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Minimum Wage and Tax Evasion: Theory and Evidence

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MINIMUM WAGE AND TAX EVASION: THEORY AND EVIDENCE*

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This paper examines the interaction between minimum wage legislation and tax evasion by employed labor. I develop a model in which firms and workers may agree to report less than the true amount of earnings to the fiscal authorities. I show that introducing a minimum wage creates a spike in the distribution of declared earnings and induces higher compliance by some agents, thus reducing their disposable income. The comparison of food consumption before and after the massive minimum wage hike that took place in Hungary in 2001 reveals that households who appear to benefit from it actually experienced a drop compared to similar but unaffected household, thus supporting the prediction of the theory.

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"Did you know that more than half of the people nominally employed at the minimum wage earn more, and the only reason for such a declaration is to evade taxes and social security contributions? [1] *"*

(Advertisement in *Metro* newspaper for the Hungarian government Green Book, 22 September 2006)

I. Introduction

What are the fiscal implications of introducing or increasing the minimum wage? What is its impact on disposable income? This paper contributes to answering these questions by examining the interaction between minimum wage legislation and tax evasion by employed labor.

I build a simple model in which workers and firms may agree to report less than the true amount of the worker's earnings to the fiscal authorities to avoid the payment of taxes and social security contributions. The minimum wage poses a constraint on this decision and, in this way, has an effect on compliance with fiscal regulation. In particular, when a minimum wage is introduced or increased, some worker-firm pairs prefer to increase their compliance than to decrease it by going completely underground. Thus, a spike in the distribution of declared earnings appears at the minimum wage level. Moreover, workers who appear to receive a higher wage, actually experience a drop in their disposable income, as they are forced to swap undeclared earnings for declared, and taxable, ones. The massive increase in the minimum wage that took place in Hungary in 2001 provides a quasi experiment to test this prediction of the model. Hungary is a country where, like in many other developing and transition countries, underreporting of earnings is widespread. I use panels derived from the household budget survey for the years 1999-2001 to compare the dynamics of food consumption, as a proxy for true income, for households that appear to benefit from the minimum wage hike, the treatment group, and for similar but unaffected households, the control group. The analysis consistently shows across different specifications that the treated households experienced a drop in consumption compared to households in the control group, thus supporting the prediction of the theory. Instead, the dynamics of food consumption experienced by the treatment and the control groups in the pre-policy period did not differ,

1. "Tudta, hogy a papíron minimálbérért dolgozók több mint fele többet keres annál, és csak azért van minimálbérre bejelentve, hogy kikerülje az adó- és járulékfizetést?" (own translation).

thus validating the control group.

Undeclared work is a serious issue in many countries. It is difficult to obtain reliable data on its extent, but raw estimates indicate that the phenomenon is relevant, particularly in transition and developing countries. In a recent report by Eurostat (2007), based on a representative survey of individuals in the European Union, 5% of all dependent employees admitted having received all or part of their salary as envelope wages within the past 12 months. The country with the highest incidence is Romania, with a share of 23%, followed by Latvia, Bulgaria, Poland, and Lithuania, all with a double digit share, with Estonia and Hungary just below. In Russia, 8% of the employees reported that they received part of their income "under the table" (Petrova, 2005). The phenomenon is not limited to Central and Eastern European economies. OECD estimates a 30% shortfall in social security contributions due to undeclared work for Hungary, Mexico and South Korea, and a shortfall above 20% for Italy, Poland, Spain and Turkey (OECD, 2004a). In Turkey, firms belonging to the formal sector are estimated to underreport 28% of their wage bill and for around 50% of the employees enrolled in the Social Security Organization, the wages reported by employers are at the minimum insurable level (World Bank, 2006). According to the World Bank, "in Argentina, roughly 15 percent of workers receive pay partly on the books and partly off the books" (World Bank, 2007). A World Bank study on labor 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), creating incentives to sustain a high minimum wage to sustain tax revenue" and calls for further research on this aspect of minimum wage policy. This is indeed the aim of this paper.

This work can be seen as integrating two strands of literature. The literature on the minimum wage is very rich and informs a lively policy debate, mainly focusing on the effects on employment [2]. Recently, several empirical studies have considered the impact of the minimum wage on other aspects than employment, like fringe benefits (Simon and Kaestner, 2004), prices (Lemos, 2008), profits (Draca et al., 2006), reservation wages (Falk et al., 2004). This paper highlights another aspect of minimum wage policy that has not been considered so far and shows how the minimum wage affects workers and firms through

2. See Brown (1999) for a review.

the "fiscal channel"[3]. The literature on minimum wage also deals extensively with its effects on the wage distribution. A spike at the minimum wage level has been observed in several instances (see, for instance, DiNardo et al., 1996, Dickens and Manning, 2004). Such a spike has been defined as a "puzzle" for several standard types of labor market models (Brown, 1999) and as an "anomalous finding from the standpoint of the standard model of the low wage labor market" (Card and Krueger, 1995, p. 152). Proposed rationalizations include reductions in non-wage compensation or increases in required effort to offset a binding minimum wage, flatter earnings profiles and adjustments in the amounts of hours worked. The model presented here proposes an alternative rationale for the observed spike in a perfect competition framework with perfect elasticity of substitution between labor types and, in related work (Tonin, 2007), I present some cross-country evidence suggesting that the mechanism analyzed here indeed contributes to shape the observed distribution of earnings in Europe.

The second strand of literature that this paper addresses deals with the theoretical and empirical study of tax evasion and the shadow economy[4]. The literature on tax evasion has mainly been focused on personal income tax and the compliance decision by an individual filling the tax declaration form. However, due to the tax withholding and information reporting systems present in many countries, this is not an accurate description for the case of employed labor. Indeed, the rate of non-compliance for wages and salaries at the stage of filling the tax declaration form is often negligible. For instance, Klepper and Nagin (1989) report a mere 0.1% of non-compliance for wages and salaries at this stage in the US, i.e. lower than for any other income category. Therefore, to study tax evasion by employed labor it is necessary to take the interaction between the employer and the employee into account[5,6]. Here I model the interaction by developing a novel and simple model of tax evasion based on the plausible assumption that tax authorities possess an imperfect detection technology. On

3. A related paper is McIntyre (2006), who uses Brazilian data and focuses on estimating the cost associated with evasion and finds, in line with the assumption in this paper, that there is no fixed cost of evading, while the marginal cost equals 8.1% of the distance from the legal requirement.

4. 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.

5. The study of tax evasion by employed labor is of particular interest as the fiscal imposition on labor in the form of social security contributions (SSC) and personal income tax (PIT) represents the bulk of fiscal revenues in many countries, for instance labor taxes are the largest source of tax revenue in the EU-25, representing around half of total tax receipts (Eurostat, 2006).

6. For a recent contribution on the role of firms in tax enforcement see Kleven et al. (2009).

the empirical side, this paper contributes to the methodology pioneered by Pissarides and Weber (1989) to study underreporting by using income and consumption data from household budget surveys. Pissarides and Weber (1989) study underreporting by self-employed in the UK by assuming expenditure on food to be correctly reported by all income groups, while income is correctly reported by employees, but underreported by the self-employed. Instead of food consumption, Feldman and Slemrod (2007) use charitable cash contributions in unaudited tax returns. They estimate the relationship between charitable contributions and reported income, depending on the source of income, and attribute to underreporting the fact that the propensity to make a contribution is higher out of self-employment income than out of wages and salaries. This methodology has also been used to study underreporting by private sector employees, using public sector employees as a control group assumed to correctly report income (Besim and Jenkins, 2005). However, Gorodnichenko and Sabirianova (2007) take the opposite view in their study on bribery in Ukraine. They use the large estimated sectorial gap in reported earnings between the public and the private sector and the absence of an expenditure gap to identify the size of unreported bribes to public officials. A weakness of the approach used in this literature is indeed the need to identify a group that is not evading. An advantage of the approach used in this paper is that it does not need to assume that a group truthfully reports income. The minimum wage hike represents a shock to the "underreporting technology" affecting some workers but not others and this variation is exploited to identify the impact of the minimum wage on underreporting. In their recent paper on tax evasion in Russia, Gorodnichenko, Martinez-Vazquez and Sabirianova (2009) employ a similar methodology, looking at the impact of the flat tax reform of 2001.

The next section introduces the model. In section 3, the various effects of the minimum wage are explored. The following section tests the implication of the model for disposable income by using Hungarian microdata. The last section concludes.

II. The model without minimum wage

The size of the population is exogenously given and normalized to 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 $\underline{y} \geq 0$. The labor market is competitive, each firm employs one worker, there is no capital, and production is equal to labor input. Moreover,

there is free entry of firms, firms can observe workers' productivity, and workers can move from one firm to another at no cost.

Firms are risk-neutral and maximize expected profits. In an environment without tax evasion, profits for a firm employing a worker with productivity y_i are given by

$$\pi_i = y_i - w_i,$$

where w_i is the gross wage[7]. Firms have an obligation to withhold taxes and social security contributions and transfer them to the fiscal authorities. Taxation is at the proportional rate $t \in (0, 1)$. Workers are risk-averse, their (indirect) utility is an increasing function of net income, given by

$$I_i = w_i(1 - t).$$

The wedge between the gross wage paid by the firm and the net wage received by the worker, tw_i, is paid to the fiscal authorities. Free entry of firms implies that in equilibrium, the expected profits are zero which, in turn, in the full compliance case implies that 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 evade taxes and social security contributions by not reporting part or all of the worker's earnings to the authorities. A firm employing a worker with productivity y_i must therefore decide how much of the worker's production to declare to the tax authorities, x_i, and how much to conceal, $y_i - x_i$. If $x_i = y_i$, the firm is fully compliant with the regulations. If $x_i = 0$, the full product is hidden from the authorities and the firm-worker pair operates completely in the black economy. If $x_i \in (0, y_i)$, there is underreporting. A worker-firm pair can thus operate in the formal economy, by declaring a strictly positive income, or be completely in the black market, by declaring nothing. A worker can also decide to be inactive. In this case, income is normalized to 0.

