Essays on Labour Market Structure and Policies

Mirco Tonin

Stockholm University

ISSN 0346-6892
ISBN 978-91-7155-471-0

Cover Picture: Mirco Tonin, *Labour Regulation*
Printed in Sweden by Intellecta, Stockholm 2007
Distributor: Institute for International Economic Studies

Doctoral Dissertation
Department of Economics
Stockholm University

Abstract

The thesis consists of three essays on labour market structure and policies.

Minimum Wage and Tax Evasion: Theory builds a theoretical model to analyse the interaction between minimum wage legislation and tax evasion by employed labour. The firm and the worker agree on the amount of earnings to report to the fiscal authorities, which possess an imperfect detection technology. The introduction of the minimum wage poses a constraint on the reporting decision and induces an increase in compliance by some agents. As a consequence, a spike at the minimum wage appears in the distribution of declared earnings. Moreover, a nominally neutral fiscal regime becomes regressive, while fiscal revenues may increase.

Minimum Wage and Tax Evasion: Empirical Evidence tests the prediction derived from the model in the first essay that a minimum wage hike implies a fall in true income even for those workers who appear to benefit from it. It uses the massive increase in the minimum wage that took place in Hungary in 2001 as a quasi-natural experiment. A difference-in-difference approach is used, comparing food consumption before and after the minimum wage hike for households affected by it and for similar but unaffected households. The treatment effect is negative and significant across different specifications, thus supporting the prediction of the model. The control group is validated by showing that it did not differ from the treatment group in the pre-policy period.

In-Work Benefits in Search Equilibrium investigates the general equilibrium effects of in-work benefits in a search framework. Introducing in-work benefits reduces equilibrium unemployment, moderate wages, and boosts participation and search. Total employment increases as a result. Compared to a partial equilibrium analysis, accounting for general equilibrium effects reinforces the impact of benefits on labour market variables. The case when benefits are financed through proportional taxation on wages is also analysed.

To Mónika

Acknowledgments

Science is a collaborative effort and the essays in this thesis are no exception. Many people have directly contributed through their critique and advice, many through their support and endorsement. My advisor, John Hassler, belongs to both these categories, and I wish to thank him for his continuous guidance and encouragement. I also wish to thank my co-author Ann-Sofie Kolm. I learned a great deal through our “stubborn” discussions.

Throughout my PhD studies, I have greatly benefited from the engaging atmosphere at the Institute for International Economic Studies. I wish to thank all the people responsible for this and my undergraduate thesis supervisor, Guido Tabellini, for encouraging me to apply. The faculty members at IIES have been a constant source of advice and example. Among them, I owe a special thanks to Nicola Gennaioli, Ethan Kaplan, Dirk Niepelt, Torsten Persson, David Strömberg and Fabrizio Zilibotti. The administrative staff at the Institute has been extremely supportive. In particular, I wish to express my gratitude to Christina Lönnblad for the countless times she answered my queries and for editorial assistance, and to Annika Andreasson for her help with the job market and the thesis. I also gratefully acknowledge the financial support provided by Jan Wallander and Tom Hedelius’ Research Foundations. Last but not least, my fellow students and friends at the Institute and at other departments have made my experience in Stockholm not only more interesting, but also much more enjoyable: Cristina Amado, Samuel Azasu, Milo Bianchi, Dario Caldara, Stefano Castriota, Erika Färnstrand Damsgaard, Daria Finocchiaro, Jaewon Kim, Andrea Mascotto, Ganeshkumar Munnorcode, Agatha Murgoci, Elena Paltseva, José Mauricio Prado Jr., to mention just a few. I also wish to thank Igor Bazov and Alexej Schuplev, who adopted me as an honorary Russian, and Andrew Tham.

During my PhD, I have had the privilege to visit the Economics Department at Central European University several times. I have greatly enjoyed working there and exchanging ideas with both faculty and students. In particular, I wish to thank Gábor Kézdi and Attila Rátfai. I am also very grateful to the Institute of Economics at the Hungarian Academy of Sciences for its hospitality during the winter of 2006 and for providing the data used in the second essay. I am particularly indebted to György Molnár, who guided me through the dataset and provided invaluable advice during my visit to the Academy and with whom I have had several very pleasant conversations afterwards. My stay at the Hungarian National Bank during the summer of 2006 has been a great experience, both personally and professionally. In particular, I would like to thank Péter Benczúr, István Kónya and Andri Chassamboulli for their friendship and encouragement. My interest in Central and Eastern European labour markets has been greatly stimulated by conversations with Sandrine Cazes while I was an intern at the ILO in the summer of 2003 and afterwards. I wish to thank her for this and the ILO for the hospitality. I also wish to thank Jim Albrecht, Peter Fredriksson, János Köllő, Mária Lackó, and Per Skedinger for useful discussions and many conference and seminar participants for comments and suggestions.

My family and friends, both in Italy and Hungary, have been very supportive throughout my doctoral studies. Having to explain to them countless times what exactly I was doing up there in Stockholm made it clearer to myself. In particular, I wish to thank my parents, Silvana and Ferruccio, and my brother and sister, Massimo and Michela. A very special mention is for my wife to be Mónika Papp. Without her support, none of this would have been possible. I dedicate this thesis to her.

Stockholm, July 2007

Mirco Tonin

Table of Contents

Chapter 1

Introduction

This thesis consists of three chapters on labour market structure and policies. The first two chapters analyse the interaction between underreporting of earnings by employed labour and minimum wage legislation from a theoretical and empirical perspective. The third chapter investigates the impact of in-work benefits in search models.

Tax evasion by employed labour in the form of underreporting of earnings to fiscal authorities is a widespread phenomenon in several countries. This practice is particularly common in Eastern Europe and the Former Soviet Union (World Bank, 2005; Renooy et al., 2004), but also affects other economies, like Turkey (World Bank, 2006), Argentina (World Bank, 2007), Mexico, Italy and Spain (OECD, 2004). The study of tax evasion by employed labour is of particular interest as the fiscal imposition on labour in the form of social security contributions and personal income tax represents the bulk of fiscal revenues in many countries. Despite the fact that, among labour market policies, the minimum wage is probably the most studied one, its implications for compliance with fiscal regulation have largely been overlooked. The first two essays in the thesis aim at filling this gap and contributing to the understanding of tax evasion by employed labour by looking at the interaction between underreporting of earnings and minimum wage legislation.

The first essay, entitled *Minimum Wage and Tax Evasion: Theory*, builds a model of a perfectly competitive labour market, where the firm and the worker agree on the amount of earnings to report to the fiscal authorities, which possess an imperfect detection technology. The introduction of the minimum wage poses a constraint on the reporting decision and induces an increase in compliance by some agents, while pushing others out of the formal labour market into the black economy or into inactivity. The overall effect when enforcement is not too effective is to unambiguously increase fiscal revenues. The distribution of the fiscal burden is also altered, turning a nominally neutral fiscal regime into a regressive one. Moreover, an otherwise smooth distribution of declared earnings is transformed into a distribution presenting a spike at the minimum wage level by the introduction of the minimum wage. The model also predicts a positive correlation between the size of the informal economy and the size of the spike at the minimum wage level, which finds some support in the data. The model is extended in three directions: first we allow for underreporting of both hours of work and hourly wage, then we allow for discontinuities in productivity and expected fines when a worker-firm pair operates completely in the black economy, and, finally we account for entitlements from social security. A simple numerical example shows how the model is able to generate the double digit spike at the minimum wage level observed in the wage distribution of some countries. Moreover, it shows that the increase in revenues due to the introduction of the minimum wage can be sizeable, despite the fact that it mainly affects low productivity workers.

Another prediction of the theory is that a minimum wage hike implies a fall in true income for those workers officially earning between the old and the new minimum wage before the hike. Also workers who appear to benefit from the hike, as they keep their job and experience an increase in official earnings, actually experience a drop in true income. This is due to the fact that the higher minimum wage forces them to officially declare at least part of the earnings that were previously received informally. The second essay, *Minimum Wage and Tax Evasion: Empirical Evidence*, tests this prediction using the massive increase in the minimum wage that took place in Hungary in 2001 as a quasi-natural experiment. Hungary is a country where the degree of informality in the labour market is relatively high and, moreover, the minimum wage is particularly important as it applies to all employees without any exceptions. In 2001, the minimum wage was increased by almost 50% in real terms, causing a massive price shock that, according to the theory, affected the "underreporting technology" of some workers, while leaving others unaffected. This variation is used to identify the impact of the minimum wage legislation on underreporting, by adapting the methodology developed by Pissarides and Weber (1989) to a panel framework and applying it to the Hungarian Household Budget Survey Rotation Panel. A difference-in-difference approach is used, comparing food consumption before and after the minimum wage hike by households affected by it, the treatment group, to food consumption by similar but unaffected households, the control group. The treatment effect is negative and significant across different specifications, thus supporting the prediction of the model. The control group is validated by showing that it did not differ from the treatment group in the pre-policy period.

By analysing the interaction between minimum wage and tax evasion, the first two essays contribute to the policy debate on minimum wage in countries where underreporting of earnings is common. They show that the minimum wage may indeed be effective in increasing compliance by employed labour and, therefore, may be used as a blunt, but substantially inexpensive, instrument to fight underreporting. On the other hand, if the aim of the minimum wage hike is to boost income for low productivity people, as it is often claimed when such policies are introduced, the policy could backfire if not accompanied by a decrease in fiscal pressure for minimum wage workers.

The last chapter, *In-Work Benefits in Search Equilibrium*, deals with in-work benefits, like the EITC in the US and the WTC in UK. This type of labour market policy is becoming increasingly important, as it is used or is in the process of being introduced in an increasing number of countries, while its scope has been progressively extended in countries where it was adopted a long time ago. In-work benefits are usually introduced to "make work pay": by supplementing low wages, they provide employment incentives (Blundell, 2006). Research has almost exclusively been concerned with the supply-side effects of in-work benefits. However, the expansion of this type of programmes makes it increasingly relevant to account for their general equilibrium effects. The aim of the paper is indeed to study the equilibrium impact of in-work benefits in a simple analytical framework displaying involuntary unemployment. Using a search model a la Pissarides (2000), we show that the introduction of in-work benefits reduces equilibrium unemployment, moderates wages and boosts participation and search effort. Total employment increases as a result. We show that accounting for the general equilibrium effects actually reinforces the impact of benefits on labour market variables. With the expansion of benefit programmes, the resources needed to finance them are not negligible and their impact should be accounted for. Another contribution of the paper is to look at the issue of financing. The analysis of financing reveals the conditions under which benefits that are financed through proportional taxation on wages increase labour force participation, employment, and search intensity by the targeted group.

Bibliography

[1] Blundell, R. (2006), "Earned income tax credit policies: Impact and optimality", *Labour Economics*, vol. 13, pp. 423-443.

[2] OECD (2004), *Employment Outlook*, OECD, Paris.

[3] Pissarides, C. (2000), *Equilibrium unemployment theory*, MIT Press, Boston, MA.

[4] Pissarides, C., and Weber, G. (1989), "An expenditure-based estimate of Britain's black economy", *Journal of Public Economics*, vol. 39, pp. 17-32.

[5] Renooy, P., Ivarsson, S., van der Wusten-Gritsai, O., and Meijer, R. (2004), "Undeclared work in an enlarged Union", European Commission, Bruxelles.

[6] World Bank (2005), *Enhancing Job Opportunities: Eastern Europe and the Former Soviet Union*, World Bank, Washington, DC.

[7] World Bank (2006), *Turkey. Country Economic Memorandum*, World Bank, Washington, DC.

[8] World Bank (2007), *Informality: Exit and Exclusion*, World Bank, Washington., DC.

Chapter 2

Minimum Wage and Tax Evasion: Theory*

1 Introduction

What are the fiscal implications of introducing or increasing the minimum wage? How can we explain the very high spike at the minimum wage level appearing in the wage distribution of some countries? This paper contributes to answering these questions by studying the effects of the interaction between tax evasion and minimum wage legislation.

The minimum wage is the subject of a rich literature and policy debate[1] , mainly focusing on its effect on employment. The traditional view of adverse labour market effects has been challenged (Card and Krueger, 1995) and, at present, there is no overwhelming consensus on the issue. Potential beneficial effects of the minimum wage for workers through shifts in the composition of jobs toward good (i.e. high-wage) jobs have also been discussed (Acemoglu, 2001.) 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 the "fiscal channel".

Large efforts have also been devoted to the theoretical and empirical study of tax

* I thank the Department of Economics at Central European University, where part of this research was conducted, for its hospitality. Comments and suggestions by John Hassler, Jim Albrecht, Milo Bianchi, Peter Fredriksson, Nicola Gennaioli, Laszlo Goerke, Ethan Kaplan, Gábor Kézdi, Torsten Persson, David Strömberg, and several seminar and conference participants have been most helpful. I am grateful to Christina Lönnblad for editorial assistance. Financial support from Jan Wallander's and Tom Hedelius' Research Foundations is gratefully acknowledged.

[1] See Brown (1999) for a review.

evasion and the shadow economy[2]. The study of tax evasion by employed labour is of particular interest as the fiscal imposition on labour in the form of social security contributions (SSC) and personal income tax (PIT) represents the bulk of fiscal revenues in many countries[3]. However, to the best of my knowledge, the effects of the interaction between underreporting of earnings and minimum wage legislation have not previously been addressed in a formal model.

Undeclared work is a serious issue in many countries. It is difficult to obtain reliable data on its extension, but raw estimates indicate that the phenomenon is relevant, particularly in transition and developing countries but also in some OECD economies. In a report for the European Commission, the authors stress how the practice of paying "envelope wages" above the officially declared minimum "exists in practically all of the Central and Eastern European countries" (Renooy et al., 2004.) An OECD study of the Baltic countries (OECD, 2003) estimates that in Latvia and Lithuania, 20% of the private-sector employees earn more than what is officially reported[4]. Similar figures have been estimated for Bulgaria (Tomev, 2004.) 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 CEE 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[5] (OECD, 2004). 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 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), creating incentives to sustain a high minimum wage to sustain tax revenue" and calls for further research on this

[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.

[3] Labour taxes are the largest source of tax revenue in the EU-25, representing around half of total tax receipts (Eurostat, 2006).

[4] The Latvian Central Statistical Office publishes data on earnings under the heading "Gross wage of employed *excluding all kinds of irregular payments* by kind of activity" (italics added).

[5] 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 SSK (Social Security Organization), the wages reported by employers are at the minimum insurable level (World Bank, 2006).

aspect of minimum wage policy. This is indeed the aim of the present paper.

A simple model of the labour market is created where underreporting of earnings is made possible by imperfect detection of tax evasion. The introduction of the minimum wage induces some worker-firm pairs to increase compliance, while pushing others out of the formal labour market into the black economy or into inactivity. The increase in compliance is due to the fact that the minimum wage poses a constraint on reporting behaviour, as agents must choose whether to report nothing or report at least the minimum wage. When faced with such a restriction, agents may prefer to increase their reporting to the minimum wage level rather than decreasing it to zero. The overall effect when enforcement is not too effective is to unambiguously increase fiscal revenues. The distribution of the fiscal burden is also altered, turning a nominally neutral fiscal regime into a regressive one. Moreover, an otherwise smooth distribution of declared earnings is transformed by the introduction of the minimum wage into a distribution presenting a spike at the minimum wage level. The model also predicts a positive correlation between the size of the spike at the minimum wage level and the size of the informal economy. Some supporting evidence on this is presented.

The next section discusses some of the related literature. The model is introduced in the third section. In section 4, the various effects of introducing the minimum wage are explored. Section 5 looks at the model implications for the relationship between the spike at the minimum wage and the underground economy. The following section briefly explores the quantitative implications of the model. In section 7, some extensions of the model are discussed. The last section concludes.

2 Related literature

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 labour. 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 labour it is necessary to take the interaction between the employer and the employee into account.

The literature specifically looking at the labour market effects of tax evasion often considers the formal and informal sections of the labour market as separate, with workers and firms being either completely underground or completely compliant with the regulation. Boeri and Garibaldi (2007) are a recent example of this. Fugazza and Jacques (2003) also take this approach in their study of the effect of labour market institutions when there is an underground sector.

Another strand of the literature, in line with the view taken in this paper, considers that workers' compliance with regulation can also be partial. Sandmo (1981) and Cowell (1985) study models where working time can be allocated between the formal and informal sectors. The former is mainly interested in determining the optimal income tax and enforcement, the latter in investigating the effects of fiscal and enforcement parameters on the dimension of the informal sector. Kolm and Nielsen (2005) study a search model with wage bargaining, where the worker and the firm agree on the amount of remuneration not to be reported to the fiscal authorities. They find that both higher taxes and weaker enforcement reduce unemployment. Bargaining between the firm and the workers over the true and reported wage is also assumed by Yaniv (1992) who explores the impact of fiscal and detection parameters on tax evasion and contrasts a withholding and a self-declaration system. However, none of the above mentioned studies considers the impact of minimum wage legislation in an economy with underreporting.

