by the minimum wage and with a productivity higher than the minimum wage prefer to increase compliance and declare the minimum.

Proof of Proposition 1 When $\alpha \leq \frac{1}{2}$,

$$\frac{S}{L} = \frac{\int_{\varpi}^{\varpi/(1-a)} g(y)dy.}{\int_{\varpi}^{\bar{y}} g(y)dy}$$

and

$$\frac{\partial S/L}{\partial \alpha} = \frac{\varpi g(\varpi/(1-a))}{(1-a)^2 \int_{\varpi}^{\bar{y}} g(y)dy} > 0.$$

When $\frac{1}{2} < \alpha < 1$, then

$$\frac{S}{L} = \frac{\int_{\varpi/(2-2\alpha)}^{\varpi/(1-a)} g(y)dy.}{\int_{\varpi/(2-2\alpha)}^{\bar{y}} g(y)dy}.$$

Given that

$$\frac{\partial S}{\partial \alpha} = \frac{\varpi}{(1-a)^2} g(\varpi/(1-a)) - \frac{\varpi}{2(1-\alpha)^2} g(\varpi/(2-2\alpha))$$

and that

$$\frac{\partial L}{\partial \alpha} = -\frac{\varpi}{2(1-\alpha)^2} g(\varpi/(2-2\alpha)),$$

then

$$\begin{aligned} \frac{\partial S/L}{\partial \alpha} &= \frac{\left(\begin{array}{c} \left[\frac{\varpi}{(1-a)^2} g(\varpi/(1-a)) - \frac{\varpi}{2(1-\alpha)^2} g(\varpi/(2-2\alpha)) \right] \int_{\varpi/(2-2\alpha)}^{\bar{y}} g(y)dy \\ + \frac{\varpi}{2(1-\alpha)^2} g(\varpi/(2-2\alpha)) \int_{\varpi/(2-2\alpha)}^{\varpi/(1-a)} g(y)dy \end{array} \right)}{\left[\int_{\varpi/(2-2\alpha)}^{\bar{y}} g(y)dy \right]^2} > 0 \Leftrightarrow \\ g(\varpi/(1-a)) &> \frac{1}{2} g(\varpi/(2-2\alpha)) \frac{\int_{\varpi/(1-a)}^{\bar{y}} g(y)dy}{\int_{\varpi/(2-2\alpha)}^{\bar{y}} g(y)dy}, \end{aligned}$$

where

$$\frac{\int_{\varpi/(1-a)}^{\bar{y}} g(y)dy}{\int_{\varpi/(2-2\alpha)}^{\bar{y}} g(y)dy} < 1.$$

Proof of Proposition 2 When $0 < \alpha < \frac{t}{2}$,

$$U = \int_{\varpi}^{\varpi/(1-a)} (y - \varpi)g(y)dy + \alpha \int_{\varpi/(1-a)}^{\bar{y}} yg(y)dy,$$

then

$$\begin{aligned} \frac{\partial U}{\partial \alpha} &= \frac{\varpi}{(1-a)^2}(\varpi/(1-a) - \varpi)g(\varpi/(1-a)) + \int_{\varpi/(1-a)}^{\bar{y}} yg(y)dy + \alpha\frac{\varpi}{(1-a)^2}\varpi/(1-a)\, g(\varpi/(1-a)) \\ &= \int_{\varpi/(1-a)}^{\bar{y}} yg(y)dy > 0. \end{aligned}$$

When $\frac{t}{2} \leq \alpha \leq \frac{1}{2}$,

$$U = \int_{\underline{y}}^{\varpi} yg(y)dy + \int_{\varpi}^{\varpi/(1-a)} (y - \varpi)g(y)dy + \alpha \int_{\varpi/(1-a)}^{\bar{y}} yg(y)dy,$$

and, given that $\int_{\underline{y}}^{\varpi} yg(y)dy$ does not depend on α, the derivative is the same as in the previous case. At $\alpha = \frac{t}{2}$ the size of the underground economy jumps up by $\int_{\underline{y}}^{\varpi} yg(y)dy$.