Tax authorities may inspect firms to find out whether they comply with fiscal regulation. We assume there to be an exogenously given probability of an audit being performed $\gamma \in [0, 1]$. Fines proportional to the amount of evasion are imposed on firms in case tax evasion is detected and, given the assumption of risk-neutral firms and risk-averse workers, there is no

7. No distinction is made between labor cost and gross wage and the two concepts are equivalent in the model.

incentive for workers and firms to negotiate a different risk-sharing arrangement. However, the fact that an audit is performed does not imply that the authority with certainty discovers the true tax liability. Instead, it may find evidence to impute an income $\hat{y}_i \in [0, y_i]$, where y_i is the true product. Imperfect detection is a plausible assumption and is supported by empirical evidence. For instance, Feinstein (1991) estimates that IRS examiners on average managed to detect only half of the tax evasion in the forms they audited[8], while Erard (1997) rejects the hypothesis of perfect detection in his empirical investigation based on the TCMP (Taxpayer Compliance Measurement Program).

I assume that $\hat{y}_i$ is distributed over the support $[0, y_i]$[9] according to pdf $h(\cdot)$ and cdf $H(\cdot)$, so that $H(0) = 0$ and $H(y_i) = 1$, and $H(\cdot)$ does not depend on x_i. To simplify the discussion, I assume that $h(\cdot) > 0$ within the support, so that $H(\cdot)$ is invertible within $[0, y_i]$.

Given a declaration of x_i and collected evidence of a true tax liability of $\hat{y}_i$, the tax authority imposes on the firm, in case $\hat{y}_i > x_i$, the payment of $\theta t\,(\hat{y}_i - x_i)$, consisting of taxes plus an additional fine proportional to the assessed tax evasion, thus $\theta > 1$. In case $\hat{y}_i \leq x_i$, the tax authority cannot prove any tax evasion, so no fine is imposed[10]. Given a true product y_i and a reported one $x_i \in [0, y_i]$, the expected fine in case of auditing, f_i, is

$$f_i = t\theta \int_{x_i}^{y_i} (\hat{y}_i - x_i) h(\hat{y}_i) d\hat{y}. \tag{1}$$

Below, I determine the equilibrium wage and evasion. For convenience, subscripts are suppressed where not necessary.

8. An IRS study found that for every dollar of underreported income detected by examiners without the aid of third-party information documents, another $ 2.28 went undetected (cited in Feldman and Slemrod, 2007).

9. The assumption is that the tax authority cannot assess and upheld in court a tax liability higher than the true one. To extend the model to situations where this may not be the case, due for instance to ambiguity in the tax code, would be straightforward.

10. An equivalent narrative is that in an audit, the tax authority may find no evidence at all of tax evasion with probability $H(x_i)$, which is increasing as the tax liability declared to the authorities increases. Conditional on detection taking place, the density for any given level of income $\hat{y}_i \in [x_i, y_i]$ being discovered is given by $h\,(\hat{y}_i)\,/\,[1 - H\,(x_i)]$.

II.A. Equilibrium without minimum wage

For a firm employing a worker with productivity y, declaring x, and paying a gross wage w, the possible realizations of profits are given by[11]

$$\pi = \begin{cases} y - w & \text{with probability } 1 - \gamma \\ y - w - f & \text{with probability } \gamma \end{cases},$$

where f, the expected fine in case an audit is conducted, is given by (1). Therefore, the expected profits for the firm are

$$E(\pi) = y - w - \gamma f. \tag{2}$$

Income I for a worker employed in a firm paying a gross wage w and declaring to the fiscal authorities x is given by

$$I = w - tx. \tag{3}$$

This expression captures the fact that taxes and social security contributions are deducted from the worker's declared gross wage x, not from his true gross wage, w. As income is non-stochastic, income maximization corresponds to utility maximization, given the assumption that (indirect) utility only depends on net income.

The firm and the worker agree to choose x so as to maximize the expected total surplus available to them, equivalent to the product minus total expected payments to fiscal authorities, represented by taxes and social security contributions paid on the declared wage and expected fines. Therefore, the optimal declaration is

$$x^* = \arg \max_{x \in [0,y]} y - \gamma f - tx. \tag{4}$$

After substituting (1) into (4), the first-order condition is

$$H(x^*) = 1 - \frac{1}{\gamma\theta} \Longleftrightarrow x^* = H^{-1}\left(1 - \frac{1}{\gamma\theta}\right).$$

11. Actually, when an audit is performed, possible realizations of profits are a continuum, due to the stochastic nature of the fine. For expositional convenience, the expected value of the fine is considered.

The second-order condition, $-t\gamma\theta h(x) < 0$, is always satisfied. The boundary condition $x \leq y$ is always satisfied. Notice that full compliance (i.e. $x = y$) does not take place unless $\gamma\theta \to +\infty$. The condition $x \geq 0$ implies that full evasion will take place, i.e. $x = 0$, when enforcement is very weak, i.e. $\gamma\theta \leq 1$. To simplify the notation, the two enforcement parameters are summarized by $\alpha \equiv 1/(\gamma\theta)$. To summarize, the solution to the reporting problem without minimum wage is given by

$$x^* = \begin{cases} H^{-1}(1-\alpha) & \text{if} \quad \alpha < 1 \\ 0 & \text{if} \quad \alpha \geq 1 \end{cases} . \tag{5}$$

As $\partial\alpha/\partial\gamma < 0$ and $\partial\alpha/\partial\theta < 0$, in an interior solution, the fraction of production that is evaded decreases as enforcement improves.

The equilibrium fine, f^*, is given by substituting (5) into (1). Substituting this into (2) and considering the free entry condition, we get the equilibrium gross wage, $w^* = y - \gamma f^*$, that substituted into (3) gives the equilibrium net income

$$I^* = y - \gamma f^* - tx^*. \tag{6}$$

To obtain a closed form solution, from now on I will assume $h(\cdot)$ to be uniform in the support $[0, y]$, i.e. $\hat{y}_i \sim U_{[0,y_i]}$[12]. The expression for the expected fine becomes[13]

$$\gamma f = \gamma t\theta(y-x)^2/(2y). \tag{7}$$

Thus, the cost of evasion is quadratic in the amount of evasion, $y - x$, as assumed, for instance, in Marion and Muehlegger (2008). The optimal reporting behavior given by (5) becomes

$$x^* = \begin{cases} (1-\alpha)\, y & \text{if} \quad \alpha < 1 \\ 0 & \text{if} \quad \alpha \geq 1 \end{cases} . \tag{8}$$

12. Notice that this assumption is needed to derive simple analytical solutions, but it is not necessary for the Propositions below to hold. What is actually required is a model that generates an internal solution to the tax evasion problem through maximization of a smooth utility function that depends on income and in which declared income increases with productivity.

13. In Tonin (2007) I present an alternative setting for imperfect detection in which the tax authority devotes an amount of "auditing resources" to every taxpayer. This gives rise to an equivalent expression for the expected fine. I also show that the mechanism presented in this paper is robust to the case of the probability of an audit being conditioned on declared income.

Thus, the model implies that, irrespective of the specific level of productivity, a constant fraction of the true tax liability is revealed to the fiscal authorities. Using (7), the expected fine is given in equilibrium by

$$\gamma f^* = \begin{cases} yt\alpha/2 & \text{if} \quad \alpha < 1 \\ yt/(2\alpha) & \text{if} \quad \alpha \geq 1 \end{cases} \tag{9}$$

and thus, substituting (8) and (9) into (6), I get the worker's equilibrium net income

$$I^* = \begin{cases} y(1-t) + \alpha yt/2 & \text{if} \quad \alpha < 1 \\ y\left[1 - t/(2\alpha)\right] & \text{if} \quad \alpha \geq 1 \end{cases}. \tag{10}$$

Given the detection technology, the expected fraction of unreported tax liability, $y - x^*$, that is discovered in case of auditing is

$$\int_x^y (\hat{y} - x^*) h(\hat{y}) d\hat{y} / (y - x^*) = \alpha/2, \tag{11}$$

i.e. a fraction corresponding to half the ratio of evaded income over true product. Thus, it is relatively easy to get away with tax-evasion. For example, in an economy where 30% of the income is concealed, only 15% of the evasion is, on average, detected in case of auditing.

III. Effects of the minimum wage

In this section, I study what are the effects of introducing a minimum monthly wage ϖ, with universal coverage, in the economy described in the previous section. Workers cannot be legally employed at a wage below the minimum, in the sense that their reported gross wage cannot be below the minimum. The assumption in the model is that the minimum wage is fixed on a monthly basis for full-time work and that no alternative working-time arrangements are available. This is a good approximation of the Hungarian case, on which I conduct the empirical analysis[14]. Moreover, in Tonin (2007), the model is extended to

14. In 2001-2000 part-timers accounted for only 3.6% of all employees. See section IV. for further details on Hungary. According to Eurostat data from LFS, the share of part-timers in Central and Eastern European countries is generally low, at around 7% of the employees. Notice that according to the OECD "To counter this [under-declaring earnings per employee], the tax authorities may appeal to employment regulations such as the minimum wage and *restrictions on part-time and temporary work*. This issue helps explain why countries with a large informal economy maintain de facto strict employment regulations, even though these

the case where the minimum wage is fixed on an hourly basis, labor supply can vary across workers and underreporting can involve both hours of work and hourly wage. The results remain qualitatively unchanged. In the following, I focus on the case with partial evasion, i.e. $\alpha \in (0,1)$ [15].