The literature on minimum wage deals extensively with its effects on wage distribution and employment. 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 labour market models (Brown, 1999) and as an "anomalous finding from the standpoint of the standard model of the low wage labour 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. The positive correlation between the size of the spike at the minimum wage and the estimated size of the informal economy in the data presented in the Appendix suggests that the mechanism analysed in this paper indeed contributes to shape the observed distribution of earnings in some countries. 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, 2005), profits (Draca et al., 2006.) The impact of the minimum wage on tax evasion has, to the best of my knowledge, never been investigated.

3 The model without minimum wage

The size of the population is exogenously given and normalized to 1. Every individual has an exogenously given productivity y_i, distributed in the population according to pdf $g(y)$ and cdf $G(y)$ on the support $[\underline{y}, \bar{y}]$, where $\underline{y} \geq 0$. We assume the labour market to be competitive, each firm employs one worker, there is no capital, and production is equal to labour 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[6] . Firms have an obligation to withhold taxes and social security contributions and transfer them to the 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

[6] No distinction is made between labour cost and gross wage and the two concepts are equivalent in the model.

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 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 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, but it may find evidence to impute an income $\hat{y}_i \in [0, y_i]$, where y_i is the true product. For instance, Feinstein (1991) estimates that IRS examiners on average managed to detect only half of the tax evasion in the forms they audited[7] , while Erard (1997) rejects the hypothesis of perfect detection in his empirical investigation of a model where detection can be either complete or null.

We assume that $\hat{y}_i$ is distributed over the support $[0, y_i]$[8] 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, we assume that $h(\cdot) > 0$ within the support, so that $H(\cdot)$ is invertible within $[0, y_i]$.

[7] 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).

[8] 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 relatively straightforward.

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[9] . 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

$$f_i = t\theta \int_{x_i}^{y_i} (\hat{y}_i - x_i) h(\hat{y}_i) d\hat{y}. \tag{2.1}$$

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

3.1 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[10]

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

where f, the expected fine in case an audit is conducted, is given by (2.1). Therefore, the expected profits for the firm are

$$E(\pi) = y - w - \gamma f. \tag{2.2}$$

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

$$I = w - tx. \tag{2.3}$$

[9] 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 $h(\hat{y}_i) / [1 - H(x_i)]$.

[10] 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.

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

$$x^* \quad s.t. \quad \max_{x\in[0,y]} y - \gamma f - tx. \tag{2.4}$$

After substituting (2.1) into (2.4), the first-order condition is

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

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

$$x^* = \begin{cases} H^{-1}(1-\alpha) & \text{if} \quad \alpha < 1 \\ 0 & \text{if} \quad \alpha \geq 1 \end{cases}. \tag{2.5}$$

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 (2.5) into (2.1). Substituting this into (2.2) and considering the free entry condition, we get the equilibrium gross wage

$$w^* = y - \gamma f^*,$$

that substituted into (2.3) gives the equilibrium net income

$$I^* = y - \gamma f^* - tx^*. \tag{2.6}$$

To simplify the discussion, from now on we will assume $h(\cdot)$ to be uniform in the support $[0, y]$, i.e. $\hat{y}_i \sim U_{[0,y_i]}$. The expression for the expected fine becomes[11]

$$\gamma f = \gamma t\theta (y - x)^2 / (2y) \, . \tag{2.7}$$

The optimal reporting behaviour given by (2.5) becomes

$$x^* = \begin{cases} (1-\alpha)\, y & \text{if} \quad \alpha < 1 \\ 0 & \text{if} \quad \alpha \geq 1 \end{cases} \tag{2.8}$$

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 (2.7), the expected fine is given in equilibrium by

$$\gamma f^* = \begin{cases} yt\alpha/2 & \text{if} \quad \alpha < 1 \\ yt/(2\alpha) & \text{if} \quad \alpha \geq 1 \end{cases} \tag{2.9}$$

and thus, substituting (2.8) and (2.9) into (2.6), we get the worker's equilibrium net income

$$I^* = \begin{cases} y(1-t) + \alpha y t/2 & \text{if} \quad \alpha < 1 \\ y\left[1 - t/(2\alpha)\right] & \text{if} \quad \alpha \geq 1 \end{cases} . \tag{2.10}$$

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

$$\int_x^y (\hat{y} - x^*) h(\hat{y}) d\hat{y} / (y - x^*) = \alpha/2, \tag{2.11}$$

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

---

[11] The Appendix presents an alternative setting for imperfect detection giving rise to an equivalent expression for the expected fine. It also discusses the case of the probability of an audit being conditioned on declared income.

4 Effects of the minimum wage

In this section, we 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. However, in section 7.1, 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. In the following, we focus on the case with partial evasion, i.e. $\alpha \in (0,1)$ [12] .

4.1 Effects on the distribution

With the introduction of a minimum wage, (2.4) becomes

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

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. We first analyse the case of low-productivity workers.

[12] For this to be the case, we 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 the income are evaded, only 15% of the evaded income are, 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.

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 (2.10), we get income in case of work in the black market, i.e. full evasion,

$$I_{bm} \equiv y_i \left[1 - t/\left(2\alpha\right)\right]. \tag{2.12}$$

Income in case of inactivity is assumed to be 0. The labour 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 labour 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 labour 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 labour 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.

$$(1-\alpha)y_i \leq \varpi \leq y_i \Leftrightarrow \varpi \leq y_i \leq \varpi/\left(1-\alpha\right). \tag{2.13}$$

Income in case of declaring ϖ is given by substituting $x = \varpi$ in (2.7) and (2.6)

$$I_{mw} \equiv y_i(1-t) + \left(y_i - \varpi\right)t - t\left(y_i - \varpi\right)^2/\left(2\alpha y_i\right). \tag{2.14}$$

Declaring a wage higher than the minimum is never optimal for this group. Moreover, as $I_{mw} > 0$ for productivities satisfying (2.13), 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 (2.12) gives the following condition

$$I_{mw} \geq I_{bm} \Leftrightarrow y_i \geq \varpi / \left[2(1-\alpha)\right] \equiv y_{mw}. \quad (2.15)$$

As the choice between employment at the minimum wage and employment in the black market is only relevant for workers satisfying (2.13) to determine the behaviour 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 (2.13). 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 2.1 *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 labour force.*

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

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

where $g(\cdot)$ is the pdf of the productivity distribution. After the introduction of the minimum wage, distribution of declared earnings is given by

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

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, we can state the following:

Proposition 2.2 *In a perfectly competitive labour market with underreporting of earnings, a spike at the minimum wage level appears in the distribution of declared earnings.*

Figure 2.1 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.

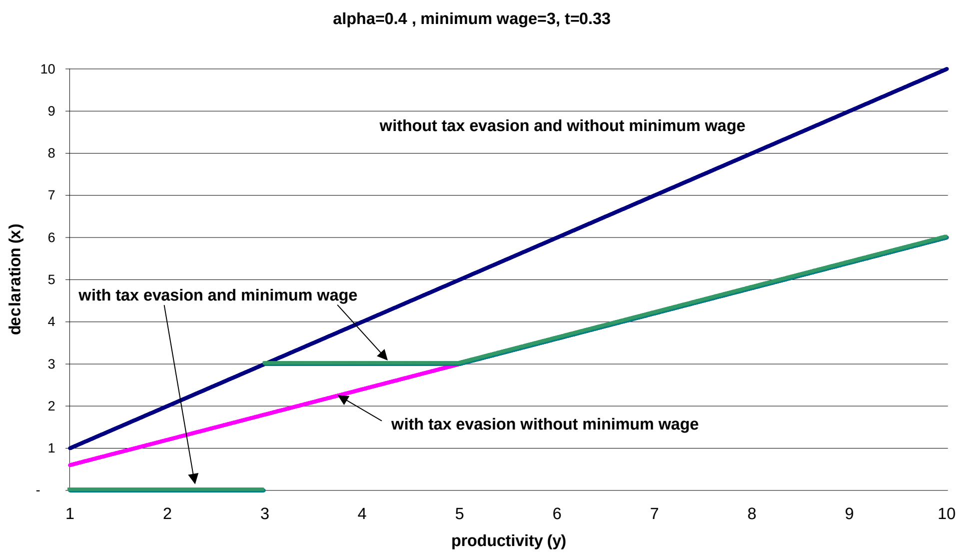
4.2 Fiscal effects

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, we first determine payments to fiscal authorities for each category. Then, we 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, these quantities are

$$P_1 = (1-\alpha/2)ty \begin{array}{l} \nearrow \\ \searrow \end{array} \begin{array}{l} T_1 = yt(1-\alpha) \\ F_1 = yt\alpha/2 \end{array}.$$

Figure 2.1: Declared income



Underreporting gives worker-firm pairs with a relatively high productivity the opportunity to reduce the "effective"[13] tax rate by a factor $\alpha/2$. For worker-firm pairs declaring the minimum wage, fiscal payments are given by

$$P_2 = t\varpi + t(y-\varpi)^2/\left(2\alpha y\right) \begin{array}{l} \nearrow \\ \searrow \end{array} \begin{array}{l} T_2 = t\varpi \\ F_2 = t(y-\varpi)^2/\left(2\alpha y\right) \end{array}.$$

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 labour market (when $\alpha < t/2$). For workers in the black market, fines are the only type of payment, so that

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

Workers who withdraw from the labour market do not contribute to the public finances, so

$$P_4 = F_4 = 0.$$

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

Notice that $P_3/y \geq P_2/y \geq P_1/y$ in the relevant intervals[14] . 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 possible to state the following:

Proposition 2.3 *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 labour 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 2.2 shows the effective tax rate as a function of productivity.

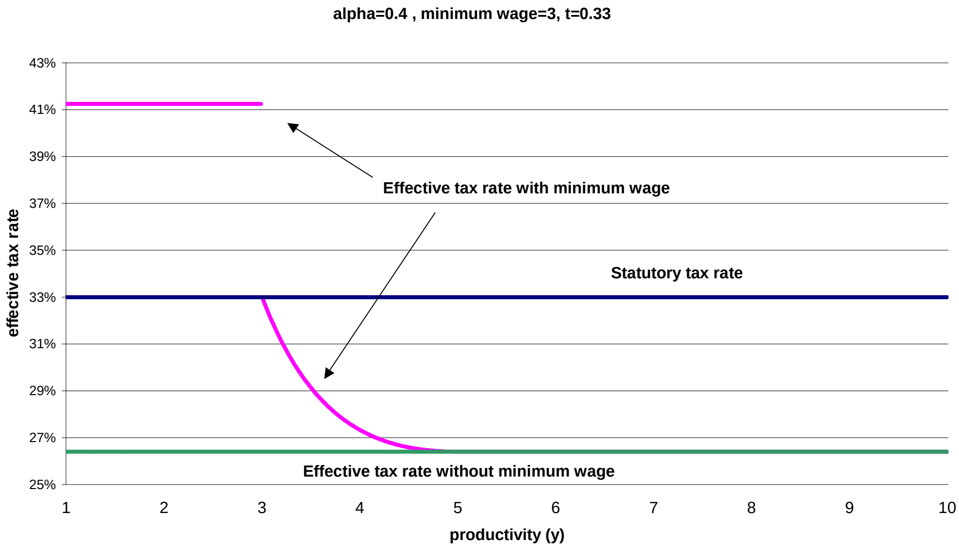
Effects of the minimum wage on revenues When workers with productivity below the minimum wage work in the black market, i.e. when $\alpha \geq t/2$, total revenues R are given by

$$R = \int_{0}^{\varpi \max\left\{\frac{1}{2(1-\alpha)},1\right\}} ty/\left(2\alpha\right) g\left(y\right) dy + \int_{\varpi \max\left\{\frac{1}{2(1-\alpha)},1\right\}}^{\varpi/(1-a)} [t\bar{w} + t\left(y-\varpi\right)^2 / \left(2\alpha y\right)] g\left(y\right) dy + \\ + \int_{\varpi/(1-a)}^{\bar{y}} (1-\alpha/2)\, tyg(y)dy. \tag{2.16}$$

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

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

Figure 2.2: Effective tax rate



Effective Tax Rate = Total Payments to Fiscal Authorities / Productivity

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 labour 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 (2.16). Then,

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

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

Proposition 2.4 *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 labour 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.

The revenue boosting effect of the introduction of a minimum wage can be substantial. In Bulgaria, for instance, social security contribution payments increased by almost 20% in 2003 "[a]s a result from the registration of the labour contracts and the introduction of the minimum insurance income upon principal economic activities and qualification groups of professions, as well as from the improved economic situation" (NSSI).

5 Underground economy and minimum wage spike

Both the size of the spike at the minimum wage and the size of the underground economy relative to the economy as a whole are determined by the interplay of the productivity distribution, the fiscal enforcement parameters as summarized by α, and the minimum wage, ϖ. In this section, we study the link between the size of the underground economy and the size of the spike.

The spike at the minimum wage The size of the spike at the minimum wage is given by

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

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

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

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. If this is the case, the spike is always increasing as α increases.

The effect on the size of the spike of a marginal increase in the minimum wage depends on the interplay between two effects: as ϖ increases, some workers previously declaring the minimum wage are pushed out of the formal labour market, thus decreasing the size of the spike, while some, previously declaring more, declare the minimum wage, thus increasing the size of the spike. Given α, the condition for the size of the spike to increase as the minimum wage increases is

$$\frac{\partial S}{\partial \varpi} > 0 \Leftrightarrow g\left(\frac{\varpi}{1-a}\right) > g(\varpi) \max\{1-a, 1/2\}.$$

Also in this case are a single peaked productivity distribution and a minimum wage binding for workers with productivity lower than the mode sufficient conditions for the spike to increase with the minimum wage.[15]

[15] 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:

$$L = \int_{\varpi \max\left\{\frac{1}{2(1-\alpha)},1\right\}}^{\bar{y}} g(y)dy.$$

The conditions for the spike relative to the officially employed workforce, S/L, to increase with α and ϖ are looser than those for S, as the size of the officially employed workforce is not increasing with α and ϖ.

The informal economy 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 underground economy[16] is given by:

$$U = \underbrace{\int_{\underline{y}}^{\varpi \max\left\{\frac{1}{2(1-\alpha)},1\right\}} yg(y)dy}_{\text{black economy}} + \underbrace{\int_{\varpi \max\left\{\frac{1}{2(1-\alpha)},1\right\}}^{\varpi/(1-a)} (y-\varpi)g(y)dy + \alpha \int_{\varpi/(1-a)}^{\bar{y}} yg(y)dy}_{\text{underreporting}}. \tag{2.17}$$

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.

An increase in the minimum wage pushes some workers previously declaring the minimum wage into the black economy, thus increasing informality, but also forces workers continuing to declare the minimum to declare more of their true income, thus reducing informality. Which effect prevails depends on the shape of the productivity distribution.

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 (2.17). 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[17] . The absolute size of the informal economy decreases with an increase in the minimum wage, as workers declaring the minimum increase their compliance. However, in this case, an increase in the minimum wage reduces the size of the economy that is given by $Y = \int_{\varpi}^{\bar{y}} yg(y)dy$. The effect of an increase in the minimum wage on the

[16] The analysis is made on the size of the informal economy in absolute terms, U. 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 or ϖ. Thus, the derivatives of U, U/Y, $U/(Y-U)$ w.r.t. α and ϖ all have the same sign.