When $\frac{1}{2} < \alpha < 1$,

$$U = \int_{\underline{y}}^{\varpi/(2-2\alpha)} yg(y)dy + \int_{\varpi/(2-2\alpha)}^{\varpi/(1-a)} (y - \varpi)g(y)dy + \alpha \int_{\varpi/(1-a)}^{\bar{y}} yg(y)dy,$$

then

$$\begin{aligned} \frac{\partial U}{\partial \alpha} &= \frac{\varpi}{2(1-\alpha)^2}\frac{\varpi}{(2-2\alpha)}g(\frac{\varpi}{(2-2\alpha)}) - \frac{\varpi}{2(1-\alpha)^2}(\frac{\varpi}{(2-2\alpha)} - \varpi)g(\frac{\varpi}{(2-2\alpha)}) + \\ &\quad + \frac{\varpi}{(1-a)^2}(\varpi/(1-a) - \varpi)g(\varpi/(1-a)) + \int_{\varpi/(1-a)}^{\bar{y}} yg(y)dy + \alpha\frac{\varpi}{(1-a)^2}\varpi/(1-a)\, g(\varpi/(1-a)) \\ &= \frac{\varpi^2}{2(1-\alpha)^2}g(\frac{\varpi}{(2-2\alpha)}) + \int_{\varpi/(1-a)}^{\bar{y}} yg(y)dy > 0. \end{aligned}$$

When $0 < \alpha < \frac{t}{2}$, the size of the economy is given by $Y = \int_{\varpi}^{\bar{y}} yg(y)dy$. When $\alpha \geq \frac{t}{2}$, the size of the economy is given by $Y = \int_{\underline{y}}^{\bar{y}} yg(y)dy$. In both case, it does not depend on α. As

$$\frac{\partial \frac{U}{Y-U}}{\partial \alpha} > 0 \Leftrightarrow \frac{\partial U}{\partial \alpha}(Y-U) - \frac{\partial (Y-U)}{\partial \alpha}U > 0 \Leftrightarrow \frac{\partial U}{\partial \alpha}(Y-U) + \frac{\partial U}{\partial \alpha}U > 0 \Leftrightarrow \frac{\partial U}{\partial \alpha} > 0,$$

the derivatives of U, U/Y, $U/(Y-U)$ w.r.t. α all have the same sign.

Proof related to Lighthouse effect If $\frac{t}{2} \leq \alpha \leq \frac{1}{2}$, then

$$A = \frac{\int_{\underline{y}}^{\varpi} y\left[1 - t/(2\alpha)\right] g(y)dy}{G(\varpi)},$$

then

$$\begin{aligned} \frac{\partial A}{\partial \varpi} &= \frac{\left[\varpi\left[1 - t/(2\alpha)\right] g(\varpi)\right] G(\varpi) - g(\varpi)\int_{\underline{y}}^{\varpi} y\left[1 - t/(2\alpha)\right] g(y)dy}{G^2(\varpi)} > 0 \Leftrightarrow \\ \varpi G(\varpi) &> \int_{\underline{y}}^{\varpi} yg(y)dy \Leftrightarrow \\ \int_{\underline{y}}^{\varpi} \varpi g(y)dy &> \int_{\underline{y}}^{\varpi} yg(y)dy \end{aligned}$$

that is always the case as $y \in \left[\underline{y}, \varpi\right]$.

If $\frac{1}{2} < \alpha < 1$, then

$$A = \frac{\int_{\underline{y}}^{\varpi/(2-2\alpha)} y\left[1 - t/(2\alpha)\right] g(y)dy}{G(\varpi/(2-2\alpha))},$$

then

$$\begin{aligned} \frac{\partial A}{\partial \varpi} &= \frac{\left(\begin{array}{c} \frac{1}{(2-2\alpha)}\frac{\varpi}{(2-2\alpha)}\left[1 - t/(2\alpha)\right] g(\frac{\varpi}{(2-2\alpha)}) G\left(\frac{\varpi}{(2-2\alpha)}\right) \\ -\frac{1}{(2-2\alpha)} g\left(\frac{\varpi}{(2-2\alpha)}\right)\int_{\underline{y}}^{\varpi/(2-2\alpha)} y\left[1 - t/(2\alpha)\right] g(y)dy \end{array}\right)}{G^2(\varpi/(2-2\alpha))} > 0 \Leftrightarrow \\ \frac{\varpi}{(2-2\alpha)} G\left(\frac{\varpi}{(2-2\alpha)}\right) &> \int_{\underline{y}}^{\varpi/(2-2\alpha)} yg(y)dy \Leftrightarrow \\ \int_{\underline{y}}^{\varpi/(2-2\alpha)} \frac{\varpi}{(2-2\alpha)} g(y)dy &> \int_{\underline{y}}^{\varpi/(2-2\alpha)} yg(y)dy \end{aligned}$$

that is always the case as $y \in \left[\underline{y}, \varpi/(2-2\alpha)\right]$.