III.A. Effects on the distribution

With the introduction of a minimum wage, (4) becomes

$$x^* = \arg \max_{x \in \{0\} \cup [\varpi, y]} \quad y - \gamma f - tx.$$

The only difference is in the choice set which shrinks from $[0, y]$ to $\{0\} \cup [\varpi, y]$. The introduction of the minimum wage divides worker-firm pairs into three categories:

1. High productivity: $y_i > \varpi/(1-\alpha)$
2. Intermediate productivity: $\varpi \leq y_i \leq \varpi/(1-\alpha)$
3. Low productivity: $y_i < \varpi$.

Worker-firm pairs characterized by high productivity would have declared more than the minimum wage anyway, so they are unaffected by it. The minimum wage is instead a binding constraint for worker-firm pairs that would have declared less in its absence. I first analyze the case of low-productivity workers.

Low productivity A worker with productivity below the minimum wage, $y_i < \varpi$, can only work in the black market or be inactive. The possibility of a worker paying back part of his wage to the firm is thus excluded. The main results are qualitatively unaffected by this modelling choice. From (10), I get income in case of work in the black market, i.e. full

regulations are seen by many analysts as a prime cause of informality." (OECD, 2004, page 227, italics added).

15. For this to be the case, I need $\gamma\theta > 1$. By assumption $\theta > 1$, but γ, the probability of being subject to an audit, may be low, so this condition may seem restrictive. Notice, however, that in this model, an audit is extremely ineffective. As already mentioned if, for instance, 30% of income is evaded, only 15% of evaded income is, on average, discovered during an audit. Thus, instead of a full-fledged investigation, an audit should in the present set-up rather be interpreted as a routine check by the fiscal authorities, thus occurring much more frequently than a thorough inquiry.

evasion,

$$I_{bm} \equiv y_i \left[1 - t/\left(2\alpha\right)\right]. \tag{12}$$

Income in case of inactivity is assumed to be 0. The labor market status is chosen by comparing income in the two cases, giving the following condition

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

Then, if $\alpha > t/2$, workers with productivity below the minimum wage work in the black market, otherwise they withdraw from the labor market. Thus, the prediction is that, for a given tax rate, in economies where enforcement is quite effective, i.e. α is low, the minimum wage pushes workers into inactivity and therefore, it has a negative impact on efficiency, as productive labor remains idle. Instead, in economies where enforcement is not very effective, the minimum wage has no negative impact on efficiency as workers continue to produce in the black market. Naturally, this is true as far as going completely underground does not entail a drop in productivity.

Intermediate productivity The possibility of declaring the minimum wage and thus, participating in the formal labor market, is available for worker-firm pairs whose optimal declaration in case of no minimum wage regulation is less than ϖ, but with a productivity above ϖ, i.e.

$$(1-\alpha)y_i \leq \varpi \leq y_i \Leftrightarrow \varpi \leq y_i \leq \varpi/\left(1-\alpha\right). \tag{13}$$

Income in case of declaring ϖ is given by substituting $x = \varpi$ in (7) and (6)

$$I_{mw} \equiv y_i(1-t) + \left(y_i - \varpi\right)t - t\left(y_i - \varpi\right)^2/\left(2\alpha y_i\right). \tag{14}$$

Declaring a wage higher than the minimum is never optimal for this group. Moreover, as $I_{mw} > 0$ for productivities satisfying (13), these workers will never go into inactivity. The choice is thus between declaring the minimum wage or working in the black market and declaring 0. The comparison between income in case of declaring the minimum wage and

income in the black market as given by (12) gives the following condition

$$I_{mw} \geq I_{bm} \Leftrightarrow y_i \geq \varpi / \left[2(1-\alpha)\right] \equiv y_{mw}. \tag{15}$$

As the choice between employment at the minimum wage and employment in the black market is only relevant for workers satisfying (13) to determine the behavior once a minimum wage is introduced, it is necessary to position y_{mw} in the interval $[\varpi, \varpi/(1-\alpha)]$. 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 defined by condition (13). 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.

The results are summarized in the below proposition.

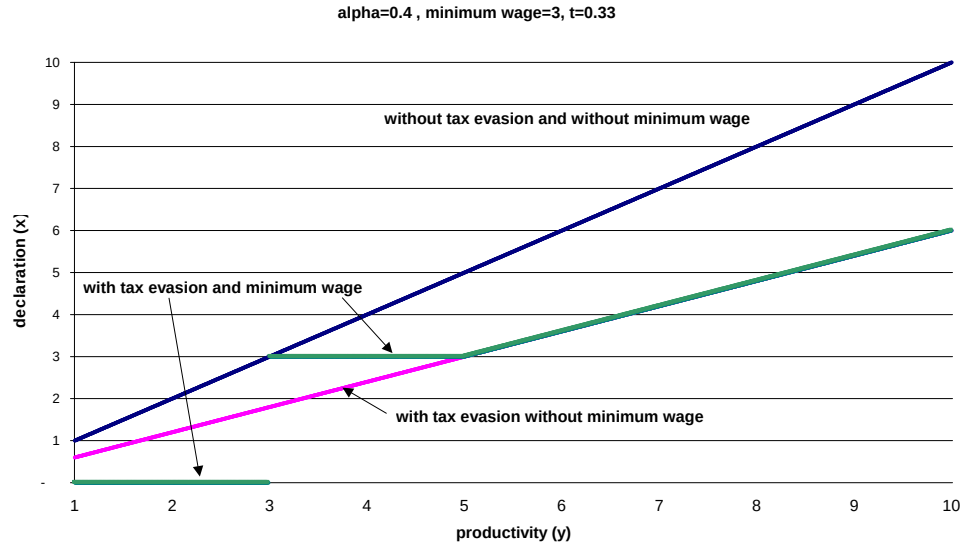
Proposition 1 *The introduction of the minimum wage in an economy with underreporting of earnings induces some workers to increase compliance by increasing declared earnings to the minimum wage level. Workers with a high productivity are unaffected. Workers with a productivity below the minimum wage work in the black market if enforcement is not too effective, otherwise they withdraw from the labor force.*

The distribution of declared earnings x before the introduction of the minimum wage is given by

$$g_x(x) = \begin{cases} g\left(\frac{x}{1-\alpha}\right) & if \quad \underline{y}(1-\alpha) < x < \bar{y}(1-\alpha) \\ 0 & otherwise \end{cases},$$

where $g(\cdot)$ is the pdf of the productivity distribution. After the introduction of the minimum

FIGURE I: DECLARED INCOME



wage, the distribution of declared earnings is given by

$$g_{mw}(x) = \begin{cases} \int_{\underline{y}}^{\varpi \max\left\{\frac{1}{2(1-\alpha)},1\right\}} g(y)dy & if \quad x = 0 \\ \int_{\varpi \max\left\{\frac{1}{2(1-\alpha)},1\right\}}^{\frac{\varpi}{1-\alpha}} g(y)dy & if \quad x = \varpi \\ g\left(\frac{x}{1-\alpha}\right) & if \quad \varpi < x \leq \bar{y}(1-\alpha) \\ 0 & otherwise. \end{cases}.$$

Thus, a "smooth" distribution of productivity is associated with a "smooth" distribution of declared earnings without a minimum wage. However, with the introduction of the minimum wage, two spikes appear at the minimum wage level and at zero. Thus, I can state the following:

Proposition 2 *In a perfectly competitive labor market with underreporting of earnings, a spike at the minimum wage level appears in the distribution of declared earnings.*

Figure I depicts declared income as a function of productivity with and without the minimum wage. Declared income when there is no tax evasion is also plotted as a reference.

III.B. Fiscal effects

The minimum wage divides worker-firm pairs into three categories: those declaring nothing, those declaring the minimum wage and the unaffected, i.e. those declaring more than the minimum. Here, I first determine payments to fiscal authorities for each category. Then, I use the above analysis of the distribution of declared earnings to find out the effects of the minimum wage on fiscal revenues.

Payments to fiscal authorities Total payments, P, to fiscal authorities include taxes, T, and expected fines, F. For worker-firm pairs not affected by the minimum wage, taxes are $T_1 = yt(1-\alpha)$, while expected fines are $F_1 = yt\alpha/2$, giving a total payment of

$$P_1 = (1-\alpha/2)ty.$$

Underreporting gives worker-firm pairs with a relatively high productivity the opportunity to reduce the "effective"[16] tax rate by a factor $\alpha/2$. For worker-firm pairs declaring the minimum wage, taxes are $T_2 = t\varpi$, expected fines are $F_2 = t(y-\varpi)^2/(2\alpha y)$, giving a total payment of

$$P_2 = t\varpi + t(y-\varpi)^2/(2\alpha y).$$

The remaining category is represented by worker-firm pairs that are either in the black economy (when $\alpha \geq t/2$) or do not participate in the labor market (when $\alpha < t/2$). For workers in the black market, fines are the only type of payment, so that