[17] 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 we can state that the size of the informal economy always increases as enforcement decreases. The same is true if we consider the size of the informal economy relative to the whole economy, U/Y, or relative to the formal economy, $U/(Y-U)$.

size of the informal economy relative to the economy as a whole, U/Y, or relative to the formal economy, $U/(Y-U)$, is ambiguous, as it depends on the shape of the productivity distribution. To summarize:

Proposition 2.5 *When enforcement decreases, the size of the informal economy increases, both in absolute terms or relative to the formal economy. Sufficient conditions for the size of the spike at the minimum wage to increase when enforcement decreases are a single peaked productivity distribution combined with a minimum wage binding for workers with productivity lower than the mode or a not too weak enforcement. The effect of an increase in the minimum wage on the size of the informal economy relative to the formal economy is ambiguous. A sufficient condition for the size of the spike at the minimum wage to increase when the minimum wage increases is a single peaked productivity distribution combined with a minimum wage binding for workers with productivity lower than the mode.*

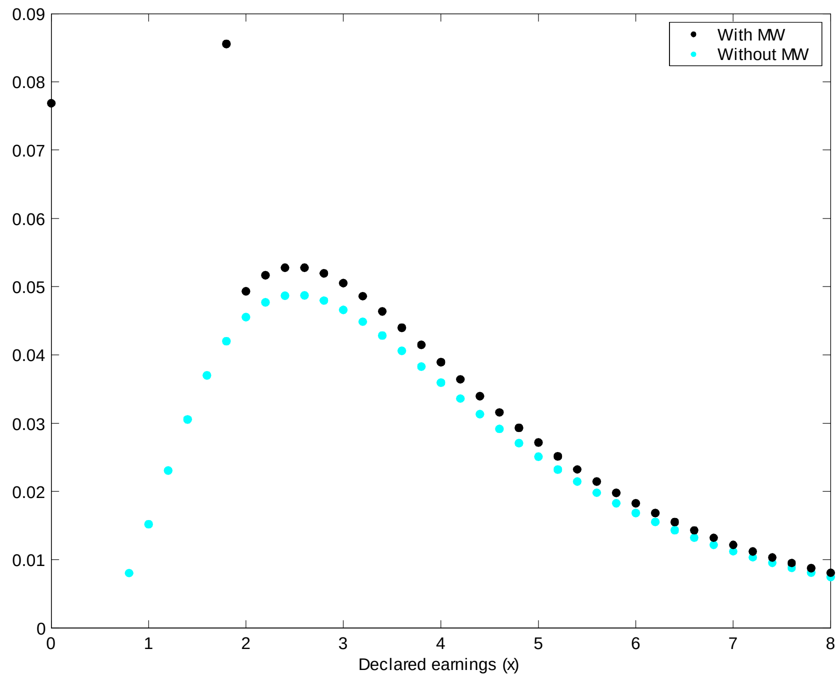
Thus, under mild conditions, the common dependence on α should induce a positive correlation between the spike at the minimum wage and the size of the informal economy. Some evidence on this correlation is presented in the Appendix.

6 A numerical example

In this section, the quantitative properties of the model are briefly explored. Workers' productivity is assumed to be distributed across 37 categories in the range 1-10, with the distance between adjacent productivity categories being 0.25. In the baseline scenario, the distribution of the workforce across the different categories is generated by normalizing the corresponding values of a lognormal with parameters (1.5; 0.6). Tax and social security contributions are assumed to be equivalent to 30% and enforcement parameters are such that without a minimum wage, all agents evade 20% of their income, i.e. $\alpha = 0.2$. The minimum wage is assumed to be equal to the income declared by the 6th productivity category, i.e. 1.8.

Figure 2.3 shows the distribution of declared earnings among the official workforce before and after the introduction of the minimum wage. Without the minimum wage, declared earnings are in the range 0.8-8, as 20% of the product is evaded. The

Figure 2.3: Distribution of declared earnings



distribution of declared earnings changes with the introduction of the minimum wage. The minimum wage creates two spikes, at the minimum wage level and at zero. As the minimum wage reduces the size of the official workforce by truncating it from below, the distribution of declared earnings is shifted upward above the minimum wage. Notice that in the figure, the spike at the minimum wage is the percentage of the *official workforce* declaring the minimum wage. Instead, the spike at zero is the percentage of the *population* not participating in the official labour market.

Table 2.1 reports the size of the two spikes. Other indicators are also calculated. In the model developed in this paper, the minimum wage is assumed to apply to the workforce as a whole; thus the Kaitz index is simply the minimum wage divided by the average declared wage. The percentage increase in total fiscal revenues (taxes and fines) due to the introduction of a minimum wage is also calculated. Finally, the size of the informal economy as a percentage of the formal economy is presented. In the baseline scenario, the informal economy would be 25% of the formal economy without a minimum wage, as 20% of income would be evaded. With the minimum wage, the informal economy is equivalent to 28% of the formal economy. Four other scenarios are explored. In the "high evasion" scenario, enforcement is assumed to be

Table 2.1: Numerical results

Spike ϖ[1]	Spike 0[2]	Kaitz Index[3]	ΔRevenues[4]	Informal Economy[5]
Scenario 1 - Baseline: $\mu = 1.5$ $\sigma = 0.6$ $\alpha = 0.2$ $\varpi = 1.8$				
8.6	7.7	46.5	4.52	28
Scenario 2 - High Evasion: $\mu = 1.5$ $\sigma = 0.6$ $\alpha = 0.3$ $\varpi = 1.575$				
11.5	4.6	47.3	1.41	44
Scenario 3 - High MW: $\mu = 1.5$ $\sigma = 0.6$ $\alpha = 0.2$ $\varpi = 2.2$				
15.3	11.4	55.2	7.58	29.4
Scenario 4 - High Evasion, High MW: $\mu = 1.5$ $\sigma = 0.6$ $\alpha = 0.3$ $\varpi = 1.926$				
18.7	7.7	56.2	2.76	44.6
Scenario 5 - Spread-out Distribution: $\mu = 1.5$ $\sigma = 0.8$ $\alpha = 0.2$ $\varpi = 1.8$				
10.7	14.3	46.2	8.33	30.7

1: as % of workforce in formal employment.

2: as % of total population.

3: minimum wage over average declared wage.

4: % change in total fiscal revenues due to the introduction of the minimum wage.

5: size of the informal economy as % of official economy.

weaker, so that 30% of income would be evaded without a minimum wage constraint, i.e. $\alpha = 0.3$. The minimum wage remains equivalent to the income declared by the sixth productivity category[18] . The share of the population affected by the minimum wage is the same as in the baseline scenario, as only a reshuffle between workers declaring zero and workers declaring the minimum wage takes place[19] . As established in section 5, the size of the spike at the minimum wage level increases, together with the size of the informal economy.

In the "high minimum wage" scenario, the minimum wage is assumed to be equivalent to the income declared by the eighth productivity category, i.e. 2. In this case, the minimum wage bites deeper into the wage distribution. As established in section 5, the size of the spike at the minimum wage level increases. The significance from a fiscal point of view is also increased as compared to the baseline scenario, as established by Proposition 2.4.

[18] Due to the increase in evasion, though, the actual level of the minimum wage is lower than in the baseline scenario.

[19] Notice that the size of the spike at the minimum wage level and the size of the spike at zero do not add up to the same number in scenarios 1 and 2 and in scenarios 3 and 4 only because the reported spike at the minimum wage level is expressed as a percentage of the official workforce, while the spike at zero is expressed as a percentage of the total population.

The "high evasion, high minimum wage" scenario combines the two previous variations. In this case, both the spike at the minimum wage level and the size of the informal economy reach very high levels.

In the last scenario, the distribution generating the frequencies is changed, in particular the standard deviation parameter is increased to 0.8. The resulting sizeable change in some of the indicators points to the fact that the quantitative implications of the model are sensitive to the assumption about the underlying distribution of productivity. However, these simple calculations show that the model is able to match the very high spike at the minimum wage observed in some countries and that the fiscal implications of imposing a minimum wage can be sizeable, even if only people with the lowest productivity are affected.

7 Extensions

In this section, the robustness of the model along several dimensions is discussed and some extensions are proposed. First, we look at the issue of working time. The model is extended to account for the fact that hours can also be underreported. Then, we check the robustness of the model for possible discontinuities arising when a firm-worker pair goes completely underground. In particular, discontinuities in productivity and expected fines are considered. Finally, we look at the implications for the model of accounting for entitlements from social security.

7.1 Working time

A minimum wage fixed on an hourly basis in an environment where firms could declare the amount of hours worked with full flexibility and no risk of detection in case of underreporting would pose an extremely loose constraint on reporting behavior. However, the minimum wage can still play its role against underreporting of earnings if there are legislative constraints on the amount of hours that can be reported or incentives not to declare a minimal amount of hours[20] ,[21] or if misreporting hours

[20] 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.

[21] According to 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 econ-

of work can also be detected and punished. In this section, we consider the latter case.

Suppose that a worker with hourly productivity y_i inelastically supplies h_i hours of work per period. However, the worker-firm pair can choose to report product per hour $x_i \in [0, y_i]$ and hours of work $\tau_i \in [0, h_i]$. The audit and detection technologies are the same in the two dimensions. In case of audit, the tax authorities manage to impute $\hat{x}_i \in [0, y_i]$ and $\hat{\tau}_i \in [0, h_i]$. For analytical convenience, the probabilities of detection are assumed to be independent and uniformly distributed over the relevant intervals, so that $g_{\hat{x}_i}(\hat{x}_i) = 1/y_i$ and $g_{\hat{\tau}_i}(\hat{\tau}_i) = 1/h_i$. The corresponding c.d.f. are indicated as $G_{\hat{x}_i}$ and $G_{\hat{\tau}_i}$. The imposed fine, f_i, depends on the detected and declared hours of work and product per hour. In particular, it is possible to distinguish four cases:

1. $\hat{x}_i < x_i$ and $\hat{\tau}_i < \tau_i \Rightarrow f_i = 0$
2. $\hat{x}_i < x_i$ and $\hat{\tau}_i > \tau_i \Rightarrow f_i = t\theta\left(\hat{\tau}_i - \tau_i\right) x_i$
3. $\hat{x}_i > x_i$ and $\hat{\tau}_i < \tau_i \Rightarrow f_i = t\theta\left(\hat{x}_i - x_i\right) \tau_i$
4. $\hat{x}_i > x_i$ and $\hat{\tau}_i > \tau_i \Rightarrow f_i = t\theta\left(\hat{x}_i\hat{\tau}_i - x_i\tau_i\right).$

In cases 2 and 3, underreporting is discovered in one dimension only and the fine is imposed on assessed underreporting in that dimension multiplied by the declared value on the other dimension. Thus, given a declaration (x_i, τ_i), the expected fine is given by (subscripts are suppressed where not necessary):

$$f = t\theta \left[\begin{array}{c} \int\limits_x^y \int\limits_\tau^h \left(\hat{x}\hat{\tau} - x\tau\right) g(\hat{x}, \hat{\tau}) d\hat{\tau} d\hat{x} + \tau G_{\hat{\tau}}(\tau) \int\limits_x^y \left(\hat{x} - x\right) g_{\hat{x}}(\hat{x}) d\hat{x} + \\ + x G_{\hat{x}}(x) \int\limits_\tau^h \left(\hat{\tau} - \tau\right) g_{\hat{\tau}}(\hat{\tau}) d\hat{\tau} \end{array} \right],$$

where $g(\hat{x}, \hat{\tau}) = g_{\hat{x}}(\hat{x}) g_{\hat{\tau}}(\hat{\tau})$. Given the hypothesis on the distributions, the expected fine is equal to:

$$f = t\theta \left[\left(h^2 + \tau^2\right) \left(y^2 + x^2\right) - 4\tau y x h \right] / \left(4yh\right). \tag{2.18}$$

In what follows, the equilibria with and without the minimum wage are character-

---

omy maintain de facto strict employment regulations, even though these regulations are seen by many analysts as a prime cause of informality." (OECD, 2004, page 227, italics added).

ized.

Equilibrium without minimum wage If the worker-firm pair chooses to declare τ hours and a product per hour x, the total surplus remaining within the firm-work pair, equivalent to the worker's net income because of the free entry assumption, is given by

$$I = yh - x\tau t - \gamma f, \tag{2.19}$$

where f is given by (2.18.) Therefore, the optimal declaration, equivalent to (2.4), is given by:

$$(x^*, \tau^*) \qquad s.t. \max_{x\in[0,y],\tau\in[0,h]} yh - x\tau t - \gamma f. \tag{2.20}$$

The first-order conditions are simultaneously satisfied iff

$$\tau^* = h\sqrt[2]{1-2\alpha} \qquad x^* = y\sqrt[2]{1-2\alpha},$$

where $\alpha = 1/(\gamma\theta)$. To have an interior solution, it is necessary that $\alpha < 1/2$, otherwise full evasion in both dimensions takes place. In what follows, it is assumed that $\alpha < 1/2$, i.e. enforcement is sufficiently strong to avoid full evasion. The maximand is locally concave at (x^*, τ^*); however, it is not globally concave. To establish whether (x^*, τ^*) is indeed the global maximum point, it is necessary to check the value of the function along the boundaries. As a reference, the income corresponding to reporting (x^*, τ^*) is

$$I^* = yh(1-t) + \alpha yht. \tag{2.21}$$

First, we analyse the boundaries within the axes, i.e. with full evasion in at least one dimension.

1 . Substituting $x = 0$ in (2.19), we get $I|_{x=0} = yh - t\left(h^2 + \tau^2\right)y/\left(4\alpha h\right)$, that is maximized for $\tau = 0$;

2. Substituting $\tau = 0$ in (2.19), we get $I|_{\tau=0} = yh - t(y^2 + x^2)h/\left(4\alpha y\right)$, that is maximized for $x = 0$;

Thus, when there is total evasion in one dimension, then it is also optimal to have total evasion in the other dimension. A positive declaration would only represent a lower bound on the fine to be paid. Therefore, we need to compare I^* given by (2.21) with the income corresponding to total evasion given by substituting $x = 0, \tau = 0$ in (2.19):

$$I^*_{bm} = yh - \gamma t\theta hy/4. \tag{2.22}$$

For $\alpha < 1/2$, we always have that $I^* > I^*_{bm}$.

The case with full compliance in at least one dimension is parallel to the case analyzed in the main model, where indeed there is assumed to be full reporting of the amount of hours worked.

3. In case $x = y$, then I is maximized for $\tau = (1-\alpha)h$, resulting in an income $I^*|_{x=y} = yh(1-t) + \alpha tyh/2$;

4. In case $\tau = h$, then I is maximized for $x = (1-\alpha)y$, resulting in the same income as in the previous case.

Thus, the income when there is total compliance in one dimension is $I^*_{fc} = I^*|_{x=y} = I^*|_{\tau=h}$. It is straightforward to show that $I^* > I^*_{fc}$.

So, the analysis at the boundaries shows that (x^*, τ^*) is indeed the global maximum point.

Equilibrium with a minimum hourly wage Given an hourly minimum wage ϖ, problem (2.20) becomes:

$$(x^*, \tau^*) \qquad s.t. \max_{x\in\{0\}\cup[\varpi,y],\tau\in[0,h]} yh - x\tau t - \gamma f.$$

Parallel to the main model, workers split into three categories:

1. High productivity: $y_i > \varpi/\sqrt[2]{1-2\alpha}$;
2. Intermediate productivity: $\varpi \leq y_i \leq \varpi/\sqrt[2]{1-2\alpha}$;
3. Low productivity: $y_i < \varpi$.

High productivity workers are unaffected by the introduction of the minimum wage as they would have declared higher hourly earnings anyway. Low productivity workers are expelled from the formal labour market and can choose black market activity or inactivity. The choice is made by comparing income in the two cases, given by (2.22) and 0, respectively. This gives rise to the following condition:

$$I^*_{bm} > 0 \Leftrightarrow \alpha > t/4. \tag{2.23}$$

As in the main model, if enforcement is very effective (low α), then the minimum wage has an efficiency cost as workers with positive productivity withdraw into idleness. If enforcement is instead not too effective, workers with an hourly productivity below the minimum wage work completely underground.

To analyse the behaviour of workers with intermediate productivity, we need to compare the income when declaring the minimum wage to the income when being completely underground and when fully reporting.

When declaring the minimum wage, i.e. $x = \varpi$, the amount of declared hours maximizing income is given by $\tau_{mw} = 2yh\varpi(1-\alpha)/\left(y^2+\varpi^2\right)$, giving an income:

$$I_{mw}^{*} = yh - th\left[(y^2+\varpi^2)^2 - (2y\varpi)^2\left(1-\alpha\right)^2\right]/\left[4\alpha y\left(y^2+\varpi^2\right)\right].$$

A worker firm pair can always choose to be completely in the informal economy, i.e. $x = \tau = 0$. We have seen that this is the best that can be done when there is full evasion in at least one dimension. Income in case of full evasion is given by (2.22).

The choice between full evasion and declaring the minimum wage is made by comparing income in the two cases. It turns out that:

$$I_{mw}^{*} > I_{bm}^{*} \Leftrightarrow y_i > \varpi/\sqrt[2]{4\left(1-\alpha\right)^2 - 1} \equiv y_{mw}.$$

As the minimum wage constraint is binding only if $y_i < \varpi/\sqrt[2]{1-2\alpha}$ and $y_{mw} < \varpi/\sqrt[2]{1-2\alpha}$ $\quad\forall\alpha < 1/2$, there is always a productivity interval where workers prefer increasing their compliance to the minimum wage rather than decreasing it by declaring zero.

To complete the analysis, we need to analyse the remaining boundaries, i.e. the case with full reporting in at least one dimension.

In case $x = y$, the maximum income that can be achieved is I_{fc}^{*} , where $I_{mw}^{*} > I_{fc}^{*}$ and $I_{bm}^{*} > I_{fc}^{*}$ for workers whose productivity is such that they are affected by the minimum wage. In case $\tau = h$, the maximum income that can be achieved is certainly less than I_{fc}^{*} and thus less than I_{mw}^{*} and I_{bm}^{*}. Thus, the choice faced by this type of worker is indeed between increasing compliance to the minimum wage level or decreasing it to zero.