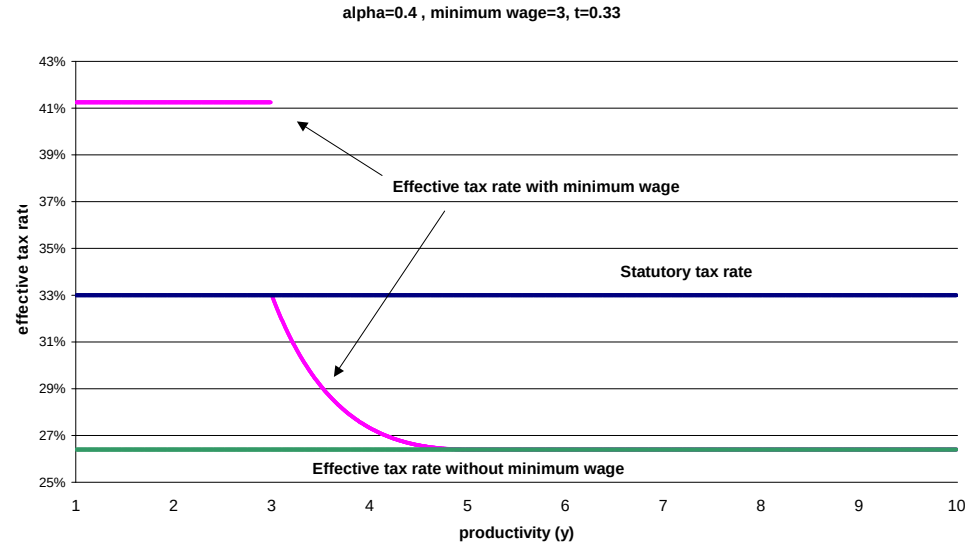
$$P_3 = F_3 = ty/(2\alpha).$$

Workers who withdraw from the labor market do not contribute to the public finances. Notice that $P_3/y \geq P_2/y \geq P_1/y$ in the relevant intervals[17]. Expected payments as a portion of income are highest for worker-firm pairs in the black economy and lowest for worker-firm pairs not affected by the minimum wage. Thus, considering expected total payments, it is

16. In the sense of total expected payments to fiscal authorities, including fines, over total product, i.e. P/y.

17. In particular, $P_2/y \geq P_1/y \ \ \forall y$, $P_3/y \geq P_1/y \ \ \forall y, P_3/y \geq P_2/y \Leftrightarrow y \geq \varpi/[2(1-\alpha)]$. As only workers with productivity $y_i \geq \varpi \max\{1, 1/[2(1-\alpha]\}$ will declare the minimum wage, $P_3/y \geq P_2/y$ for the relevant interval.

FIGURE II: EFFECTIVE TAX RATE



Effective Tax Rate = Total Payments to Fiscal Authorities / Productivity

possible to state the following:

Proposition 3 *The interaction of minimum wage and underreporting transforms a nominally neutral tax system into a regressive one.*

The intuition behind this result is simple: worker-firm pairs try to minimize the share of the product paid to fiscal authorities. The minimum wage is not a binding constraint for high productivity workers who manage to reduce the "effective" tax rate. For instance, if $\alpha = 40\%$, the "effective" tax rate for these workers is 80% of t. For workers with intermediate productivity, the minimum wage is binding. Thus, they are less "successful" in minimizing their "effective" tax rate, even if they still manage to reduce it below t. Low productivity workers are even more constrained, as their only choice is to work in the black market or withdraw from the labor market, and they may end up facing an "effective" tax rate above t. With $\alpha = 40\%$, for instance, the "effective" tax rate for these workers is indeed 125% of t. Figure II shows the effective tax rate as a function of productivity.

Effects of the minimum wage on revenues When workers with productivity below the minimum wage work in the black market, i.e. when $\alpha \geq t/2$, total revenues R are given by

$$R = \int_0^{\varpi \max\left\{\frac{1}{2(1-\alpha)},1\right\}} ty/\left(2\alpha\right) g\left(y\right) dy + \int_{\varpi \max\left\{\frac{1}{2(1-\alpha)},1\right\}}^{\varpi/(1-a)} \left[t\bar{w} + t\left(y-\varpi\right)^2/\left(2\alpha y\right)\right] g\left(y\right) dy +$$

$$+ \int_{\varpi/(1-a)}^{\bar{y}} \left(1-\alpha/2\right) tyg(y)dy. \tag{16}$$

The marginal worker is indifferent between being employed in the black market or declaring the minimum wage if $\alpha > 1/2$, while he prefers not to be completely underground if $t/2 \leq \alpha \leq 1/2$. In the first case, the only effect of a marginal increase in the minimum wage is to extract higher payments from workers declaring it while in the second case, there is the additional effect of pushing worker-firm pairs previously in the official economy into the black market. In both cases, total revenues increase with an increase in the minimum wage, i.e.

$$\frac{\partial R}{\partial \varpi} > 0.$$

When workers with a productivity below the minimum wage withdraw from the labor market, i.e. when $\alpha < t/2$, there is no black market from which to extract fines, and total revenues are given by the last two terms in expression (16). Then,

$$\frac{\partial R}{\partial \varpi} = -t\bar{w}g(\varpi) + \int_{\varpi}^{\varpi/(1-a)} \left[1-\left(y-\varpi\right)/\left(\alpha y\right)\right] tg(y)dy.$$

The first term represents the fiscal loss due to the withdrawal of workers from the labor market, the second term the higher payments by workers declaring the minimum wage. The net effect depends on the shape of the distribution. It is possible then to state the following proposition:

Proposition 4 *When underreporting is high, revenues increase with the minimum wage. When underreporting is low, the effect of increasing the minimum wage on revenues depends on the productivity distribution.*

The intuition is straightforward: maximization of workers' net income is equivalent to minimization of transfers to the government. Choice is limited to the possible declaration space $\{0\} \cup [\varpi, +\infty)$. Increasing the minimum wage shrinks the possible declaration space, so that the newly chosen compliance after the increase in the minimum wage cannot make workers better off. When the increase in the minimum wage does not have a negative impact on production, i.e. it does not "shrink the pie", this implies that the government cannot be made worse off, i.e. revenues cannot decrease. This can be counterbalanced by a decrease in revenues due to reduced total production when an increase in the minimum wage pushes low productivity workers out of the labor market.

This implies that countries where underreporting is serious because of limited enforcement capacity can use the minimum wage to boost fiscal revenues, without having to worry too much about the impact on efficiency. As enforcement improves, the minimum wage becomes a less effective fiscal instrument and efficiency issues become more prominent. However, equity issues are also at stake, as the minimum wage increases revenues by extracting more payments from low productivity workers.

III.C. The impact of a minimum wage hike

Here, I characterize the effects of a minimum wage hike on disposable income. Suppose that in the first period, the minimum wage is ϖ_1, increasing to $\varpi_2 > \varpi_1$ in the second period. The change in income due to the minimum wage hike is $\Delta I = I_2 - I_1$, where I_t is income in period t.

If a worker already operates in the underground market or declares earnings above ϖ_2 in the first period, he will not change his behavior after the minimum wage hike and thus, his income remains unchanged, $\Delta I = 0$. A worker whose official earnings are exactly equal to the minimum wage in the first period, ϖ_1, may experience an increase in declared earnings to ϖ_2, with a corresponding income change of

$$\Delta I = -t\left(\varpi_2 - \varpi_1\right)\left[\varpi_2 + \varpi_1 - 2y(1-\alpha)\right] / \left(2\alpha y\right) < 0 \ ^{18}.$$

Alternatively, his declared earnings may decrease to 0. The income change in this case is

18. This is due to the fact that workers in this situation have productivity y_i s.t. $(1-\alpha)\, y_i \leq \varpi_1 < \varpi_2$.

given by

$$\Delta I = t\varpi_1 \left[\varpi_1 - 2y(1-\alpha)\right] / (2\alpha y) < 0 \ ^{19,20}.$$

In any case, the minimum wage hike results in an income decline for this type of worker. The last type of worker to be analyzed here is the one with declared earnings between the old and new minimum wage in the first period. Also in this case declared earnings may increase in the second period to ϖ_2, resulting in an income drop given by

$$\Delta I = -t \left[y\left(1-\alpha\right) - \varpi_2\right]^2 / (2y\alpha) < 0,$$

or decrease to 0, with the corresponding income change given by

$$\Delta I = -ty\left(1-\alpha\right)^2 / (2\alpha) < 0 \ ^{21}.$$

Notice that the decline in income for workers declaring ϖ_2 in the second period increases as the distance between the declared income in the first period and ϖ_2 increases. Thus, a worker who was declaring marginally above the minimum wage ϖ_1 in the first period and increases his declaration to ϖ_2 experiences a larger income decline than a worker also declaring ϖ_2 in the second period, but whose declared income in the first period was higher. The income decline is even larger for workers who declared the minimum wage in the first period. The model thus predicts the following:

Proposition 5 *As a result of a minimum wage hike, workers whose declared earnings before the hike are between the old and the new minimum wage experience a decline in income. Other workers are unaffected. For those workers declaring the new minimum wage after the hike, the decline in income increases with the distance between the new minimum wage and the declared income before the hike.*

The intuition behind these results is that increasing the minimum wage effectively shrinks the choice set of workers declaring an amount between the new and the old minimum wage

19. This is due to the fact that workers in this situation have productivity y_i s.t. $y_i > \varpi_1$ if $\alpha \leq 1/2$ and $y_i > \varpi_1 / \left[2(1-\alpha)\right]$ if $\alpha > 1/2$.

20. This assumes that workers go underground. If $\alpha < t/2$, so that workers withdraw from the labor market, the decline in income is obvious.

21. See previous note.

in the previous period, thereby making them worse-off. These predictions are tested in the following section.

IV. The empirical effect of a minimum wage hike on incomes

I test the above prediction of the model by analyzing the effects of the massive increase in the minimum wage that took place in Hungary in 2001.

In Hungary underreporting of earnings is widespread[22]. For instance, 56% of the households interviewed in a survey claim that in their neighborhood, employers are declaring the minimum wage to the tax authority, while unofficially paying additional wages (ECONSTAT, 1999.) This may be related to the fact that taxation on labor is very heavy, also for low paid workers. In the period 2000-2002, the tax wedge on a single person without children earning 2/3 of the average production wage was at around 46%, i.e. one of the highest in Europe, with marginal rates above 55% (OECD, 2001 and 2002).

The statutory minimum wage[23] was increased from 25,500 HUF in 2000 (98 EUR or 90 USD using the average exchange rate for the corresponding year) to 40,000 HUF in 2001 (156 EUR, 140 USD.) As a consequence, the corresponding total monthly payments to the fiscal authorities (PIT and SSC) increased by around 9,000 HUF (36 EUR, 32 USD)[24]. It is interesting to notice how the hike was decided one-sidedly by the centre-right government, against the opposition of the largest trade union federation. The share of full-time employees

22. The failure to correctly report tax liability involves the payment of a penalty corresponding to 50% of the tax evaded, plus late payment interest corresponding to twice the prime rate of the Hungarian National Bank, at around 11% in the period 2000-2001, for up to three years (OECD, 2004b). Economic organizations with legal entity status were in the period 2000-2001 subject to a 45% "audit intensity", defined as the number of completed audits in the tax year (without cash-flow audits) divided by the number of taxpayers in the given taxpayer group at the end of the previous year. The corresponding number for economic organizations without legal entity status was around 19% (APEH, 2006).

23. The statutory minimum wage covers all employment contracts and relates to gross monthly earnings net of overtime pay, shift pay and bonuses for full-time employment. For part-timers, it is proportionally lower, but part-timers only account for a small portion of all employees (3.6% in 2001-2002). Regarding contractual types, the only source of data I am aware of, the Hungarian Unemployment Insurance Exit to Job Survey, reports that 64.7% of the low-wage UI recipients who found a job in April 2001 received a fixed salary, 33.8% were paid an hourly wage and the remaining 1.5% concluded a business contract with the employer (Kertesi and Köllő, 2003). Thus, the model assumption of a monthly minimum wage is well suited for the Hungarian case.

24. See table II for details.

paid 95%-105% of the minimum wage in firms employing more than five workers jumped from 5% in 2000 to 12.1% in 2001 (Kertesi and Köllő, 2003). The labor market impact of this massive hike was modest. Kertesi and Köllő (2003) compare the job loss risk of workers earning 90-110% of the minimum wage in 2001 to that of workers earning 110-125% and find only a small effect on the quarterly outflow into unemployment[25], while they find no effect on the flow from employment to non-participation. They also find a high level of compliance with the minimum wage regulation, with only a minor spillover on the wage distribution[26]. The conclusion of their study is that "despite the brutal price shock the immediate effect did not seem dramatic". Overall, in the period 2000-2001, the activity rate remained stable at around 60%, with unemployment declining from 6.4% to 5.7% and youth unemployment from 12.5% to 11.3% (see table I for more details).

Hungary is thus an ideal case to study the interaction between tax evasion and minimum wage: underreporting is widespread and in 2001 a massive minimum wage hike took place with a very modest impact on the labor market. To the best of my knowledge, no other institutional change took place at the same time that may affect income or food consumption. In what follows, I describe the empirical methodology and results.

IV.A. The statistical framework

The prediction of the model derived in the previous section is that as a consequence of a minimum wage hike disposable income, I, declines for workers affected by the minimum wage hike, i.e. $\Delta I < 0$, while it does not change for unaffected workers. Disposable income is the sum of after-tax declared labor income, $(1-t)x$, other declared income and undeclared income. Affected workers who do not go completely underground experience an increase in declared income that is more than compensated by a decline in undeclared income, so that disposable income indeed declines. This is due to the fact that declaring previously undeclared income makes it subject to taxation. Disposable income at the household level is

25. For a 25-year old male with five years of tenure, for instance, the estimated quarterly flow is 0.243% for the treated and 0.119% for the control group. At average age and tenure of the control group (40, 7.33), the figures are 0.0168% for the treated and 0.0068% for the control group. Average age and tenure of the treatment group are not very different at 39.2 and 6.67, respectively. Notice that both these rates indicate rather long prospective tenures and thus a very modest job-loss risk, even for workers affected by the minimum wage.

26. Looking at the job finding probability, they find a 7-8% drop for the low-wage unemployed, defined as those receiving lower than average unemployment benefits, relative to the unskilled as a whole, defined as those with less than secondary education.

the sum of disposable income for all household members, $Y = \sum_j I_j$, and equals the sum of after-tax declared income at the household level, Y^D, and undeclared income at household level, Y^U,

$$Y = Y^D + Y^U. \tag{17}$$

To test the prediction of the model, in the empirical analysis I look at the dynamics of food consumption, as a proxy for the unobservable disposable income, for households that appear to benefit from the minimum wage hike, the treatment group, and for similar but unaffected households, the control group. The use of food consumption is standard in the literature estimating tax evasion by using household budget survey data. This is due to the fact that food consumption is more precisely recorded than consumption of other types of goods. This is the case also for the dataset used here: data on consumption of food and some other items, e.g. some types of clothing, come from a diary that each household keep in a given month during the year, while expenditures of more significant value are retrospectively collected for the year as a whole in subsequent interviews (see the Appendix and Kapitány and Molnár, 2004, for more details).

If households are credit constrained, then food consumption for household i at time t, $C_{i,t}$, depends on disposable income, so that

$$C_{i,t} = Z_{i,t}\varphi + \delta Y_{i,t} + error, \tag{18}$$

where $Z_{i,t}$ is a row vector of household characteristics. Taking first differences, I get

$$\Delta C_i = \Delta Z_i \varphi + \delta \Delta Y_i + error, \tag{19}$$

and substituting expression (17) for disposable income,

$$\Delta C_i = \Delta Z_i \varphi + \delta \Delta Y_i^D + \delta \Delta Y_i^U + error. \tag{20}$$

The change in unreported income, ΔY_i^U, is unobservable, but according to the theory, the minimum wage hike represents a shock to the "underreporting technology" for some households as some of their members are forced to decrease underreporting to remain employed in

the formal labor market. Households unaffected by the minimum wage hike should instead not change their reporting behavior. This variation is used to identify the impact of the minimum wage on tax evasion. Thus, the following specification is estimated

$$\Delta C_i = \vartheta + \Delta Z_i \varphi + \delta \Delta Y_i^D + \beta TREAT_i + \varepsilon_i, \tag{21}$$

where ΔC_i is the change in food consumption in two consecutive years, ϑ is a constant, $TREAT_i$ is an indicator of whether a given household have been affected by the minimum wage hike, the exact definition of which is provided in what follows, and ε_i is a random error term. This specification is similar to the one used in Johnson, Parker, and Souleles (2006) to study the impact of the 2001 federal income tax rebates on consumption expenditures. The coefficient of interest is β and the theory predicts it to be negative.

If households are not credit constrained and consumption depends on permanent income, Y^P, then expressions (18) and (19) should have $Y_{i,t}^P$ instead of $Y_{i,t}$. Assuming the relationship between the change in permanent income and the change in disposable income is given by

$$\Delta Y_i^P = \lambda \Delta Y_i + error, \tag{22}$$

then (20) becomes

$$\Delta C_i = \Delta Z_i \varphi + \lambda \delta \Delta Y_i^D + \lambda \delta \Delta Y_i^U + error \tag{23}$$

and can still be estimated through (21). The difference is that now in ε_i there is also the error term from expression ((22). Particular care must thus be taken not to confound the shock to the ability to underreport with other shocks to permanent income related to the minimum wage hike due, for instance, to increased labor market risk. For this reason, I consider in the analysis only employees who remained employed for at least 12 months after the hike: their employment status is clearly not adversely affected by the minimum wage hike in this period. Also, in some specifications, I control for a rich set of employee characteristics and geographical dummies, thus controlling for possible shocks along these dimensions.

It is important to underline that the reason for preferring a specification in levels to one in logs is that the shock to underreporting is not proportional to income but absolute. Every worker declaring the minimum wage in 2000 and then increasing his declaration to the new

minimum in 2001 experiences a decline in his income of around 9,000 HUF, irrespective of differences in the income level that may arise from the availability of other sources of income or heterogeneity in the degree of underreporting.

All regressions include a set of dummies allowing for different trends depending on the months in which the household is surveyed in two consecutive years. These dummies control for time shocks, e.g. seasonal fluctuations in food prices. As already mentioned, a set of regressions also includes controls for all employee characteristics available in the dataset (sector of employment, position, type of employer) and for geographical characteristics (county and type of settlement). These variables control, for instance, for labor market shocks that are specific to a given sector or to a specific area of the country or for differences in food inflation among different types of settlements, e.g. cities or villages. Also, in some specifications I do not control for changes in reported income. The exact definition of all variables is provided in the Appendix.