In this section, the model has been extended by allowing hours of work to be underreported, subject to the same detection technology as earnings. Also in this case does the introduction of the minimum wage induce some workers to increase compliance, thereby producing a spike at the minimum wage level. Proposition 2.2 is thus robust to this extension. As the minimum wage acts as an effective constraint for the low-productivity part of the workforce, Propositions 2.3 and 2.4 extend to this more general setting.

7.2 The black economy

The model presents no discontinuity when a firm-worker pair leaves the formal economy and goes completely underground. It may, however, be argued that being completely in the black economy is substantially different than being part of the official economy. In particular, we analyse the implication of possible discontinuities in two key variables: productivity and expected fines. In the analysis, we assume that enforcement parameters are such that there is underreporting.

Productivity discontinuity While it seems unlikely that the product generated by a firm-worker pair is dependent on the reporting behavior in case of simple underreporting, it is more plausible that completely entering into the black economy may have an effect. More difficult access to the legal protection system to enforce contracts and property rights, inability to tap formal credit, restricted possibility to advertise, no access to support programmes (like training schemes, subsidies to R&D) for enterprises are some of the factors that may cause a decrease in the surplus once a firm goes underground. On the other side, the avoidance of official regulation and red tape may boost the product of firms fully in the underground economy (see Loayza, 1996, for a review). The relative relevance of the pros and cons depends on the specific situation of a country. For instance, an ineffective court system and a credit market that is not accessible for some types of enterprises (like SME) even if registered may decrease the disadvantage of being underground.

Extending the model to take this potential discontinuity into account is straightforward. Assume that productivity is

$$\begin{cases} y_i & if \;\; x_i > 0 \\ y_i + d & if \;\; x_i = 0 \end{cases} \text{ or } \begin{cases} y_i & if \;\; x_i > 0 \\ \eta y_i & if \;\; x_i = 0 \end{cases} .$$

In case $d < 0$ or $\eta < 1$, the cons of being in the black market outweight the pros.

When there is no minimum wage nothing changes. When there is a minimum wage ϖ, then the worker-firm pair has a greater incentive to increase compliance to the minimum wage level, instead of going into the black market, thus reinforcing the tendency to show a spike at the minimum wage level and the positive impact of minimum wage on fiscal revenues.

In case $d > 0$ or $\eta > 1$ (and $\alpha > t/2$), being in the black market provides an advantage as compared to being in the official economy. In case of an addictive productivity difference, when there is no minimum wage, worker-firm pairs characterized by low productivity, i.e. with $y_i < d(2\alpha - t)/\left[t\,(1-\alpha)^2\right]$, will go into the black market, while nothing changes for higher productivity pairs. When there is a minimum wage, a positive productivity advantage of being in the black market reduces the incentive for firms to declare the minimum wage level instead of going into the black economy, but as long as the minimum wage is sufficiently high as compared to the productivity differential, in particular for $d < t\varpi\left[2y\,(1-\alpha) - \varpi\right]/\left[(2\alpha - t)\,y\right]$, there is still a spike at the minimum wage level. In case the productivity difference is multiplicative, for the no minimum wage case, a sufficiently low productivity advantage, i.e. $\eta < 1 + t(1-\alpha)^2/\left(2\alpha - t\right)$, is necessary for avoiding that all agents go into the black market. In such circumstances, the incentives to declare the minimum wage are reduced, but do not disappear. In particular, a spike at the minimum wage level will be present anyway.

Discontinuity in expected fines A discontinuity at zero declaration may also exist with regard to the expected fine. Once more, it is not a priori obvious in which direction such a discontinuity may work. On the one hand, the non-existence of a company in official registers may make it more difficult to localize it and perform an audit. On the other hand, once an audit is performed, proving underreporting is much more difficult than proving non-reporting, as in the latter case the operation of a firm without registration constitutes evidence in itself. Discontinuities may also exist in the fine applied in case of detection, with complete underreporting being likely to be punished more harshly than partial underreporting. Assume the expected fine to be:

$$\begin{cases} \gamma f & if \;\; x_i > 0 \\ \rho\gamma f & if \;\; x_i = 0 \end{cases}, \text{ where } f \text{ is given by (2.1).}$$

In case $\rho > 1$, being in the black market gives rise to higher expected fines due to a higher probability of auditing or higher fines imposed in case of detection. Without a minimum wage, nothing changes. With a minimum wage, the incentives to declare the minimum are stronger.

In case $\rho \in (0, 1)$, being in the black market gives rise to lower expected fines due to a lower probability of auditing. Unless the advantage of being in the black market is not too high, every agent goes underground. In particular for $\rho > (2 - \alpha)\,\alpha$, the equilibrium without a minimum wage will not change, while in case of a minimum wage, the incentives to declare the minimum wage instead of going into the black economy are reduced, but do not disappear, with a spike remaining at the minimum wage level.

7.3 Entitlements from social security

Social security contributions usually provide entitlements in the form of pensions, unemployment benefits, health insurance, maternity benefits and so on. If workers value such entitlements, their existence represents an incentive to contribute and should be taken into account when analyzing the evasion decision. Entitlements are usually partly linked to contributions and partly independent of them. Below, the implications for the model are analyzed for each case.

Proportional transfers Suppose that workers receive a transfer proportional to their declared wage, ϑx, from social security institutions. In theory, their value of this could be more than its cost, i.e. $\vartheta > t$. This may be the case when social security funds run a deficit or are subsidized by the general budget (and thus by fiscal imposition on a different tax base) or when workers value these transfers highly (for instance because they provide some insurance that, due to some market failure, cannot be purchased separately.) In this case, however, there is no reason to evade taxes, so we assume, more realistically, that $\vartheta < t$. Equation (2.3) becomes:

$$I = w - tx + \vartheta x.$$

In case equation (2.1) is also modified, so that fines are paid only on the amount of evasion net of foregone benefits, the model is simply modified by substituting $(t - \vartheta)$

to t. In case fines continue to be paid on evaded taxes, the solution to (2.4) becomes

$$x = (1 - \alpha + \alpha\vartheta/t)\, y.$$

Not surprisingly, evasion declines, while a positive correlation between the tax rate and the portion of income that is evaded appears. This is consistent with the results reported by Alm et al. (1990) in their study about Jamaican employees' tax evasion and avoidance. They find that "the tax base rises with higher benefit for payroll tax contributions and falls with higher marginal tax rates", albeit estimated elasticities are small. As for the effects of the minimum wage, the productivity threshold above which workers prefer to declare the minimum wage is lower in case of transfers proportional to contributions, thus possibly increasing the size of the spike.

Lump-sum transfers Here, the case of a lump-sum transfer δ is analyzed. The transfer is assumed to be conditional on formal working status. In the absence of a minimum wage, the only effect of a lump-sum transfer is to displace complete evasion emerging when enforcement is weak with a minimal declaration, so as to qualify for the transfer by formally being part of the workforce. More interestingly, in case of a minimum wage, a transfer conditional on formal working status represents a further incentive to declare the minimum wage instead of going into the black market and thus reduces the productivity threshold above which workers prefer to declare the minimum wage. In particular, the threshold (2.15) becomes

$$y_{mw} = \varpi / \left[2(1 - \alpha) + 2\alpha\delta / (t\varpi)\right].$$

The lump-sum transfer δ should be intended as the difference between transfers conditional on being employed and transfers conditional on not being employed (unemployment benefits or other forms of social support.) In case $\delta < 0$, then the threshold would be higher as being formally employed would mean giving up some net transfer, but the effects of the minimum wage will not disappear as far as the monetary loss in case of official employment status is sufficiently low compared to the minimum wage, in particular for $|\delta| / \varpi < t(1 - \alpha) / (2\alpha)$.

8 Conclusions

The paper develops a tractable model of underreporting of earnings by employed labour and works out the implications of introducing minimum wage regulation in such an environment.

A contribution of the paper to the literature on tax evasion is to show that imperfect detection alone is able to generate an internal solution to the tax evasion decision, even with a fixed probability of an audit and risk neutrality by the agent subjected to this.

The interaction between tax evasion and minimum wage gives rise to a spike at the minimum wage level. This is a mechanism that has never been proposed in the literature, that works in a perfectly competitive labour market and that can account for the double digit spike present in some countries.

In addition, the model contributes to the policy discussion on minimum wage in countries where underreporting of earnings is a relevant phenomenon. In particular, it is shown that introducing or increasing the minimum wage can boost fiscal revenues. The discussion of the fiscal impact of the minimum wage has usually focused on the expenditure side. The role of the state as an employer or the fact that, in some countries, social benefits are indexed to the minimum wage are two reasons why a higher minimum wage might deteriorate the fiscal balance. This paper claims that this may not be the case, if the effect on revenues is sufficiently large to counterbalance the higher spending. However, the boost in revenues is due to extracting more resources from the lower end of the productivity distribution and introduces some degree of regressivity in the fiscal system.

The model also makes a new prediction about the correlation between the size of the spike at the minimum wage level and the size of the informal economy that finds some support in the data.

The optimal auditing strategy by a tax authority in case it possesses an imperfect detection technology is subject to ongoing research.

Bibliography

[1] Acemoglu, D. (2001), "Good jobs versus bad jobs", *Journal of Labor Economics*, vol. 19, pp. 1-21.

[2] Alm, J., Bahl, R., and Murray, M. (1990), "Tax structure and tax compliance", *The Review of Economics and Statistics*, vol. 72(4), pp. 603-613.

[3] Andreoni, J., Erard, B., and Feinstein, J. (1998), "Tax compliance", *Journal of Economic Literature*, Vol. 36, pp. 818-860.

[4] Boeri, T., and Garibaldi, P. (2007), "Shadow Sorting", in: Pissarides, C. and Frenkel, J. (eds.) *NBER International Seminar on Macroeconomics 2005*, MIT Press, Cambridge, MA.

[5] Brown, C. (1999), "Minimum wages, employment, and the distribution of income", *Handbook of Labor Economics*, vol. III, Elsevier, Amsterdam.

[6] Card, D., and Krueger, A. (1995), *Myth and measurement*, Princeton University Press, Princeton, NJ.

[7] Cowell, F. (1985), "Tax evasion with labour income", *Journal of Public Economics*, vol. 26, pp. 19-34.

[8] Dickens, R., and Manning, A. (2004), "Spikes and spill-overs: the impact of the national minimum wage on the wage distribution in a low-wage sector", *Economic Journal*, vol. 114, pp. 95-101.

[9] DiNardo, J., Fortin, N., and Lemieux, T. (1996), "Labor market institutions and the distribution of wages, 1973-1992: a semiprametric approach", *Econometrica*, vol. 64(5), pp. 1001-1044.

[10] Draca, M., Machin, S., and Van Reenen, J. (2006), "Minimum wage and firm profitability", IZA DP 1913.

[11] Erard, B. (1997), "Self-selection with measurement errors. A microeconometric analysis of the decision to seek tax assistance and its implications for tax compliance", *Journal of Econometrics*, vol. 81, pp. 319-356.

[12] Eurostat (2004), "Minimum Wages - EU Member States, Candidate Countries and the US", *Statistics in focus 10/2004*.

[13] Eurostat (2006), "Small decline in overall taxation to 39.3% of GDP in 2004", *News release 62/2006*.

[14] Feinstein, J. (1991), "An econometric analysis of income tax evasion and its detection", *RAND Journal of Economics*, vol. 22, pp. 14-35.

[15] Feldman, N., and Slemrod, J. (2007), "Estimating tax noncompliance with evidence from unaudited tax returns", *The Economic Journal*, vol. 117(518), pp. 327-352.

[16] Fugazza, M., and Jacques, J. (2003), "Labor market institutions, taxation and the underground economy", *Journal of Public Economics*, vol. 88, pp. 395-418.

[17] Klepper, S., and Nagin, D. (1989), "The anatomy of tax evasion", *Journal of Law, Economics, and Organization*, vol. 5(1), pp. 1-24.

[18] Kolm, A., and Nielsen, S.B. (2005), "Under-Reporting of Income and Labor Market Performance", WP 2005:5, Stockholm University.

[19] Lemos, S. (2006), "A Survey of the Effects of the Minimum Wage on Prices", forthcoming *Journal of Economic Surveys*.

[20] Loayza, N. (1996), "The economics of the informal sector: a simple model and some empirical evidence from Latin America", *Carnegie-Rochester Conference Series on Public Policy*, vol. 45, pp 129-162.

[21] NSSI (Undated), "Report from Jordan Hristoskov - governor of the National Social Security Institute, concerning of the State Social Security Budget, 2003", *National Social Security Institute*, Sofia.

[22] OECD (2003), *Labour market and social policies in the Baltic countries*, OECD, Paris.

[23] OECD (2004), *Employment Outlook*, OECD, Paris.

[24] Petrova, A. (2005), "Wages: On the Payroll or Under the Table?", *Public Opinion Foundation*, Moscow.

[25] Renooy, P., Ivarsson, S., van der Wusten-Gritsai, O. and Meijer, R. (2004), "Undeclared work in an enlarged Union", European Commission, Bruxelles.

[26] Sandmo, A. (1981), "Income tax evasion, labour supply, and the equity-efficiency tradeoff", *Journal of Public Economics*, vol. 16, pp. 265-288.

[27] Schneider, F. (2005), "Shadow economies of 145 countries all over the world: estimation results over the period 1999 to 2003", Working Paper.

[28] Schneider, F., and Enste, D. (2000), "Shadow economies: size, causes, and consequences", *Journal of Economic Literature*, vol. 38(1), pp. 77-114.

[29] Simon, K.I., and Kaestner, R. (2004), "Do minimum wages affect non-wage job attributes? Evidence on fringe benefits", *Industrial and Labor Relations Review*, vol. 58, pp. 52-70.

[30] Slemrod, J., and Yitzhaki, S. (2002), "Tax avoidance, evasion, and administration", in: Auerbach, A., Feldstein, M. (eds.) *Handbook of Public Economics*, vol. III, Elsevier, Amsterdam.

[31] Tomev, L. (2004), "Thematic feature - industrial relations and undeclared work", EIRO, www.eiro.eurofound.eu.int.

[32] Yaniv, G. (1992), "Collaborated employee-employer tax evasion", *Public Finance/ Finances Publiques*, vol. 47(2), pp. 312-321.

[33] World Bank (2005), *Enhancing Job Opportunities: Eastern Europe and the Former Soviet Union*, World Bank, Washington, DC.

[34] _. (2006), *Turkey. Country Economic Memorandum*, World Bank, Washington, DC.

[35] _. (2007), *Informality: Exit and Exclusion*, World Bank, Washington., DC.

Appendix

A1 - An alternative setting for imperfect detection

The tax authority devotes $\gamma \geq 0$ units of "auditing resources" to every firm-worker pair. The more resources, the more income is discovered in expectation. In particular, if γ units of resources are used, then $\hat{y}$, the income for which the tax authority can find evidence, is distributed with uniform probability over the interval $[(1-a^{-\gamma})y, y]$, where $a > 1$ measures the effectiveness of auditing. Thus,

- if $\gamma = 0$, i.e. no resources are used, the interval is $[0, y]$. The fact that even with no resources there is the possibility of discovering some evasion may be interpreted as the emergence of evidence from other investigations or from receiving denunciation or by other costless means;
- if $\gamma \to +\infty$ the (degenerated) interval is $[y, y] = \{y\}$, i.e. full income is discovered with certainty;

The pdf of the distribution over the interval $[(1-a^{-\gamma})y, y]$ is $h(\hat{y}) = a^{\gamma}/y$. Given that the tax authority devotes resources γ to a taxpayer characterized by true income y and declared income x, then the expected fine is

$$f = \begin{cases} t\theta \int_x^y (\hat{y} - x)h(\hat{y})d\hat{y} & if \qquad x \geq (1 - a^{-\gamma})y \\ \left[(1 - a^{-\gamma})y - x\right] t\theta + t\theta \int_x^y (\hat{y} - x)h(\hat{y})d\hat{y} & if \qquad x < (1 - a^{-\gamma})y \end{cases} .$$

As the part of undeclared income below $(1 - a^{-\gamma})y$ is discovered with certainty and a fine is imposed on it, it will never be the case that $x < (1 - a^{-\gamma})y$, provided that the taxpayer knows the detection technology and γ. Thus, concentrating on $x \geq (1 - a^{-\gamma})y$ we have

$$f = t\theta \int_x^y (\hat{y} - x)h(\hat{y})d\hat{y} = a^{\gamma} t\theta (y - x)^2 / (2y) \, ,$$

which is equivalent to (2.7), where the probability of an audit being performed, $\gamma \in [0, 1]$, is substituted by the coefficient $a^{\gamma} \geq 0$.