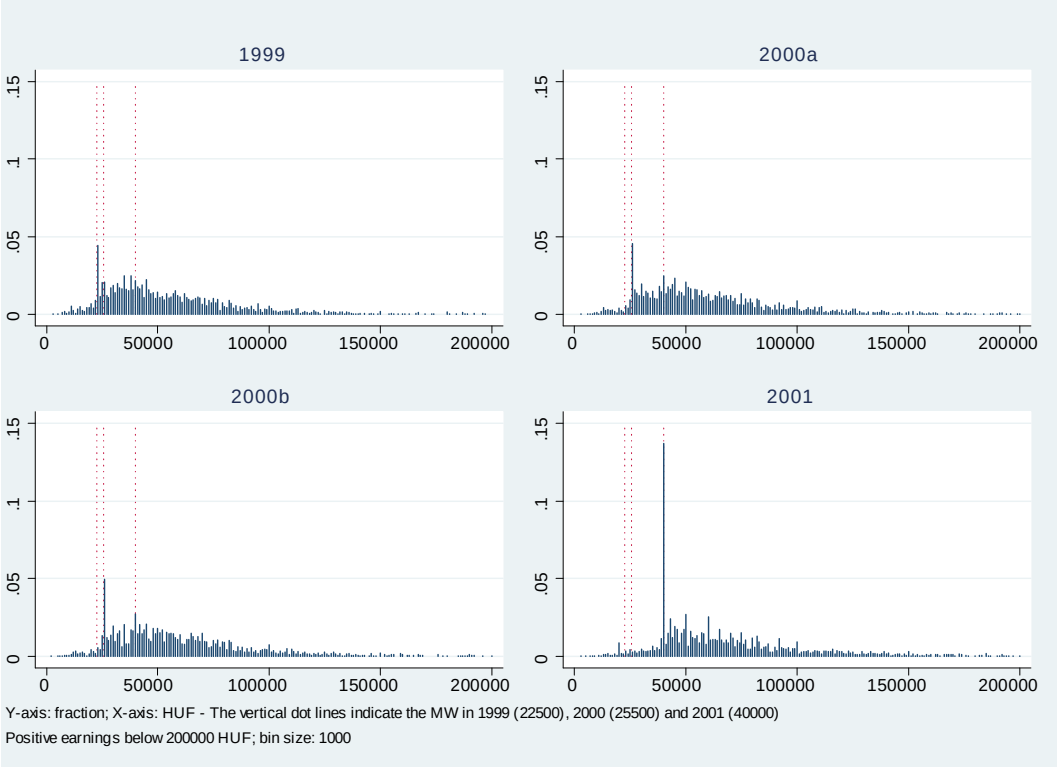
IV.B. Empirical implementation

I use data from the Hungarian Household Budget Survey Rotation Panel[27], in particular the 1999-2000 and 2000-2001 panels. More information about the way the survey is conducted is available in the Appendix and in Kapitány and Molnár (2004). It is worth underlining that surveyors are expected to collect the income data from documentation like the tax return sheet or the tax certification of employer. This makes it more likely that income in the survey corresponds to income reported to the fiscal authorities, rather than to the possibly different true income. The distribution of earnings in the dataset (see figure III) clearly presents a spike at the minimum wage level, corresponding to 4-5% in 1999-2000 and increasing to around 14% in 2001. These figures are consistent with LFS data and underline the relevance of the minimum wage hike.

I consider a household as treated if at least one of its members has been affected by the minimum wage hike. I use two different methods to single out these individuals. In the first case, I select individuals employed in 2000 at a wage between the minimum wage in 2000 and the will-be minimum wage in 2001. The treatment group is thus only defined on basis

27. The Hungarian Household Budget Survey Rotation Panel is created by the Institute of Economics (IE), Hungarian Academy of Sciences from the original HHBS of the Hungarian Central Statistical Office. The data set is work in progress. The IE made every effort to clean the data and it cannot be held liable for any remaining errors.

FIGURE III: EARNINGS FROM MAIN ACTIVITY



of pre-treatment characteristics. In the second case, I impose an additional requirement: being employed in 2001 at the minimum wage. The reported earnings of these employees are thus actually pushed up by the policy intervention while, in the former case, they were only potentially pushed up. For this reason, I label the two cases "actual" and "potential". In both instances, I define the variable "treatment" as the number of household members conforming to the above mentioned criteria. I also employ an alternative definition of treatment. Instead of simply counting their number, I sum up the difference between the minimum wage in 2001 and earnings in 2000 for all members of the household affected by the hike. The aim of this continuous measure is to capture the intensity of treatment. I label this definition of treatment "continuous" as opposed to the "dummy" treatment previously described.

I define households in the control group on the basis of the presence among their members of individuals earning somewhat more than the 2001 minimum wage. To check for the validity of the control group, below I conduct a "placebo test" where I ascertain the absence of a treatment effect in the pre-policy period. For this purpose, I look at changes in food consumption in the period 1999-2000. Sample size considerations restrict this analysis to

the "potential" treatment case.

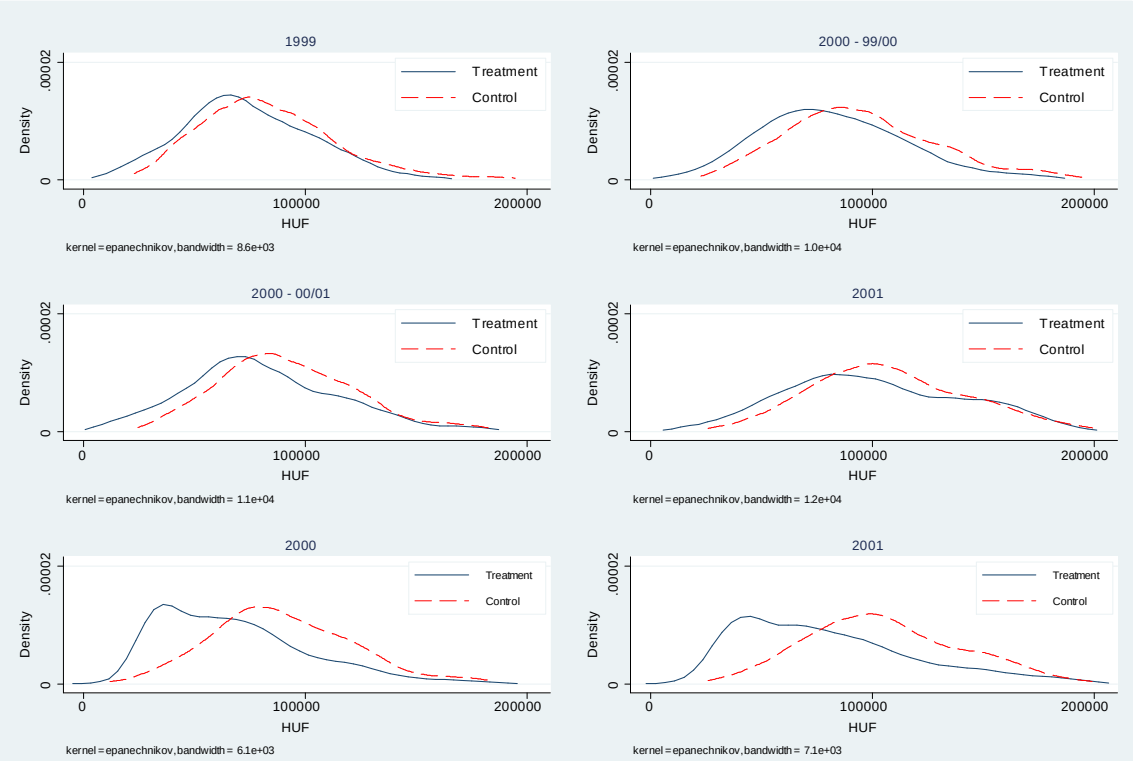
To ensure comparability, I restrict the analysis to households that keep a constant composition and whose income is within certain limits. Moreover, I consider only employees with stable positions, i.e. employees who keep their job for at least 12 months after the minimum wage hike, to avoid confounding an increase in labor market risk with an increase in compliance with fiscal regulation[28]. I provide the precise definitions of treatment and control groups in what follows.

All regressions include a set of dummies for the months in which the household kept the diary. These dummies control for time shocks, e.g. fluctuations in food prices. A set of regressions also includes controls for all employee characteristics available in the dataset (sector of employment, position, type of employer) and for geographical characteristics (county and type of settlement). These variables control, for instance, for labor market shocks that are specific to a given sector or for differences in food inflation among different areas of the country. Also, in some specifications I control for changes in reported income.

Potential treatment For the potentail treatment case, I analyse the two panels covering the years 1999-2000 and 2000-2001. For each two-year panel, I consider only households that kept a constant composition in the period and that had a positive monthly net income below 200,000 HUF (approx. 780 EUR) in both years. Moreover, I only consider households where at least one member has been employed for the whole period and whose wage in 2000 is between the minimum wage in 2000 and 200% of the minimum wage in 2001. I restrict the sample in this way to ensure comparability between treatment and control groups. In the "dummy treatment", the variable $TREAT_i$ contains the total number of members of household i classified as private sector employees who have been employed for the whole period and who in the year 2000 earn a wage between the minimum wage in that year (25,500 HUF) and the minimum wage in the year 2001 (40,000 HUF). In the "continuous treatment", the variable $TREAT_i$ is the sum within household i of the difference between the minimum wage in 2001 and the wage in 2000 for the same people as in the "dummy treatment".

28. Excluding individuals who become unemployed after the minimum wage hike does not entail a big loss in terms of observations. Of the 301 individuals who were employed in the private sector for the whole of 2000 at a wage between the minimum wage in 2000 and the will-be minimum wage in 2001, 20 were unemployed in 2001.

FIGURE IV: HOUSEHOLD INCOME DISTRIBUTION



Upper and middle row : Potential Treatment; Low er row : Actual Treatment

It is worthe noticing how households in the treatment and in the control group are very similar. In 2001 the total net income of households in the control group is only 7% higher than net income of households in the treatment group (see table III) and there is considerable overlap in the distribution of income (see figure IV, first two rows). This is due to the fact that workers affected by the minimum wage are not the sole earners in the household. Both types of household spend around 25% of net income in food and the estimated relationship between food consumption and income is very similar in the pre-treatment period (see figure V, first two rows).

The estimation results (see table IV) show that the dynamic of food consumption did not differ between the treatment and control group in the pre-treatment period 1999-2000. This placebo test confirms the validity of the control group. As predicted by the theory, the coefficient of the treatment variable is always negative and significant in the period 2000-2001, after the policy has been implemented. The magnitude of the estimated coefficients of around 1,300-2,000 HUF (5-8 EUR) in the "dummy treatment" represents 6-9% of food

consumption for the treatment group. Thus, they are also economically significant. Gross reported earnings by "treated" employees increased by around 15,000 HUF on average. According to the model, this should translate into a drop in true income of more than half of that quantity, due to increased fiscal payments. Considering that around a quarter of the income is spent on food consumption, the magnitude of the coefficients is reasonable. In the "continuous treatment", the estimated coefficients are between -0.12 and -0.20. Having earnings pushed up by the minimum wage hike by 1 HUF implies, according to the model, a decrease in true income of around 0.5 HUF due to fiscal imposition. Thus, also the magnitude of these coefficients is reasonable.