A2 - Audit conditional on report x

The probability of performing an audit can be conditioned on declared income x, so that $\gamma = \gamma(x)$

Proposition 2.6 *As far as $\gamma(x)\theta < +\infty$, it is impossible to induce full compliance.*

Proof. Given a tax liability y and a probability of an audit $\gamma(x) \in [0, 1]$ full compliance is preferred to declaring $x \in [0, y)$ iff

$$(1-t)y > y - \gamma(x)f - tx.$$

Using (2.7), this becomes

$$(1-t)y > y - \gamma(x)\frac{t\theta}{2y}(y-x)^2 - tx \Leftrightarrow \theta\gamma(x) > \frac{2y}{y-x} \equiv \gamma^*_{x,y}.$$

As $\lim_{x \to y^-} \gamma^*_{x,y} = +\infty$, then, as far as $\gamma\theta < +\infty$, there is a neighborhood of y in which the above condition cannot hold and thus underreporting is preferred to full compliance. ■

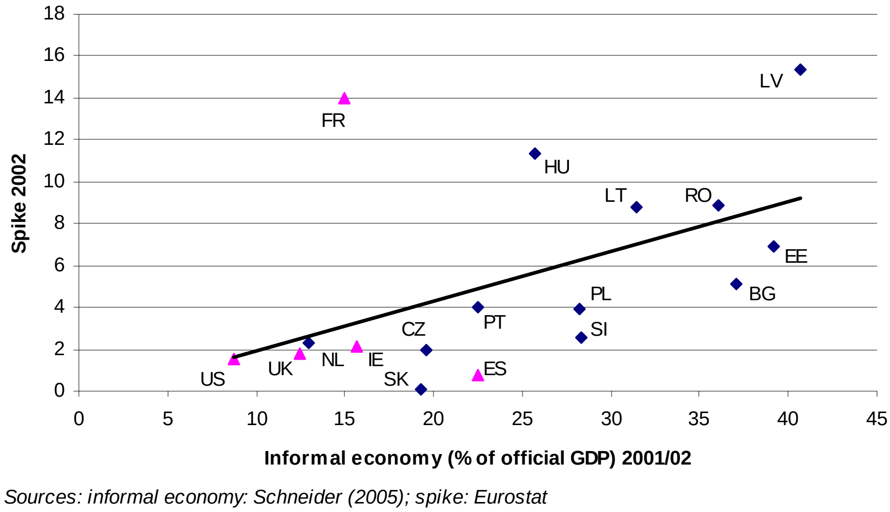
In the alternative setting for imperfect detection proposed in this appendix, the equivalent condition not to have full compliance even in case of devoted "auditing resources" conditional on declared income is $\alpha^{\gamma(x)}\theta < +\infty$.

The above proposition implies that whatever auditing policy is implemented, there will be some evasion at any income level. So, for any auditing policy, there is room for the minimum wage to exert its influence. However, a fixed cost for the taxpayer of being subject to an audit, together with a higher probability of being audited in case of non-compliance than in case of full compliance, would undo the result.

A3 - Evidence on underground economy and minimum wage spike

As stated in Proposition 2.5, a prediction of the model is that enforcement parameters (as summarized by α) should induce a positive correlation between the spike at the minimum wage and the size of the informal economy relative to the formal economy. In this section, some supporting evidence is presented.

Figure 2.4: Informal economy and minimum wage spike



The two figures in this section present the relationship of the spike at the minimum wage[22] with the size of the informal economy relative to the formal economy[23] and the ratio of the minimum wage to the average wage[24] (in what follows, this measure is indicated as the Kaitz index.) The countries included are all countries for which Eurostat reports data on the minimum wage spike and Schneider (2005) reports estimates of the informal economy. The sample includes 16 European countries and the US. Ten of the European countries are Central and Eastern European, where statutory minimum wage arrangements are common.

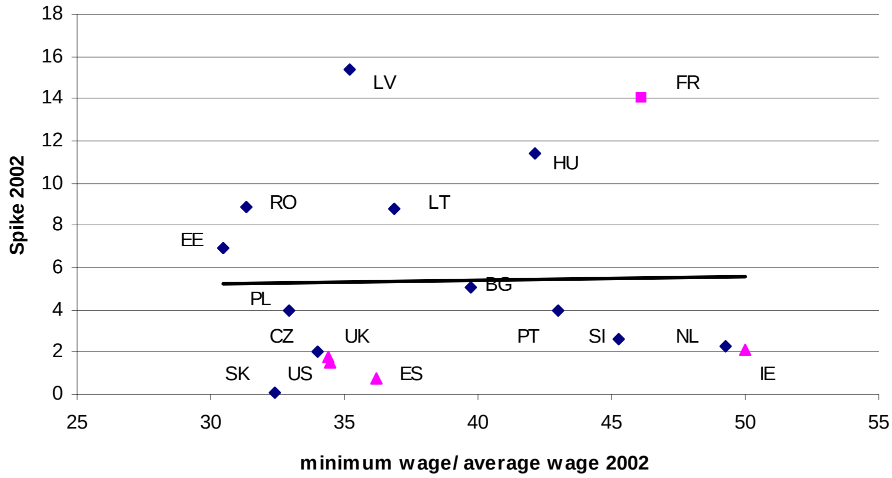
A positive correlation clearly appears between the size of the spike at the minimum wage level and the estimated size of the informal economy (see figure 2.4). As mentioned in the introduction, other mechanisms have been proposed to explain

[22] The proportion of full-time employees with earnings exactly equal to the monthly minimum wage (source: Eurostat). Notice that the data collected by Eurostat are obtained from administrative sources. For data points indicated with a triangle, the definition is different: part-time workers are included (France, Spain), minimum wage is fixed on an hourly basis (France, Ireland, UK, USA), earnings below the minimum wage are also included (UK, USA). See Eurostat (2004) for details.

[23] Informal economy as % of official GDP (source: Schneider 2005).

[24] Minimum monthly wage as a proportion of average monthly earnings in industry and services (source: Eurostat). For France, the figure has been calculated by the author dividing the hourly gross wage by the average gross hourly wage for a full-time employee in industry, trade and services (data source: INSEE.)

Figure 2.5: Kaitz index and minimum wage spike



Source: Eurostat, except France - Kaitz Index: own calculations

the existence of a spike at the minimum wage level and one natural "culprit" for a high spike would be a minimum wage "biting" deeply into the wage distribution. However, no clear relationship appears between a measure of this "bite", the Kaitz index, and the size of the spike (see figure 2.5).

Regression analysis (see table 2.2) confirms that the positive relationship between the spike and the informal economy is not driven by a high minimum wage resulting in both a high spike and a sizeable informal economy. Regressing the size of the spike on the size of the informal economy and the Kaitz index, the former is significant, while the latter is not. The model suggests that the positive correlation between the size of the spike and the size of the informal economy is instead driven by the common dependence on enforcement parameters. The regression implies that a 1% increase in the size of the informal economy is associated with a 0.28% increase in the share of employees earning the minimum wage.

Table 2.2: Determinants of minimum wage spike

Informal Economy as % of Official GDP (2002)	0.279**
	(0.113)
Minimum Wage / Average Wage (2002)	0.179
	(0.179)
Constant	−8.337
	(8.381)
R^2	0.30
Observations	17

a. Dependent variable is spike at minimum wage level in 2002.

b. OLS estimation. Standard errors in parenthesis.

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

Chapter 3

Minimum Wage and Tax Evasion: Empirical Evidence*

"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)

1 Introduction

The degree of informality of the Hungarian economy is high. For instance, a study for the European Commission (Renooy et al., 2004) put the size of undeclared work at 18% of GDP in 1998[2] . In 2001, Hungary experienced a massive increase in the minimum wage, which is particularly relevant as it applies to all employees without any exception. The combination of a high degree of informality in the labour market

* I thank the Hungarian National Bank, where part of this research was conducted, for its hospitality. I also thank the Institute of Economics at the Hungarian Academy of Sciences for its hospitality and for providing the data. Comments and suggestions by John Hassler, György Molnár, Péter Benczúr, Ethan Kaplan, Gábor Kézdi, István Kónya, János Köllo, Torsten Persson, David Strömberg, and several seminar and conference participants have been very helpful. I am grateful to Christina Lönnblad for editorial assistance. Financial support by Jan Wallander's and Tom Hedelius' Research Foundations is gratefully acknowledged.

[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)*

[2] This is compared to 6% of GDP, on average, for the 12 EU-15 countries for which they have data and 16% of GDP for the 10 CEE new member states. The figures are obtained through a combination of business surveys and expert interviews.

and a big shock in minimum wage policy, makes Hungary an ideal testing ground for the theory developed in chapter 2.

One of the predictions of the model is that a minimum wage hike implies a fall in true income for those workers officially earning between the old and the new minimum wage before the hike. Workers who appear to benefit from the hike, as they keep their job and experience an increase in official earnings, also actually experience a drop in true income, since the higher minimum wage forces them to officially declare at least part of the earnings that were previously received informally. The empirical test is done by adapting the methodology introduced by Pissarides and Weber (1989) to a panel framework. Panels derived from the household budget survey for the years 1999-2001 are used to compare food consumption, as a proxy for true income, before and after the increase in the minimum wage for households affected by this and for similar but unaffected households. The analysis suggests that the minimum wage hike was indeed effective in squeezing more fiscal revenues from affected households, thus supporting the prediction of the theory.

The next section discusses some of the empirical literature on tax evasion and participation in the informal economy. The prediction of the model is derived in the third section. Section 4 provides the institutional context, describing the macroeconomic situation, the fiscal environment, the relevance of the informal economy, and the minimum wage policy in Hungary around 2001. The statistical framework is outlined in section 5, while the following section presents the empirical implementation. The last section concludes.

2 Related literature

The empirical study of tax evasion or participation in the informal economy by labour is not straightforward. One method is to design specific surveys on these issues. For example, Lemieux et al. (1994) conducted a survey with questions on participation in the underground sector in Quebec city, Canada, and found that underground labour-market activity is concentrated among people at the low end of the income distribution. Another method is based on the comparison of income or labour force participation data from different sources. For instance, Fiorio and D'Amuri (2005) estimate tax evasion in Italy by comparing income from tax forms to survey-based data and find that for employees, evasion is high at lower levels of income, but close to zero at the median.

The method used in this paper is based on the comparison of income and consumption data from household budget surveys. This methodology was pioneered by Pissarides and Weber (1989.) They 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. Lyssiotou et al. (2004) use a demand system approach to take into account preference heterogeneity. They also focus on tax evasion by the self-employed. Tedds (2005) uses a nonparametric approach to address the same question and finds evidence of a non-linear reporting function, with underreporting decreasing as reported self-employment income increases. 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.

The methodology developed by Pissarides and Weber 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 (2006) take the opposite view in their study on bribery in Ukraine. They use the large estimated sectoral 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.

The methodology used in this paper to investigate the impact of the minimum wage on underreporting is inspired by this strand of literature. Also in this case are expenditures on food assumed to be correctly reported. There is no need, however, to assume that a group truthfully reports income. The minimum wage hike that took place in Hungary in 2001 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.

A closely related study using a different methodology is McIntyre (2006), who estimates an empirical model of illegal work on cross-sectional data from a large

Brazilian household survey. The survey includes data on participation in the social security system and possession of a legal work contract. The focus of the paper is on mandated benefits. Workers are assumed to differ in their valuation of benefits and can trade-off lower benefits for higher wages. Receiving benefits below the mandated amount and receiving a wage below the statutory minimum entails an evasion cost. This cost has a fixed component, once some form of illegality is incurred, and a variable component, dependent on the deviation from the legal requirements. When workers are illegal in both the benefit and wage dimensions, swapping one type of illegality for the other, i.e. getting a higher wage at the cost of less mandated benefits, does not change the total evasion cost. Once a worker receives at least the minimum wage, however, a further increase in the wage component of his compensation package at the expenses of mandated benefits increases the evasion costs. For this reason, the worker's budget constraint presents a kink at the minimum wage level and a mass of workers' clump at the minimum wage level. The ML estimation reveals that almost half of the agents value benefits at or above their cost and that the fixed component of the evasion cost is nil, while the marginal cost equals 8.1% of the distance from the legal requirement. The differential impact of the minimum wage for different agents is used to identify the model.

3 The effect of a minimum wage hike on incomes

Here, we characterize the change in income due to a minimum wage hike for different categories of workers implied by the theory developed in the second chapter. 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 behaviour 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

$$\Delta I = -t\left(\varpi_2 - \varpi_1\right)\left[\varpi_2 + \varpi_1 - 2y(1-\alpha)\right]/\left(2\alpha y\right) < 0 \text{ [3]}.$$

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

$$\Delta I = t\varpi_1\left[\varpi_1 - 2y(1-\alpha)\right]/\left(2\alpha y\right) < 0 \text{ [4,5]}.$$

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

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

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

$$\Delta I = -ty\left(1-\alpha\right)^2/\left(2\alpha\right) < 0 \text{ [6]}.$$

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 3.1 *As a result of a minimum wage hike, workers whose declared earn-*

---

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

[4] 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 $y_i > \frac{\varpi_1}{2(1-\alpha)}$ if $\alpha > 1/2$.

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

[6] See previous note.

ings 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 a sum between the new and the old minimum wage in the previous period, thereby making them worse-off. The predictions are tested in the following sections.

4 The Hungarian context

In the period 2000-2001, the Hungarian activity rate was around 60%, with unemployment declining from 6.4% in 2000 to 5.7% in 2001 and youth unemployment from 12.5% to 11.3%. GDP growth in 2001 was 4.1% and CPI inflation 9.2% (see table 3.1 for more details.) In Hungary, taxation on labour is 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 degree of informality is also high, with evidence of there being underreporting of earnings. For instance, 56% of the households interviewed in a survey claim that in their neighbourhood, employers are declaring the minimum wage to the tax authority, while unofficially paying additional wages (ECONSTAT, 1999.) 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 for up to three years[7] (OECD, 2004). Economic organisations with legal entity status were in the period 2000-2001 subject to an "audit intensity"[8] of around 45%. The corresponding number for economic organisations without legal entity status was around 19% (APEH, 2006).

The statutory minimum wage[9] was significantly increased from 25,500 HUF in

[7] The prime rate of the Hungarian National Bank was around 11% in the period 2000-2001.

[8] 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.

[9] 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

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.)[10] 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 impact of the minimum wage hike clearly appears in figure (3.1). The share of full-time employees 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.)

In their study on the labour market impact of the 2001 minimum wage rise, Kertesi and Köllő (2003) find a high level of compliance with the minimum wage regulation, with only a minor spillover on the wage distribution. They compare the job loss risk of workers earning 90-110% of the minimum wage in 2001, the treatment group, to that of workers earning 110-125%, the control group, and find a significant but small effect on the quarterly outflow into unemployment[11] . They find no effect on the flow from employment to non-participation. They also find a 7-8% drop in the job finding probability of 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 conclusion of their study is that “despite the brutal price shock the immediate effect did not seem dramatic”.

5 The statistical framework

Reported income, $x_{i,t}$, is observed for household i at time t. Reported income is related to true income, $I_{i,t}$, by the following relationship

$$x_{i,t} = k_{i,t} I_{i,t}, \tag{3.1}$$

is proportionally lower, but part-timers only account for a small portion of all employees (3.6% in 2001-2002.) According to the Hungarian UI Exit to Job Survey, 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).

[10] See table 3.2 for details.

[11] 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.

where $0 \leq k_{i,t} \leq 1$.

True income is related to permanent income, $I_{i,t}^P$, by the following relationship

$$I_{i,t} = p_{i,t} I_{i,t}^P, \tag{3.2}$$

where $p_{i,t} \geq 0$.

By combining (3.1) and (3.2) and taking logs, we can write permanent income as a function of reported income:

$$\ln I_{i,t}^P = \ln x_{i,t} - \ln k_{i,t} - \ln p_{i,t}. \tag{3.3}$$

The relationship between food consumption and permanent income is assumed to be

$$\ln c_{i,t} = Z_{i,t}\alpha + \beta \ln I_{i,t}^P + \varepsilon_{i,t}, \tag{3.4}$$

where $Z_{i,t}$ is a row vector of household characteristics. 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 over the limited time period in which the survey is conducted. Substituting (3.3) into (3.4), we can express consumption as a function of reported income

$$\ln c_{i,t} = Z_{i,t}\alpha + \beta \ln x_{i,t} - \beta \ln k_{i,t} - \beta \ln p_{i,t} + \varepsilon_{i,t},$$

and taking first differences we get

$$\Delta \ln c_{i,t} = \Delta Z_{i,t}\alpha + \beta \Delta \ln x_{i,t} - \beta \Delta \ln k_{i,t} - \beta \Delta \ln p_{i,t} + \Delta \varepsilon_{i,t}. \tag{3.5}$$

As seen in section 3, the theory indicates that 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, while other workers are unaffected. Thus, for the former group of workers, we have

$$\Delta \ln I_{i,t} = \Delta \ln x_{i,t} - \Delta \ln k_{i,t} < 0.$$

In particular, for workers whose official earnings increase to the new minimum after the hike, there is an increase in their compliance with the fiscal regulation, while workers unaffected by the minimum wage hike do not experience a change in their ability to underreport. Thus, labelling the former group as "treated", we have

$$-\Delta \ln k_{i,t} \begin{cases} < 0 & \text{for the "treatment group"} \\ = 0 & \text{for the "control group"} \end{cases} .$$

To identify the shock to the "underreporting technology" due to the minimum wage hike, i.e. $-\Delta \ln k_{i,t}$, we use a difference-in-difference approach. The change in food consumption for households that were affected by the minimum wage hike is contrasted to the change in food consumption for similar, but unaffected, households. As $\Delta \ln p_{i,t}$ is unobserved, particular care must 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 labour market risk.

Specification The basic specification is the following

$$\Delta c_i = \alpha + \gamma * M_i + \beta * TREAT_i + \Delta\varepsilon_i, \tag{3.6}$$

where Δc_i is the change in food consumption for household i in two consecutive years. M_i is a set of dummies allowing for different trends depending on the months in which the household is surveyed in two consecutive years. The seasonality displayed by food prices makes it important to compare households that were interviewed in exactly the same month in both years. The exact definition of this and the other variables is provided in the Appendix. The coefficient of interest is β. The exact definition of $TREAT_i$ is provided in what follows. Regressions including additional controls like the change in household income or geographical dummies are also run. 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. According to the model, 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.

Data and sample The data are from the Hungarian Household Budget Survey Rotation Panel[12] . 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.

More information about the way the survey is conducted is available in the Appendix and in Kapitány and Molnár (2004) and Molnár (2005). It is worth underlining that surveyors are expected to collect the income data used in this analysis from documentation like the tax return sheet or the tax certification of employer, whenever it is possible. This makes it more likely that income in the survey corresponds more to income reported to the fiscal authorities than to true income, which is possibly different.

The distribution of earnings in the dataset (see figure 3.2) 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. Table 3.3 summarizes the labour market status and flows for the whole sample.

6 Empirical implementation

A household is considered as treated if at least one of its members has been affected by the minimum wage hike. Two different methods are used to single out these individuals. In the first case, individuals employed in 2000 at a wage between the minimum wage in 2000 and the will-be minimum wage in 2001 are selected. The treatment group is thus only defined on basis of pre-treatment characteristics. In the second case, an additional requirement is imposed: being employed in 2001 at the minimum wage. The reported earnings of these employees are thus actually pushed

[12] The Hungarian Household Budget Survey Rotation Panel is created by the Institute of Economics, 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.

up by the policy intervention while, in the former case, they were only potentially pushed up. For this reason, the two cases are labelled "actual" and "potential". In both instances, the variable "treatment" is defined as the number of household members conforming to the above mentioned criteria. An alternative definition of treatment is explored for the "actual" case. Instead of simply counting their number, the difference between the minimum wage in 2001 and earnings in 2000 is summed up for all members of the household affected by the hike. The aim of this continuous measure is to capture the intensity of treatment. This definition of treatment is labelled "continuous" as opposed to the "dummy" treatment previously described.

Households in the control group are defined on 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, a "placebo test" is conducted where the absence of a treatment effect in the pre-policy period is ascertained. This is done by looking at changes in food consumption in the period 1999-2000. Sample size considerations restrict this analysis to the "potential" treatment case.

To ensure comparability, the analysis is always restricted to households that keep a constant composition and whose income is within certain limits. Moreover, to avoid confounding an increase in labour market risk with an increase in compliance with fiscal regulation, only employees with stable positions are considered. The precise definitions of treatment and control groups are provided in what follows.

Potential treatment In this section, the analysis is done on the two panels covering the years 1999-2000 and 2000-2001, respectively. For each two-year panel, only households that kept a constant composition in the period and that had a positive net income below 200,000 HUF in both years are considered. Moreover, we 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% (150%) of the minimum wage in 2001. The sample is restricted in this way to ensure comparability between treatment and control groups.

Definition of treatment 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 the year 2000 (25,500 HUF) and the minimum wage in the year 2001 (40,000 HUF) are considered as treated. The variable $TREAT_i$ contains the total number of members of household i classified as treated.

Descriptive analysis The treatment and the control group are not ex ante identical along all dimensions. For instance, the mean total net income and income from the main activity at the household level are higher for the treatment than for the control group (see tables 3.4 and 3.7.), with the notable exception of the smallest control group in the post-treatment period. In this case, mean total net income does not differ significantly from the treatment group, while mean expenditures on food do. However, the considerable overlap in the distribution of household total net income for treatment and control groups (see figure 3.3) indicates that the two groups are not too heterogeneous. The same conclusion emerges by comparing the estimated relationship between market food consumption and household total net income for treatment and control groups (see figures 3.4 and 3.5.) The estimated Engel curves are indeed quite overlapping in the pre-treatment period.

Results When the 2000-2001 panel is used, the coefficient of the treatment variable is, as predicted, always negative and significant whenever the larger control group is used. When the smaller control group is used, significance is not always achieved (see tables 3.5 and 3.6.) Besides the basic specification described in (3.6), regressions including the change in household income, the change in home production of food, the change and level of household income, employee characteristics and geographical dummies are also run.

The validity of the control group is confirmed by the fact that the treatment is never significant in the "placebo test", when the analysis is done using the pre-treatment panel, 1999-2000 (see tables 3.8 and 3.9.) The change in food consumption does not differ between the treatment and the control group in the pre-policy period, i.e. before the minimum wage hike. After the policy has been implemented, however, the change in food consumption is significantly lower for treated households. The magnitude of the coefficient is also reasonable. 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[13] . Considering that around a quarter of the income

[13] Social security contributions rate: 48.5%. Personal income tax marginal rate: 8% until 30,000

is spent on food consumption, a negative coefficient of around 1,500-2,000 HUF is reasonable.

Actual treatment In this case, only the 2000-2001 panel is used. To ensure comparability, also in this case do we only keep households that kept a constant composition in the period and with a positive net income below 200,000 HUF in both years in the sample. Moreover, we only select households with at least one member employed during the whole of 2001 at a wage between 90% and 200% (150%) of the minimum wage in 2001.

Definition of treatment An employee must satisfy two criteria to be considered as treated. First, he must work in the private sector for the whole of 2001 and earn a wage around the minimum wage in that year (90%-110% are the thresholds considered.) Moreover, he must have been employed at a wage between the old and the new minimum wage in 2000 (the thresholds are 90% of the minimum wage in 2000 and 110% of the minimum wage in 2001.) In the "dummy treatment", the variable $TREAT_i$ contains the number of household members belonging to this category. 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.

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

As previously, mean expenditures on food, total net income and income from the main activity at the household level differ between treatment and control groups (see table 3.10.) However, the estimated distribution of household total net income (see figure 3.6) shows a significant overlap between treatment and control groups and the estimate of the relationship between market food consumption and household total net income (see figure 3.7) shows basically identical Engel curves for treatment and control groups in the pre-treatment period. Thus, the two groups are not too dissimilar.

HUF, 18% thereafter. Total: 56.5% until 30,000 HUF, 66.5% thereafter. The decrease in expected fines due to increased compliance should be accounted for.

Results The results confirm the previous analysis. The coefficient of interest is always negative, both when using the "dummy treatment" (see table 3.11 and 3.12) and the "continuous treatment" (tables 3.13 and 3.14). In each case, regressions controlling for changes in home production of food, changes in household income, the level and change of household income as well as employee characteristics and geographical dummies are included. Significance is almost always achieved when using the "dummy treatment" and the magnitude of the coefficient in the range 1,000-1,500 HUF is reasonable, considering that in this case, earnings by "treated" employees on average increased by around 9,000 HUF[14] . In "continuous treatment", significance is mainly achieved when additional controls beside month dummies are included. Also in this case is the magnitude of the coefficient reasonable[15] .

Including in the analysis only households with a net income between 50,000 HUF and 150,000 HUF in both years (results not reported) generally makes coefficients greater in absolute value. Significance improves in the "continuous treatment" case, in particular when only month dummies are used as additional controls, while the outcome is more mixed in the "dummy treatment" case.

The negative impact on the change in food consumption of being treated has been confirmed by the use of different definitions of treatment and different specifications. The use of employees with stable working positions in the definition of treatment makes it unlikely that the effect is due to adverse labour market effects of the minimum wage hike which, anyhow, other studies have found to be rather limited. Thus, there is support for the implication of the model that the minimum wage may actually squeeze more fiscal revenues from affected households.

Some robustness checks are conducted in the remaining part of this section.

Additional placebo tests By construction, the individuals defining the control group have higher earnings than those defining the treatment group. May this be the reason for the negative treatment effect? To assess whether this is indeed the case, additional placebo tests have been conducted, repeating the analysis for fictional

[14] The reasoning is the same as in the previous case. An increase in reported income translates, according to the model, into a drop in true income due to increased fiscal payments, corresponding to more than half that quantity. Moreover, also in this case around one quarter of income is spent in food.

[15] See the previous note. Having earnings pushed up by the minimum wage increase by 1 HUF implies, according to the model, a decrease in true income of around 0.5 HUF.

minimum wage hikes. In the first test, all variables have been defined as if the minimum wage in 2000 were 50,000 HUF, increasing to 64,500 HUF in 2001. The true figures of 25,500 HUF for 2000 and 40,000 HUF for 2001 have been shifted to the right by the same amount, thus preserving the difference between the two minimum wages. In the second test, the fictional hike pushed up the minimum wage from 50,000 HUF in 2000 to 78,431 HUF in 2001. In this case, the ratio between the two minimum wages is the same in real and fictional cases. The starting point of 50,000 HUF has been chosen so that there is no overlap between individuals defining the treatment group in the real and the placebo tests.

There is never a significant treatment effect when the "actual treatment" definition is used and the sign of the coefficient is generally positive. When the "potential treatment" definition is used, the coefficient for treatment is never significant for the first placebo test. In the second placebo test, the coefficient is marginally significant in two cases, but the sign of the coefficient is positive. All in all, the results (not reported) indicate that the negative treatment effect is not due to the fact that the treatment and control groups are defined by looking at employees with different positions in the wage distribution.

Other types of consumption The whole analysis has been conducted looking at food consumption. As has already been mentioned, this is standard in the literature due to the fact that in household budget surveys, food consumption is measured with much higher precision than other types of consumption. Moreover, the fact that food represents a sizeable share of total consumption for the households analysed in this study makes its use less problematic. However, there is some concern that the negative treatment effect is due to substitution between consumption items. To check whether this is indeed the case, the analysis has been repeated for thirteen other consumption categories. These include both specific categories like "transport" or "clothing" and aggregates like "total expenditures". The results (not reported) show that the treatment effect is highly insignificant, except in a few cases. For the "beverages and tobacco" category, for instance, the treatment effect is negative and mostly significant in the "actual treatment" dummy specification, while negative but insignificant in the other specifications. For the "investment on housing" category, the treatment is significantly negative in the "potential treatment" post-policy intervention period. For the category "other personal costs", treatment is in a few cases barely significant with a positive sign. Of particular interest is the "total expenditures" category. In that case, the treatment effect generally has a negative sign in both the "actual treatment" specification and the "potential treatment" post-policy intervention period. However, only in a few cases is it significant at the 10% level. All in all, there is no evidence that the treatment group is substituting food with other consumption categories.

"Just enough income..." The methodology introduced by Pissarides and Weber (1989) to study underreporting of income and in this paper adapted to a panel framework basically uses food consumption as a proxy for true income. In the context of the present paper, the main concern surrounding this assumption is that the negative treatment effect may not be due to increased compliance with fiscal regulation, as implied by the theory, but to a drop in permanent income not mirrored by an equivalent drop in present income, for instance due to higher labour market risk for treated households after the minimum wage hike. The analysis conducted so far has addressed this concern by looking at employees remaining in employment at least 12 months after the hike and controlling for employee characteristics. In this section, we address the same issue by exploiting the fact that in the survey, there is a question asking whether "income is normally enough to cover expenses". In 2001, the possible answers were "no", "yes, just enough", "yes, more than enough". In 2000 and 1999, households could answer "yes" or "no" and in case they answered yes, they were asked whether "income is just enough to cover expenses", to which they could answer "yes" or "no". The idea is that for households answering that income is just enough to cover expenses, using consumption as a proxy for true income is less questionable. In this section, we repeat the analysis, restricting our sample to households saying in both years that their income was just enough to cover expenses, i.e. that income and consumption were broadly equivalent. This requirement reduces the sample size by half, dramatically reducing the precision of the estimates. The only case in which coefficients are generally statistically significant is when the "actual treatment" dummy specification is used. In this case (results not reported), the sign of the coefficient is always negative and generally larger in absolute value than the baseline specification. This is a limited result, but it increases the confidence that the negative treatment effect is not due to a drop in permanent income that is not mirrored by an equivalent drop in present income.

7 Conclusions

The massive minimum wage increase that took place in Hungary in the year 2001 has been exploited to investigate whether the minimum wage can be used to affect underreporting of earnings by employed labour, as implied by the theory developed in the second chapter. The analysis has been strictly positive, but it contributes to the policy discussion on minimum wage in countries where underreporting of earnings is a relevant phenomenon. On the one hand, it suggests that 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 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. The elimination of personal income tax for minimum wage workers undertaken by the newly elected centre-left government in Hungary in 2002 may be due to this kind of considerations. On the other hand, if the aim is to reduce 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 if tax evasion among employees is concentrated here, as suggested by the existing evidence (see section 2.) 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. Considerations of this type may help explain the recent implementation in Hungary of a three-tier minimum wage scheme introducing separate minimum wage levels according to educational requirements of the job (Tóth and Neumann, 2007) or the introduction in Bulgaria in 2003 of around 50 minimum social insurance thresholds, practically acting as minimum wages, according to sectors and occupation (Koleva, 2007, Neykov, 2003.)

Bibliography

[1] APEH (2006), *Bulletin*, Budapest.

[2] Besim, M., and Jenkins, G.P. (2005), "Tax compliance: when do employees behave like the self-employed", *Applied Economics*, vol. 37, pp. 1201-1208.

[3] ECONSTAT (1999), "A lakosság részvétele a rejtett gazdaságban", *Időszaki Közlemények 18*.

[4] Feldman, N., and Slemrod, J. (2007), "Estimating tax noncompliance with evidence from unaudited tax returns", *The Economic Journal*, vol. 117(518), pp. 327-352.

[5] Fiorio, C., and D'Amuri, F. (2005), "Workers' tax evasion in Italy", *Giornale degli Economisti e Annali di Economia*, vol. 64(2/3), pp. 241-264.

[6] Gorodnichenko, Y., and Sabirianova Peter, K. (2006), "Public Sector Pay and Corruption: Measuring Bribery from Micro Data", IZA DP 1987.

[7] Kapitány, Zs., and Molnár, Gy. (2004), "Inequality and income mobility in Hungary: 1993-1998", *Europe-Asia Studies*, vol. 56(8), pp. 1109-1129.

[8] Kertesi, G., and Köllő, J. (2003), "Fighting "low equilibria" by doubling the minimum wage? Hungary's experiment", IZA DP No. 970.

[9] Koleva, N. (2007), "Social partners agree minimum social security thresholds", EIRO, www.eiro.eurofound.eu.int.

[10] Lemieux, T., Fortin, B., and Frechette, P. (1994), "The effect of taxes on labour supply in the underground economy", *American Economic Review*, vol. 84(1), pp. 231-54.

[11] Lyssiotou, P., Pashardes, P., and Stengos, T. (2004), "Estimates of the black economy based on consumer demand approaches", *The Economic Journal*, vol.114, pp. 622-640.

[12] McIntyre, F. (2006), "An empirical model of illegal work", mimeo.

[13] Molnár, Gy. (2005), "Az adatállomány és a rotációs panel", in Kapitány, Zs., Molnár, Gy., Virág I. (eds.) *Háztartások a tudás- és munkapiacon*, MTA Közgazdaságtudományi Intézet, Budapest.

[14] Neykov, I. (2003) "New legislation on minimum social insurance thresholds and registration of employment contracts", EIRO, www.eiro.eurofound.eu.int.

[15] OECD (2001), *Taxing wages 2000-2001*, OECD, Paris.

[16] OECD (2002), *Taxing wages 2001-2002*, OECD, Paris.

[17] OECD (2004), *Tax Administration in OECD Countries: Comparative Information Series*, OECD, Paris.