Actual treatment For the actual treatment, I use only the 2000-2001 panel. Also in this case, I restrict the sample to households that kept a constant composition in the period and with a positive net income below 200,000 HUF (approx. 780 EUR) in both years. Moreover, I only select households with at least one member employed during the whole of 2001 at a wage between 90% and 200% of the minimum wage in 2001.

I consider an employee's fiscal behavior as affected by the minimum wage hike if two criteria are satisfied:

1. in 2000, he must have been employed at a wage between 90% of the minimum wage in 2000 and 110% of the minimum wage in 2001;

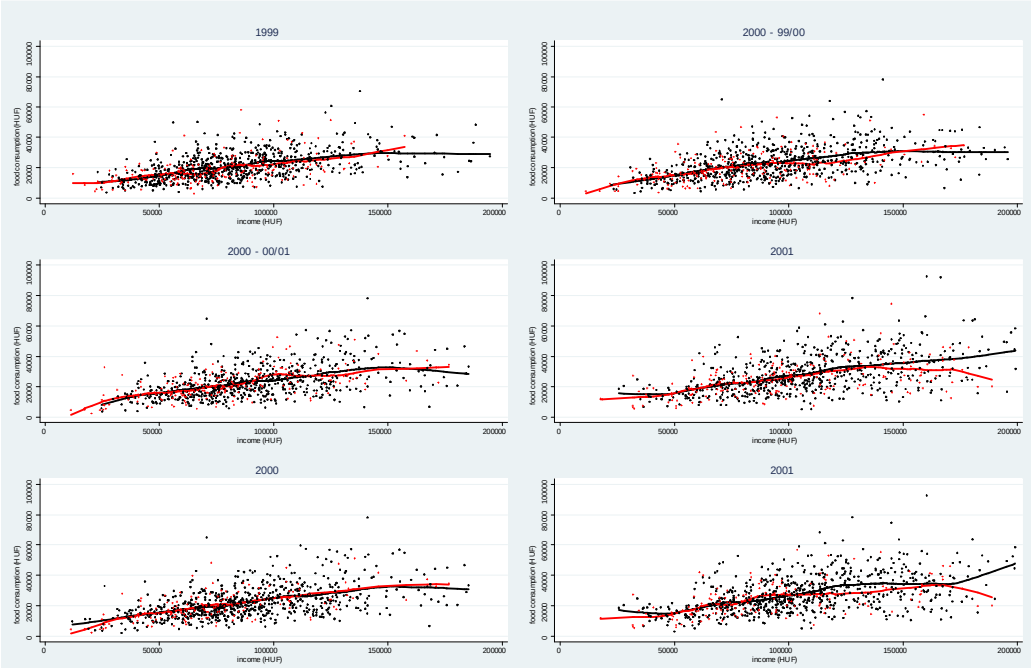
2. in 2001, he must earn a wage between 90%-110% of the minimum wage in 2001, be employed in the private sector and for the whole of 2001;

In the "dummy treatment", the variable $TREAT_i$ contains the number of household members satisfying these criteria. In the "continuous treatment", the variable $TREAT_i$ is the sum within household i of the difference between the minimum wage in 2001 and the wage in 2000 for the same people as in the "dummy treatment" with the difference that 100% and not 110% of the minimum wage in 2001 are used as the upper bound.

Also in this case, households in the treatment and control group are very similar[29], with total net income only 13% higher in 2001 for the control group than for the treatment group (see table V) and with substantial overlapping in the distribution of income (see figure IV,

29. The descriptive analysis is limited to the definitions used in the "dummy treatment".

FIGURE V: FOOD CONSUMPTION AND INCOME



Upper and middle row: Potential Treatment; Lower row: Actual Treatment
Lowess smoothing (bandwidth: 0.25). Red: treatment group; Black control group

last row). Both types of household spend around 26% of net income in food and the estimated relationship between food consumption and income is also in this case very similar in the pre-treatment period (see figure V, last row).

The estimation results confirm the previous analysis (see table VI). In the "dummy treatment", the coefficient of interest is always negative, statistically significant, and of a similar magnitude to the coefficients in the "potential treatment" case. Also in the "continuous treatment", the coefficient of interest is always negative and of a similar magnitude to the coefficients in the "potential treatment" case. Statistical significance is achieved when additional controls beside month dummies are included. Also in this case the magnitude of the coefficient is economically significant.

Robustness checks I repeated the above analysis for two fictitious minimum wage hikes: an increase from 50,000 HUF to 64,500 HUF and an increase from 50,000 HUF to 78,431 HUF. The starting point of 50,000 HUF has been chosen so that there is no overlap between individuals affected by the real hike and the ones considered to be affected by the fictitious

hike. The end points have been chosen so that the absolute difference between the two minimum wages or their ratio is the same as in the real case. All other quantities have been modified accordingly. For these two fictitious cases, there is never a significant treatment effect (results not reported). This indicates that the treatment effect found in the main analysis is not a statistical artifact, but is indeed due to the minimum wage hike.

To check whether the treatment effect is due to substitution between consumption items, I repeated the analysis for thirteen other consumption categories (results not reported). The treatment effect is significantly negative in some specifications for the "beverages and tobacco" category. The treatment effect for "total expenditures" has generally a negative sign in both the "actual treatment" specification and the "potential treatment" post-policy intervention period, but it is not significant. The lack of significance in this and in most of other categories is not surprising, as the use of food consumption in the literature is justified by the fact that in household budget surveys this item is measured with much higher precision than other types of consumption. All in all, what can be concluded is that there is no evidence of substitution effects.

To summarize, treated households experience a significant drop in their consumption of food compared to households in the control group. This is the case even if they appear to actually benefit from the minimum wage hike, in that their reported net income increases more than for the control group, both in absolute and in relative terms. A series of placebo tests confirms that this is indeed due to the minimum wage hike. Moreover, considering only households who appears to benefit from the hike excludes the alternative explanation of an adverse labor market effect of the minimum wage. Thus, we can conclude that the empirical analysis supports the theoretical prediction about the minimum wage impact on fiscal compliance.

V. Conclusions

This paper examines an aspect of minimum wage policy that has not been investigated before, by looking at its interaction with tax evasion by employed labor. There are important policy implications for countries where underreporting of earnings is a relevant phenomenon. On the one hand, if the aim of the minimum wage hike is to boost income for those affected, as is often claimed when such policies are introduced, the policy move could have opposite

consequences, if no corrective measures are taken on the fiscal side. An increase in officially reported income could actually correspond to a decrease in true income, unless the minimum wage hike is accompanied by a decrease in fiscal pressure for minimum wage earners. On the other hand, if the aim is to contrast underreporting of earnings, introducing or increasing the minimum wage may represent an effective measure that may prove to be cost effective as compared to more direct measures aimed at fighting the black economy, such as hiring new tax inspectors. The minimum wage targets the lower end of the productivity distribution, but this may be desirable as there is some evidence that tax evasion among employees is concentrated here (Lemieux et al. [1994]; Fiorio and D'Amuri [2005]). Admittedly, the minimum wage represents a rather blunt instrument to fight underreporting, but it may be sharpened by differentiating it along dimensions related to productivity (see for instance the Bulgarian experience [Koleva, 2007; Neykov, 2003]).

There are also implications for the most researched aspect of minimum wage policy, i.e. its effect on employment. Unreported income may act as a buffer to absorb minimum wage shocks, implying that the employment effect of a minimum wage hike would be smaller in countries with a high degree of informality compared to countries where the degree of informality is lower. An example of this is the subdued employment effect of the massive minimum wage hike that took place in Hungary in 2001. Another implications is that a high spike at the minimum wage level may not be due to a relatively high and binding minimum wage, but to a high degree of informality. Some supportive cross-country evidence for European countries is presented in Tonin (2007). The paper also contributes to the literature on tax evasion by introducing a new and simple way of modelling it, based on the idea that detection is not perfect. This can be used to study other aspects of reporting behavior and tax enforcement.

Appendix

The survey and main variables

The sample consists of around 10,000 households. One third of the sample is rotated in each year. The two-year panels of interest for this study, i.e. 1999-2000 and 2000-2001, contain slightly more than 3,500 households. Notice that households interviewed from 1999

till 2001 appear in both panels, so that around half of the sample is the same in the two panels. The population of interest is considerably reduced by the fact that all adults are retirees in around 40% of the households. A household consists of individuals forming a common income and/or consumption unit, completely or partly sharing the current costs of living. The selection of the sample is done by multistrata method using census data. In a given month during the year, households keep a diary registering income and expenditures during the month and "general household characteristics" containing demographic, employment and housing data. In subsequent interviews, data on personal incomes, family income, stock of consumer durables, expenditures of significant value, are retrospectively collected for the year as a whole. The main variables and categories used are:

- "Households with constant family structure" are households where the same individuals are present for the relevant period. Restricting the analysis to this type of household reduces the sample in the panel 1999-2000 from 3581 to 3181, with a loss of 400 households, for the panel 2000-2001 the loss is of 329 households, from 3529 to 3200. The advantage of only using such households is that exactly the same individuals are observed in two subsequent years.

- M is a set of dummies capturing the month of diary keeping. So, for instance in the panel 2000-2001, there is a dummy for households that kept the diary in January 2000 and January 2001 and a different dummy for households that kept the diary in January 2000 and February 2001. Potentially, there are 144 month dummies. However, in both panels, around 70% of the households kept the diary in the same month in both years.

- "Employees" are defined as employees in public or private enterprises, institutions, co-operatives, private entrepreneurs or societies (firms owned by several private entrepreneurs) with positive earnings from their main activity during the year and positive months when earnings from the main activity have been realized. "Public employees" are defined as employees in the category "public or private enterprises, institutions", active in public administration and defence, compulsory social security, education, or health and social work. "Private employees" are all employees who are not public employees. The dataset contains the number of months in which earnings from the main activity have been realized during the year. If in a given year the number of months

corresponds to twelve, the employee is considered to have been employed the whole year.