[18] Pissarides, C., and Weber, G. (1989), "An expenditure-based estimate of Britain's black economy", *Journal of Public Economics*, vol. 39, pp. 17-32.

[19] Renooy, P., Ivarsson, S., van der Wusten-Gritsai, O., and Meijer, R. (2004), "Undeclared work in an enlarged Union", European Commission, Bruxelles.

[20] Tedds, L. (2005), "Nonparametric expenditure-based estimation of income under-reporting and the underground economy", Working Paper, McMaster University.

[21] Tóth, A., and Neumann, L. (2007), "Three-year central agreement reached on minimum wage rises and pay policy guidelines ", EIRO, www.eiro.eurofound.eu.int.

Appendix

A1 The survey and main variables

The survey 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.

Main variables and categories

- "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 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 "dummies", describing the labour 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 characterising the hierarchical position[16] (e.g. skilled worker);
    3. Type of employer: the number of employees in the household working for different types of employers[17] (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[18] , the sum of net personal incomes of household members[19] plus other components[20] . A distinction is made between two types of income, including home production or not. In a household budget survey, it is questionable whether we should consider income

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

[17] 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.

[18] e.g. family allowance, income from dividends, income from agricultural sales.

[19] 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.

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

data as true income or income reported to fiscal authorities. The interview collecting data for yearly income is conducted around the time of filling the tax declaration form and the surveyors should get their data from it or from some other type of documentation whenever possible. For these reasons, we consider our income data as income reported to fiscal authorities. If income data actually corresponded to true income, then, after controlling for this, we should not find any effect of a shock to underreporting, as it would be fully accounted for by the income change.

- Food consumption is aggregated from very detailed consumption items. A distinction is made between food bought in the market and food produced at home.

Table 3.1: 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 (% labour force 15+)	7.8	7.0	6.4	5.7	5.8
Youth unemployment rate (% labour 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, CSO, European Commission.

Table 3.2: 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%
	- Monthly maximum		3000	3000
	- Applicable at minimum wage		2550	3000
Pension contribution deduction		- Rate	25%	25%
		- 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%
		- 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%
		- Payment	13080	18300
Labour 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 3.3: Labour market status - Whole sample

		Employed	Retired	Child care	Unemployed	Other	**Total**
				2001			
Employed		32.5%	1.3%	0.4%	1.7%	0.3%	**36**%
Retired	*2*	0.4%	40.1%	0.0%	0.1%	0.8%	**41**%
Child care	*0*	0.8%	0.0%	2.8%	0.2%	0.2%	**4**%
Unemployed	*0*	2.0%	0.2%	0.1%	2.5%	0.5%	**5**%
Other	*0*	1.0%	0.5%	0.1%	0.5%	10.8%	**13**%
Total		**37**%	**42**%	**3**%	**5**%	**13**%	**100**%
				1999			
Employed		31.9%	0.6%	0.6%	2.2%	1.4%	**37%**
Retired	*2*	0.9%	40.1%	0.0%	0.2%	0.7%	**42%**
Child care	*0*	0.5%	0.0%	3.1%	0.0%	0.1%	**4%**
Unemployed	*0*	1.8%	0.0%	0.3%	2.4%	1.3%	**6%**
Other	*0*	0.2%	0.3%	0.2%	0.4%	10.8%	**12%**
Total		**35%**	**41%**	**4%**	**5%**	**14%**	**100%**

a. Only people present for both years (2000-2001: 7064; 1999-2000: 7207).

Table 3.4: Descriptive statistics - Potential treatment - 2000-2001

	Treatment		Narrow control			Large control		
	mean	sd	mean	sd	t-stat	mean	sd	t-stat
2000								
N. of HH members	3.3	1.3	3.2	1.1	1.18	3.2	1.1	1.20
Area of the dwelling (m^2)	80	25	80	26	0.04	79	26	0.46
Expenditures on food (no HP)	21032	9599	22218	9967	-1.38	23167	10545	-2.63
Total net income HH (no HP)	80901	33731	87978	30028	-2.46	92221	30673	-4.15
Home production: total	7457	7622	7806	8478	-0.50	7226	8184	0.36
Home production: food	7255	7497	7448	8022	-0.28	6912	7775	0.55
HH income from main activity	71154	43404	81189	42358	-2.63	90179	45696	-5.23
HH income from self-employment	3599	17535	1724	11312	1.35	1877	11876	1.28
Total expenditures	79313	30274	81606	30824	-0.85	86029	33068	-2.62
Total expenditures with durables	82829	34330	85719	39758	-0.90	90646	40600	-2.63
Exp. on food as % of Tot. Exp.	27%		27%			27%		
Exp. on food as % of net income	26%		25%			25%		
2001								
N. of HH members	3.3	1.3	3.2	1.1	1.18	3.2	1.1	1.20
Area of the dwelling (m^2)	80	25	81	27	-0.27	80	27	0.16
Expenditures on food (no HP)	25229	11294	27102	11626	-1.85	28354	12795	-3.23
Total net income HH (no HP)	101066	38845	103751	34469	-0.81	107925	34941	-2.19
Home production: total	8663	9547	7814	9725	1.00	7152	9132	1.93
Home production: food	8439	9389	7433	9183	1.22	6804	8660	2.15
HH income from main activity	93176	53270	97730	51349	-0.98	105582	54156	-2.81
HH income from self-employment	3765	17061	1933	12845	1.32	2478	15503	0.93
Total expenditures	97268	36233	98179	37042	-0.28	101653	38120	-1.45
Total expenditures with durables	100630	41548	103488	42620	-0.77	106724	43558	-1.75
Exp. on food as % of Tot. Exp.	26%		28%			28%		
Exp. on food as % of net income	25%		26%			26%		
ΔHH net income (HUF, %)	20165	25%	15773	18%		15703	17%	
ΔHH food consumption (HUF, %)	4198	20%	4884	22%		5186	22%	
N. of HH	195		369			587		
N. of "treated" in HH	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 in 2000-2001.

b. For the treatment group the N. of "control" in HH refers to the Narrow and Large control groups.

Table 3.5: Potential treatment - Large control group - Panel 2000-2001

Treatment	-1287**	-1538**	-1298*	-1084*	-1328**	-1158*
	(644)	(655)	(661)	(635)	(646)	(648)
ΔHH income		0.05***	0.06***		0.05**	0.05***
		(0.021)	(0.021)		(0.020)	(0.020)
HH income (2000)			0.03***			0.02**
			(0.011)			(0.010)
ΔFood HP				-0.17***	-0.21***	-0.21***
				(0.063)	(0.066)	(0.065)
R^2	0.30	0.31	0.32	0.31	0.31	0.32
Additional controls	Month dummies.					
Treatment	-1942**	-2178***	-1710*	-1804**	-2023**	-1751**
	(824)	(838)	(876)	(823)	(835)	(874)
ΔHH income		0.05**	0.06***		0.05**	0.05**
		(0.022)	(0.023)		(0.022)	(0.022)
HH income (2000)			0.04**			0.02
			(0.014)			(0.013)
ΔFood HP				-0.18***	-0.22***	-0.21***
				(0.069)	(0.072)	(0.070)
R^2	0.38	0.39	0.40	0.39	0.40	0.40
Additional controls	Month dummies, employee characteristics for 2000.					
Treatment	-1717**	-1951**	-1575*	-1626*	-1840**	-1597*
	(838)	(853)	(882)	(835)	(848)	(875)
ΔHH income		0.05**	0.06**		0.05**	0.05**
		(0.023)	(0.024)		(0.023)	(0.023)
HH income (2000)			0.03**			0.02
			(0.015)			(0.014)
ΔFood HP				-0.19***	-0.22***	-0.22***
				(0.070)	(0.073)	(0.072)
R^2	0.41	0.42	0.42	0.42	0.43	0.43
Additional controls	Month dummies, employee characteristics for 2000, geographical dummies.					
Income include HP	No	No	No	Yes	Yes	Yes
Observations	782					
Treated HH	195					

a. Dependent variable is Δ 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. Treatment: N. of HH members employed for 2000-2001 s.t. $\varpi_{2000} \leq w_{2000} \leq \varpi_{2001}$ in the private sector.

e. Control: 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. $\varpi_{2000} \leq w_{2000} \leq 2 * \varpi_{2001}$.

f. Δ: change; HP: Home Production; HH: Household; ϖ_{xx}: minimum wage in xx; w_{xx}: wage in xx.

Table 3.6: Potential treatment - Narrow control group - Panel 2000-2001

Treatment	-1029	-1218	-1063	-785	-963	-838
	(733)	(745)	(749)	(719)	(731)	(733)
ΔHH income		0.04*	0.05**		0.04*	0.04*
		(0.023)	(0.023)		(0.023)	(0.022)
HH income (2000)			0.03**			0.02*
			(0.013)			(0.012)
ΔFood HP				-0.19***	-0.22***	-0.23***
				(0.070)	(0.073)	(0.071)
R^2	0.30	0.31	0.32	0.32	0.32	0.33
Additional controls	Month dummies.					
Treatment	-1843**	-1936**	-1591	-1646*	-1729*	-1544
	(923)	(931)	(970)	(907)	(914)	(956)
ΔHH income		0.03	0.04		0.03	0.03
		(0.025)	(0.026)		(0.025)	(0.025)
HH income (2000)			0.03*			0.02
			(0.017)			(0.015)
ΔFood HP				-0.19**	-0.21***	-0.21***
				(0.080)	(0.082)	(0.080)
R^2	0.41	0.42	0.42	0.42	0.43	0.43
Additional controls	Month dummies, employee characteristics for 2000.					
Treatment	-1608*	-1690*	-1449	-1485	-1554	-1435
	(952)	(959)	(984)	(941)	(946)	(975)
ΔHH income		0.02	0.03		0.02	0.02
		(0.027)	(0.027)		(0.026)	(0.027)
HH income (2000)			0.02			0.01
			(0.017)			(0.016)
ΔFood HP				-0.18**	-0.20**	-0.20**
				(0.080)	(0.082)	(0.081)
R^2	0.45	0.45	0.46	0.46	0.46	0.46
Additional controls	Month dummies, employee characteristics for 2000, geographical dummies.					
Income include HP	No	No	No	Yes	Yes	Yes
Observations	564					
Treated HH	195					

a. Dependent variable is Δ 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. Treatment: N. of HH members employed for 2000-2001 s.t. $\varpi_{2000} \leq w_{2000} \leq \varpi_{2001}$ in the private sector.

e. Control: 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. $\varpi_{2000} \leq w_{2000} \leq 1.5 * \varpi_{2001}$.

f. Δ: change; HP: Home Production; HH: Household; ϖ_{xx}: minimum wage in xx; w_{xx}: wage in xx.

Table 3.7: Descriptive statistics - Potential treatment - 1999-2000

		Treatment		Narrow control			Large control		
		mean	sd	mean	sd	t-stat	mean	sd	t-stat
1999									
N. of HH members		3.2	1.1	3.2	1.1	-0.04	3.2	1.1	-0.02
Area of the dwelling (m^2)		80	28	80	28	-0.02	79	28	0.31
Expenditures on food (no HP)		18564	8970	20455	8764	-2.45	20960	9208	-3.26
Total net income HH (no HP)		74341	28615	80302	29919	-2.37	83767	30582	-3.99
Home production:	total	7429	7478	7070	7799	0.55	6702	7591	1.19
	food	7082	7086	6785	7472	0.48	6410	7231	1.16
HH income from main activity		69409	40815	77827	43039	-2.34	83858	46057	-4.22
HH income from self-employment		2608	12733	1226	8986	1.37	1448	9120	1.19
Total expenditures		75013	29849	75995	27823	-0.39	79148	29139	-1.71
Total expenditures with durables		78994	34114	79902	31653	-0.03	82209	32719	-1.17
Exp. on food as % of	Tot. Exp.	25%		27%			26%		
	net income	25%		25%			25%		
2000									
N. of HH members		3.2	1.1	3.2	1.1	-0.04	3.2	1.1	-0.02
Area of the dwelling (m^2)		79	26	80	29	-0.33	79	28	0.16
Expenditures on food (no HP)		20181	9335	22796	10309	-3.13	23413	10441	-4.14
Total net income HH (no HP)		82338	32431	90999	33160	-3.06	95225	33690	-4.84
Home production:	total	7867	7938	7168	8619	0.99	6889	8275	1.50
	food	7612	7693	6853	8126	1.12	6573	7787	1.66
HH income from main activity		73226	44117	85009	45836	-3.04	93552	49283	-5.51
HH income from self-employment		2493	12936	1471	9900	0.98	1736	10550	0.75
Total expenditures		82402	30491	83198	33869	-0.29	86292	33267	-1.54
Total expenditures with durables		86651	34605	86382	40609	0.08	89667	38940	-1.04
Exp. on food as % of	Tot. Exp.	24%		27%			27%		
	net income	25%		25%			25%		
ΔHH net income (HUF, %)		7997	11%	10697	13%		11457	14%	
ΔHH food consumption (HUF, %)		1617	9%	2341	11%		2453	12%	
N. of HH		197		412			651		
N. of "treated" in HH		1.1		0			0		
N. of "control" in HH		0.2	0.3	1.2			1.2		

a. Only HH with constant family structure and positive income below 200,000 HUF in 1999-2000.

b. For the treatment group the N. of "control" in HH refers to the Narrow and Large control groups.

Table 3.8: Potential treatment - Large control group - Panel 1999-2000 - Placebo

Treatment	-743	-510	-446	-704	-457	-400
	(652)	(622)	(628)	(646)	(616)	(620)
ΔHH income		0.08***	0.08***		0.08***	0.08***
		(0.018)	(0.018)		(0.017)	(0.018)
HH income (2000)			0.01			0.01
			(0.010)			(0.009)
ΔFood HP				-0.09	-0.16**	-0.16**
				(0.070)	(0.074)	(0.074)
R^2	0.22	0.24	0.24	0.22	0.25	0.25
Additional controls	Month dummies.					
Treatment	212	529	520	244	581	603
	(731)	(709)	(714)	(727)	(705)	(710)
ΔHH income		0.08***	0.08***		0.08***	0.08***
		(0.018)	(0.019)		(0.018)	(0.018)
HH income (2000)			0.00			0.00
			(0.013)			(0.012)
ΔFood HP				-0.09	-0.16**	-0.16**
				(0.074)	(0.078)	(0.077)
R^2	0.30	0.32	0.32	0.30	0.33	0.33
Additional controls	Month dummies, employee characteristics for 2000.					
Treatment	156	468	477	175	508	541
	(758)	(729)	(736)	(754)	(726)	(731)
ΔHH income		0.08***	0.08***		0.08***	0.08***
		(0.019)	(0.019)		(0.019)	(0.019)
HH income (2000)			0.00			0.00
			(0.013)			(0.012)
ΔFood HP				-0.12	-0.18**	-0.18**
				(0.076)	(0.080)	(0.080)
R^2	0.32	0.35	0.35	0.33	0.35	0.35
Additional controls	Month dummies, employee characteristics for 2000, geographical dummies.					
Income include HP	No	No	No	Yes	Yes	Yes
Observations	848					
Treated HH	197					

a. Dependent variable is Δ 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. Treatment: N. of HH members employed for 1999.2000 s.t. $\varpi_{2000} \leq w_{2000} \leq \varpi_{2001}$in the private sector.

e. Control: HH with constant family structure and positive income below 200,000 HUF in 1999-2000, with at least one member employed for 1999-2000, $s.t.\varpi_{2000} \leq w_{2000} \leq 2 * \varpi_{2001}$.

f. Δ: change; HP: Home Production; HH: Household; ϖ_{xx}: minimum wage in xx; w_{xx}: wage in xx.