- Employee characteristics include three sets of variables, describing the labor market characteristics of employees in the households.

    1. Sectoral: the number of employees in the household working in each of the 60 branches according to two-digit ISIC (e.g. manufacture of textiles);

    2. Position: the number of employees in the household belonging to each of the 10 categories characterizing the hierarchical position[30] (e.g. skilled worker);

    3. Type of employer: the number of employees in the household working for different types of employers[31] (e.g. private entrepreneurs);

- Geographical dummies include a set of dummies for the 20 counties into which Hungary is divided and a set of dummies capturing whether the household's place of residence is the capital, a large city, a town or a village. Note that by construction, in subsequent years the survey only includes households whose place of residence did not change.

- Income variables include household level income[32], the sum of net personal incomes of household members[33] plus other components[34].

30. top leader; leader, manager; employee with diploma; employee with secondary qualification; administrative employee; skilled worker; semi-skilled worker; unskilled worker; self-employed; family helper.

31. In 1999, the following three categories are listed: 1. public or private enterprises, institutions; 2. cooperatives, firm owned by several private entrepreneurs; 3. private entrepreneurs.
In 2000 and 2001, the following four categories are listed: 1. public or private enterprises, institutions; 2. cooperatives; 3. private entrepreneurs; 4. firm owned by several private entrepreneurs.

32. e.g. family allowance, income from dividends, income from agricultural sales.

33. e.g. income from main activity, self-employment, authorship. Paid social security contributions and personal income tax are subtracted from gross personal income to obtain net personal income.

34. e.g. income from sales of belonging. Outgoing household transfers, like maintenance for a child outside the household, are subtracted.

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TABLE I: Hungary - Main indicators

	1998	1999	2000	2001	2002
Real GDP growth	4.9	4.2	5.2	4.1	4.4
of which household consumption	4.6	4.8	5.0	5.7	9.8
Household saving rate (% GDP)	9.5	7.0	5.7	5.2	2.7
CPI	14.3	10.0	9.8	9.2	5.3
Gross monthly earnings per full-time employee					
- HUF	67764	77187	87645	103553	122482
- real growth (%)	3.5	5.5	3.4	8.1	12.3
Net monthly earnings per full-time employee					
- HUF	45162	50076	55785	64913	77622
- real growth (%)	3.6	2.5	1.5	6.4	13.6
Activity rate (% pop. aged 15-64)	58.7	59.8	60.1	59.6	59.7
Employment rate (% pop. aged 15-64)	53.7	55.6	56.3	56.2	56.2
Unemployment rate (% labor force 15+)	7.8	7.0	6.4	5.7	5.8
Youth unemployment rate (% labor force 15-24)	15.0	12.7	12.5	11.3	12.7
Self-employed (% total employment)	16.0	15.6	15.1	14.4	13.8
Part-time employment (% total employment)	3.8	3.8	3.5	3.6	3.6
Fixed term contracts (% total employment)	6.5	6.2	7.1	7.5	7.3
Exchange rate (annual average) HUF/EUR	241	253	260	257	243

a. Sources: MNB (Hungarian National Bank), CSO, European Commission.

TABLE II: Tax wedge on minimum wage

	2000	2001
Monthly minimum wage (gross)	**25500**	**40000**
	98 €	156 €
Personal income tax rate at minimum wage	20%	20%
Tax credit - Rate	10%	10%
Tax credit - Monthly maximum	3000	3000
Tax credit - Applicable at minimum wage	2550	3000
Pension contribution deduction - Rate	25%	25%
Pension contribution deduction - Rate*Employee pension rate	2%	2%
Net personal income tax at minimum wage	2040	4200
Total social security contributions employees - Rate	12.5%	12.5%
Total social security contributions employees - Payment	3187.5	5000
Net take home pay	**20273**	**30800**
	78 €	120 €
Health care - Lump sum	3900	3900
Total social security contributions employer - Rate	36%	36%
Total social security contributions employer - Payment	13080	18300
labor cost	**38580**	**58300**
	148 €	227 €
Tax wedge	47%	47%
Total fiscal payments	**18308**	**27500**
	70 €	107 €
Difference YY		9193

a. Figures are in Hungarian Forints unless otherwise indicated.

b. Figures in € are calculated using the average exchange rate for the corresponding year.

TABLE III: Descriptive statistics - Potential treatment

	Treatment				Control			
	1999	2000a	2000b	2001	1999	2000a	2000b	2001
N. of HH members	3.2	3.2	3.3	3.3	3.2	3.2	3.2	3.2
	(1.1)	(1.1)	(1.3)	(1.3)	(1.1)	(1.1)	(1.1)	(1.1)
Total net income	74341	82338	80901	101066	83767	95225	92221	107925
	(28615)	(32431)	(33731)	(38845)	(30582)	(33690)	(30673)	(34941)
Expenditures on food	18564	20181	21032	25229	20960	23413	23167	28354
	(8970)	(9335)	(9599)	(11294)	(9208)	(10441)	(10545)	(12795)
Total expenditures	75013	82402	79313	97268	79148	86292	86029	101653
	(29849)	(30491)	(30274)	(36233)	(29139)	(33267)	(33068)	(38120)
- with durables	78994	86651	82829	100630	82209	89667	90646	106724
	(34114)	(34605)	(34330)	(41548)	(32719)	(38940)	(40600)	(43558)
Exp. on food as % of total expenditures	25%	24%	27%	26%	26%	27%	27%	28%
Exp. on food as % of net income	25%	25%	26%	25%	25%	25%	25%	26%
N. of HH	197		195		651		587	
N. of treated in HH	1.1		1.1		0		0	
N. of control in HH	0.3		0.4		1.2		1.2	

a. Only HH with constant family structure and positive income below 200,000 HUF.

b. Standard deviations in parenthesis

TABLE IV: Potential treatment

1999-2000: Dummy Treatment - Placebo					
Treatment	-743	-510	156		468
	(628)	(599)	(706)		(678)
ΔHH income		0.08***			0.08***
		(0.017)			(0.017)
R^2	0.22	0.24	0.32		0.35
Observations				848	
Treated HH				197	
2000-2001: Dummy Treatment					
Treatment	-1287**	-1538**	-1717**		-1951**
	(622)	(632)	(778)		(792)
ΔHH income		0.05***			0.05**
		(0.020)			(0.022)
R^2	0.30	0.31	0.41		0.42
2000-2001: Continuous Treatment					
Treatment	-0.12*	-0.14**	-0.19**		-0.20***
	0.06	0.06	0.08		0.08
ΔHH income		0.05***			0.05**
		0.02			0.02
R^2	0.30	0.31	0.41		0.42
Observations				782	
Treated HH				195	
Additional controls:					
Month dummies	Yes	Yes	Yes		Yes
Employee characteristics	No	No	Yes		Yes
Geographical dummies	No	No	Yes		Yes

a. Dependent variable is change in food consumption (excluding own production); monthly.

b. OLS estimation. Robust standard errors in parenthesis.

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

d. Sample: HH with constant family structure and positive income below 200,000 HUF in 2000-2001, with at least one member employed for 2000-2001, s.t. $\varpi_{2000} \leq w_{2000} \leq 2 * \varpi_{2001}$.

e. Δ: change; HH: Household; ϖ_t: minimum wage in year t; w_t: wage in year t.

TABLE V: Descriptive statistics - Actual treatment

	Treatment		Control	
	2000	2001	2000	2001
N. of HH members	3.2	3.2	3.2	3.2
	(1.2)	(1.2)	(1.2)	(1.2)
Expenditures on food	20016	23976	22374	27462
	(9493)	(10657)	(10490)	(12185)
Total net income	75383	93069	89588	105246
	(32039)	(36758)	(31588)	(34309)
Total expenditures	78188	92843	83918	98962
	(29696)	(35777)	(34515)	(36732)
- with durables	81301	96970	87965	103359
	(31789)	(42233)	(40623)	(40706)
Exp. on food as % of total expenditures	26%	26%	27%	28%
Exp. on food as % of net income	27%	26%	25%	26%
N. of HH	149		659	
N. of treated in HH	1.1		0	
N. of control in HH	0.4		1.3	

a. Only HH with constant family structure and positive income below 200,000 HUF in 2000-2001.

b. Standard deviations in parenthesis

TABLE VI: Actual treatment - Large control group - Panel 2000-2001 - Dummy

Dummy Treatment					
Treatment	-1385**	-1471**	-1595**		-1573**
	(630)	(622)	(723)		(722)
ΔHH income		0.05***			0.05***
		(0.017)			(0.018)
R^2	0.31	0.32	0.41		0.42
Observations				808	
Treated HH				149	
Continuous Treatment					
Treatment	-0.09	-0.11*	-0.14*		-0.15**
	(0.063)	(0.061)	(0.073)		(0.072)
ΔHH income		0.05***			0.05***
		(0.017)			(0.018)
R^2	0.31	0.32	0.41		0.42
Observations				808	
Treated HH				131	
Additional controls:					
Month dummies	Yes	Yes	Yes		Yes
Employee characteristics	No	No	Yes		Yes
Geographical dummies	No	No	Yes		Yes

a. Dependent variable is change in food consumption (excluding own production); monthly.

b. OLS estimation. Robust standard errors in parenthesis.

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

d. Sample: HH with constant family structure and positive income below 200,000 HUF in 2000-2001, with at least one member employed for the whole 2001, s.t. $\varpi_{2001} \leq w_{2001} \leq 2 * \varpi_{2001}$.

e. Δ: change; HH: Household; ϖ_t: minimum wage in year t; w_t: wage in year t.