Table 3.9: Potential treatment - Narrow control group - Panel 1999-2000 - Placebo

Treatment	-624	-494	-419	-572	-429	-355
	(700)	(676)	(684)	(694)	(669)	(676)
ΔHH income		0.06***	0.06***		0.06***	0.06***
		(0.022)	(0.022)		(0.021)	(0.021)
HH income (2000)			0.01			0.02
			(0.011)			(0.010)
ΔFood HP				-0.12	-0.18**	-0.17**
				(0.080)	(0.085)	(0.086)
R^2	0.21	0.23	0.23	0.22	0.24	0.24
Additional controls	Month dummies.					
Treatment	554	747	771	613	831	880
	(821)	(802)	(816)	(819)	(802)	(813)
ΔHH income		0.06**	0.06**		0.06***	0.06***
		(0.024)	(0.024)		(0.023)	(0.024)
HH income (2000)			0.00			0.00
			(0.014)			(0.013)
ΔFood HP				-0.13	-0.19**	-0.19**
				(0.087)	(0.092)	(0.092)
R^2	0.30	0.32	0.32	0.31	0.32	0.32
Additional controls	Month dummies, employee characteristics for 2000.					
Treatment	602	794	862	646	859	956
	(874)	(851)	(866)	(872)	(850)	(861)
ΔHH income		0.06***	0.06***		0.06***	0.06***
		(0.024)	(0.024)		(0.023)	(0.023)
HH income (2000)			0.01			0.01
			(0.015)			(0.014)
ΔFood HP				-0.16*	-0.22**	-0.21**
				(0.091)	(0.096)	(0.096)
R^2	0.34	0.35	0.35	0.35	0.36	0.36
Additional controls	Month dummies, employee characteristics for 2000, geographical dummies.					
Income include HP	No	No	No	Yes	Yes	Yes
Observations	609					
Treated HH	197					

a. Dependent variable is Δ 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. Treatment: N. of HH members employed for 1999-2000 s.t. $\varpi_{2000} \leq w_{2000} \leq \varpi_{2001}$ in the private sector.

e. Control: HH with constant family structure and positive income below 200,000 HUF in 1999-2000, with at least one member employed for 1999-2000, s.t. $\varpi_{2000} \leq w_{2000} \leq 1.5 * \varpi_{2001}$.

f. Δ: change; HP: Home Production; HH: Household; ϖ_{xx}: minimum wage in xx; w_{xx}: wage in xx.

Table 3.10: Descriptive statistics - Actual treatment

	Treatment		Narrow control			Large control		
	mean	sd	mean	sd	t-stat	mean	sd	t-stat
2000								
N. of HH members	3.2	1.2	3.3	1.2	-0.77	3.2	1.2	-0.04
Area of the dwelling (m^2)	80	26	78	25	0.83	79	26	0.74
Expenditures on food (no HP)	20016	9493	22214	10291	-2.38	22374	10490	-2.68
Total net income HH (no HP)	75383	32039	87727	31292	-4.07	89588	31588	-4.90
Home production: total	7473	7712	7488	8389	-0.02	7562	8616	-0.13
Home production: food	7260	7622	7163	7935	0.13	7253	8231	0.01
HH income from main activity	67010	41104	77370	48826	-2.51	82687	49099	-4.05
HH income from self-employment	1733	9311	2715	15924	-0.90	2833	15306	-1.14
Total expenditures	78188	29696	81190	32810	-1.03	83918	34515	-2.06
Total expenditures with durables	81301	31789	85169	41237	-1.26	87965	40623	-2.28
Exp. on food as % of Tot. Exp.	26%		27%			27%		
Exp. on food as % of net income	27%		25%			25%		
2001								
N. of HH members	3.2	1.2	3.3	1.2	-0.77	3.2	1.2	-0.04
Area of the dwelling (m^2)	80	26	79	26	0.44	79	27	0.31
Expenditures on food (no HP)	23976	10657	27190	11811	-3.07	27462	12185	-3.51
Total net income HH (no HP)	93069	36758	103022	33909	-2.90	105246	34309	-3.70
Home production: total	7836	8770	7419	9556	0.49	7407	9293	0.53
Home production: food	7561	8552	7083	9162	0.58	7103	8935	0.59
HH income from main activity	82209	44610	93702	50579	-2.61	98557	51347	-3.92
HH income from self-employment	3111	13998	2206	13997	0.68	2869	16552	0.18
Total expenditures	92843	35777	97002	36648	-1.21	98962	36732	-1.88
Total expenditures with durables	96970	42233	101538	41643	-1.14	103359	40706	-1.68
Exp. on food as % of Tot. Exp.	26%		28%			28%		
Exp. on food as % of net income	26%		26%			26%		
ΔHH net income (HUF, %)	17685	23%	15295	17%		15657	17%	
ΔHH food consumption (HUF, %)	3960	20%	4976	22%		5088	23%	
N. of HH	149		422			659		
N. of "treated" in HH	1.1		0			0		
N. of "control" in HH	0.3	0.4	1.2			1.3		

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

b. For the treatment group the N. of "control" in HH refers to the Narrow and Large control groups.

Table 3.11: Actual treatment - Large control group - Panel 2000-2001 - Dummy

Treatment	-1385**	-1471**	-1195*	-1206*	-1301*	-1129*
	(651)	(643)	(653)	(643)	(635)	(637)
ΔHH income		0.05***	0.05***		0.04**	0.05***
		(0.017)	(0.017)		(0.017)	(0.017)
HH income (2000)			0.03**			0.02*
			(0.011)			(0.010)
ΔFood HP				-0.15***	-0.19***	-0.19***
				(0.053)	(0.055)	(0.054)
R^2	0.31	0.32	0.32	0.32	0.33	0.33
Additional controls	Month dummies.					
Treatment	-1766**	-1745**	-1401*	-1646**	-1637**	-1478**
	(744)	(744)	(753)	(732)	(731)	(735)
ΔHH income		0.04**	0.06***		0.04**	0.05**
		(0.019)	(0.020)		(0.018)	(0.019)
HH income (2000)			0.03**			0.01
			(0.014)			(0.012)
ΔFood HP				-0.17***	-0.20***	-0.20***
				(0.056)	(0.058)	(0.057)
R^2	0.39	0.39	0.40	0.39	0.40	0.40
Additional controls	Month dummies, employee characteristics for 2001.					
Treatment	-1595**	-1573**	-1309*	-1489**	-1478*	-1355*
	(773)	(772)	(787)	(755)	(754)	(766)
ΔHH income		0.05**	0.06***		0.04**	0.05**
		(0.019)	(0.020)		(0.019)	(0.020)
HH income (2000)			0.03*			0.01
			(0.015)			(0.013)
ΔFood HP				-0.17***	-0.21***	-0.20***
				(0.059)	(0.061)	(0.060)
R^2	0.41	0.42	0.42	0.42	0.43	0.43
Additional controls	Month dummies, employee characteristics for 2001, geographical dummies.					
Income include HP	No	No	No	Yes	Yes	Yes
Observations	808					
Treated HH	149					

a. Dependent variable is Δ 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. Treatment: N. of HH members employed in the private sector for the whole 2001 s.t. $0.9 * \varpi_{2000} \leq w_{2000} \leq 1.1 * \varpi_{2001}$ and $0.9 * \varpi_{2001} \leq w_{2001} \leq 1.1 * \varpi_{2001}$.

e. Control: 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. $\varpi_{2001} \leq w_{2001} \leq 2 * \varpi_{2001}$.

f. Δ: change; HP: Home Production; HH: Household; ϖ_{xx}: minimum wage in xx; w_{xx}: wage in xx.

Table 3.12: Actual treatment - Narrow control group - Panel 2000-2001 - Dummy

Treatment	-1292*	-1372*	-1172	-1140	-1228*	-1076
	(739)	(731)	(733)	(731)	(723)	(717)
ΔHH income		0.05**	0.05**		0.04**	0.05**
		(0.022)	(0.022)		(0.021)	(0.021)
HH income (2000)			0.03*			0.02
			(0.013)			(0.012)
ΔFood HP				-0.15*	-0.18**	-0.19**
				(0.075)	(0.076)	(0.074)
R^2	0.34	0.35	0.36	0.35	0.36	0.36
Additional controls	Month dummies.					
Treatment	-1794**	-1761**	-1518*	-1684**	-1665*	-1500*
	(865)	(859)	(855)	(856)	(851)	(842)
ΔHH income		0.04*	0.05**		0.04*	0.05*
		(0.024)	(0.026)		(0.023)	(0.025)
HH income (2000)			0.03*			0.02
			(0.017)			(0.015)
ΔFood HP				-0.17**	-0.21**	-0.21***
				(0.078)	(0.080)	(0.078)
R^2	0.42	0.43	0.43	0.43	0.44	0.44
Additional controls	Month dummies, employee characteristics for 2001.					
Treatment	-1671*	-1624*	-1441	-1585*	-1552*	-1433
	(893)	(887)	(890)	(879)	(873)	(872)
ΔHH income		0.05**	0.06**		0.05**	0.06**
		(0.024)	(0.026)		(0.023)	(0.025)
HH income (2000)			0.03			0.02
			(0.018)			(0.017)
ΔFood HP				-0.19**	-0.23***	-0.24***
				(0.080)	(0.081)	(0.080)
R^2	0.45	0.45	0.46	0.46	0.46	0.47
Additional controls	Month dummies, employee characteristics for 2001, geographical dummies.					
Income include HP	No	No	No	Yes	Yes	Yes
Observations	571					
Treated HH	149					

a. Dependent variable is Δ 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. Treatment: N. of HH members employed in the private sector for the whole 2001 s.t. $0.9 * \varpi_{2000} \leq w_{2000} \leq 1.1 * \varpi_{2001}$ and $0.9 * \varpi_{2001} \leq w_{2001} \leq 1.1 * \varpi_{2001}$.

e. Control: 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. $\varpi_{2001} \leq w_{2001} \leq 1.5 * \varpi_{2001}$.

f. Δ: change; HP: Home Production; HH: Household; ϖ_{xx}: minimum wage in xx; w_{xx}: wage in xx.

Table 3.13: Actual treatment - Large control group - Panel 2000-2001 - Continuous

Treatment	-0.09	-0.11*	-0.9	-0.08	-0.09	-0.08
	(0.065)	(0.063)	(0.064)	(0.064)	(0.062)	(0.062)
ΔHH income		0.05**	0.05***		0.04**	0.05***
		(0.017)	(0.018)		(0.017)	(0.017)
HH income (2000)			0.03**			0.02*
			(0.011)			(0.010)
ΔFood HP				-0.15***	-0.19***	-0.19***
				(0.053)	(0.055)	(0.054)
R^2	0.31	0.32	0.32	0.32	0.32	0.33
Additional controls	Month dummies.					
Treatment	-0.14*	-0.14*	-0.11	-0.13*	-0.13*	-0.12*
	(0.075)	(0.074)	(0.075)	(0.073)	(0.072)	(0.073)
ΔHH income		0.04**	0.06***		0.04**	0.05**
		(0.019)	(0.020)		(0.018)	(0.019)
HH income (2000)			0.03**			0.01
			(0.014)			(0.012)
ΔFood HP				-0.17***	-0.20***	-0.20***
				(0.056)	(0.058)	(0.057)
R^2	0.38	0.39	0.40	0.39	0.40	0.40
Additional controls	Month dummies, employee characteristics for 2001.					
Treatment	-0.14*	-0.15*	-0.13	-0.14*	-0.14*	-0.13*
	(0.078)	(0.077)	(0.078)	(0.075)	(0.074)	(0.075)
ΔHH income		0.05**	0.06***		0.04**	0.05**
		(0.019)	(0.020)		(0.019)	(0.020)
HH income (2000)			0.03*			0.01
			(0.015)			(0.013)
ΔFood HP				-0.17***	-0.21***	-0.21***
				(0.059)	(0.061)	(0.061)
R^2	0.41	0.42	0.42	0.42	0.43	0.43
Additional controls	Month dummies, employee characteristics for 2001, geographical dummies.					
Income include HP	No	No	No	Yes	Yes	Yes
Observations	808					
Treated HH	114					

a. Dependent variable is Δ 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. Treatment: sum within HH of $\varpi_{2001} - w_{2000}$ for all members employed in the private sector for the whole 2001 s.t. $0.9 * \varpi_{2000} \leq w_{2000} \leq \varpi_{2001}$ and $0.9 * \varpi_{2001} \leq w_{2001} \leq 1.1 * \varpi_{2001}$.

e. Control: 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. $\varpi_{2001} \leq w_{2001} \leq 2 * \varpi_{2001}$.

f. Δ: change; HP: Home Production; HH: Household; ϖ_{xx}: minimum wage in xx; w_{xx}: wage in xx.

Table 3.14: Actual treatment - Narrow control group - Panel 2000-2001 - Continuous

Treatment	-0.08	-0.10	-0.08	-0.07	-0.09	-0.08
	(0.072)	(0.070)	(0.071)	(0.070)	(0.069)	(0.068)
ΔHH income		0.05**	0.05**		0.04**	0.05**
		(0.022)	(0.022)		(0.022)	(0.022)
HH income (2000)			0.03**			0.02*
			(0.013)			(0.012)
ΔFood HP				-0.15**	-0.19**	-0.19**
				(0.075)	(0.076)	(0.074)
R^2	0.34	0.35	0.35	0.35	0.36	0.36
Additional controls	Month dummies.					
Treatment	-0.15*	-0.16*	-0.14*	-0.14*	-0.15*	-0.14*
	(0.083)	(0.082)	(0.082)	(0.081)	(0.080)	(0.080)
ΔHH income		0.04*	0.06**		0.04*	0.05*
		(0.024)	(0.026)		(0.023)	(0.025)
HH income (2000)			0.03*			0.02
			(0.017)			(0.015)
ΔFood HP				-0.18**	-0.21***	-0.21***
				(0.078)	(0.080)	(0.079)
R^2	0.42	0.43	0.43	0.43	0.44	0.44
Additional controls	Month dummies, employee characteristics for 2001.					
Treatment	-0.14*	-0.15*	-0.14	-0.14	-0.14*	-0.14
	(0.087)	(0.086)	(0.086)	(0.085)	(0.084)	(0.084)
ΔHH income		0.05*	0.07**		0.05**	0.06**
		(0.025)	(0.026)		(0.023)	(0.025)
HH income (2000)			0.03*			0.02
			(0.019)			(0.017)
ΔFood HP				-0.20**	-0.24***	-0.24***
				(0.080)	(0.082)	(0.081)
R^2	0.45	0.45	0.46	0.46	0.46	0.47
Additional controls	Month dummies, employee characteristics for 2001, geographical dummies.					
Income include HP	No	No	No	Yes	Yes	Yes
Observations	571					
Treated HH	114					

a. Dependent variable is Δ 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. Treatment: sum within HH of $\varpi_{2001} - w_{2000}$ for all members employed in the private sector for the whole 2001 s.t. $0.9 * \varpi_{2000} \leq w_{2000} \leq \varpi_{2001}$ and $0.9 * \varpi_{2001} \leq w_{2001} \leq 1.1 * \varpi_{2001}$.

e. Control: 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. $\varpi_{2001} \leq w_{2001} \leq 1.5 * \varpi_{2001}$.

f. Δ: change; HP: Home Production; HH: Household; ϖ_{xx}: minimum wage in xx; w_{xx}: wage in xx.

Figure 3.1: Wage dynamics in Hungary, 1992-2005

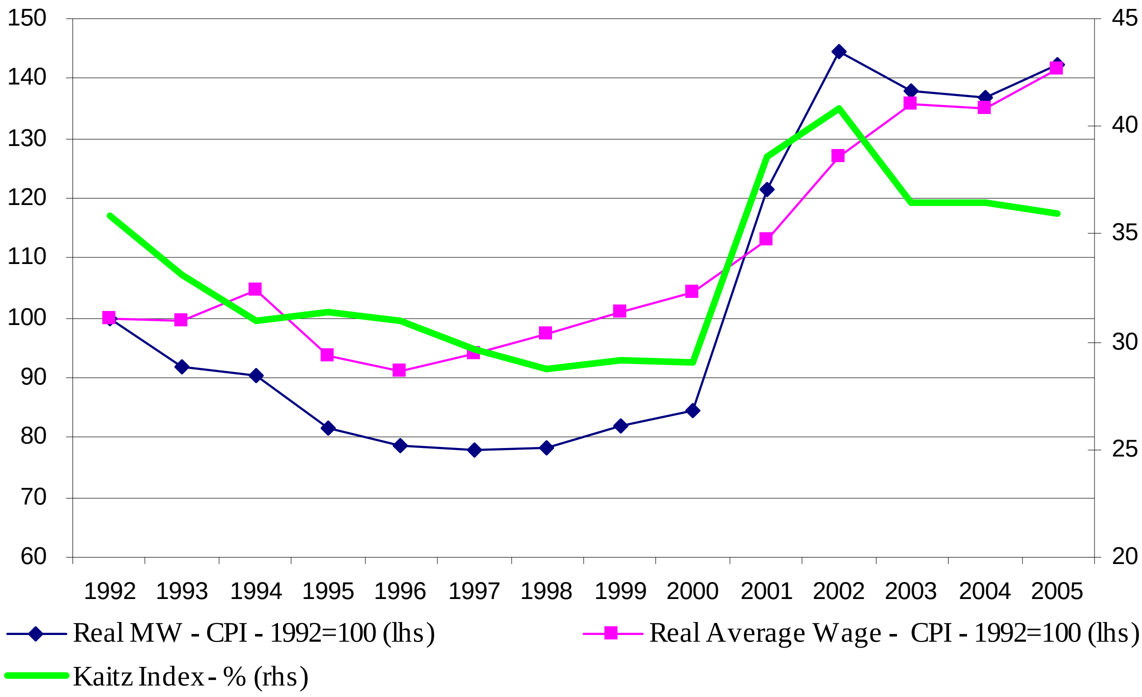
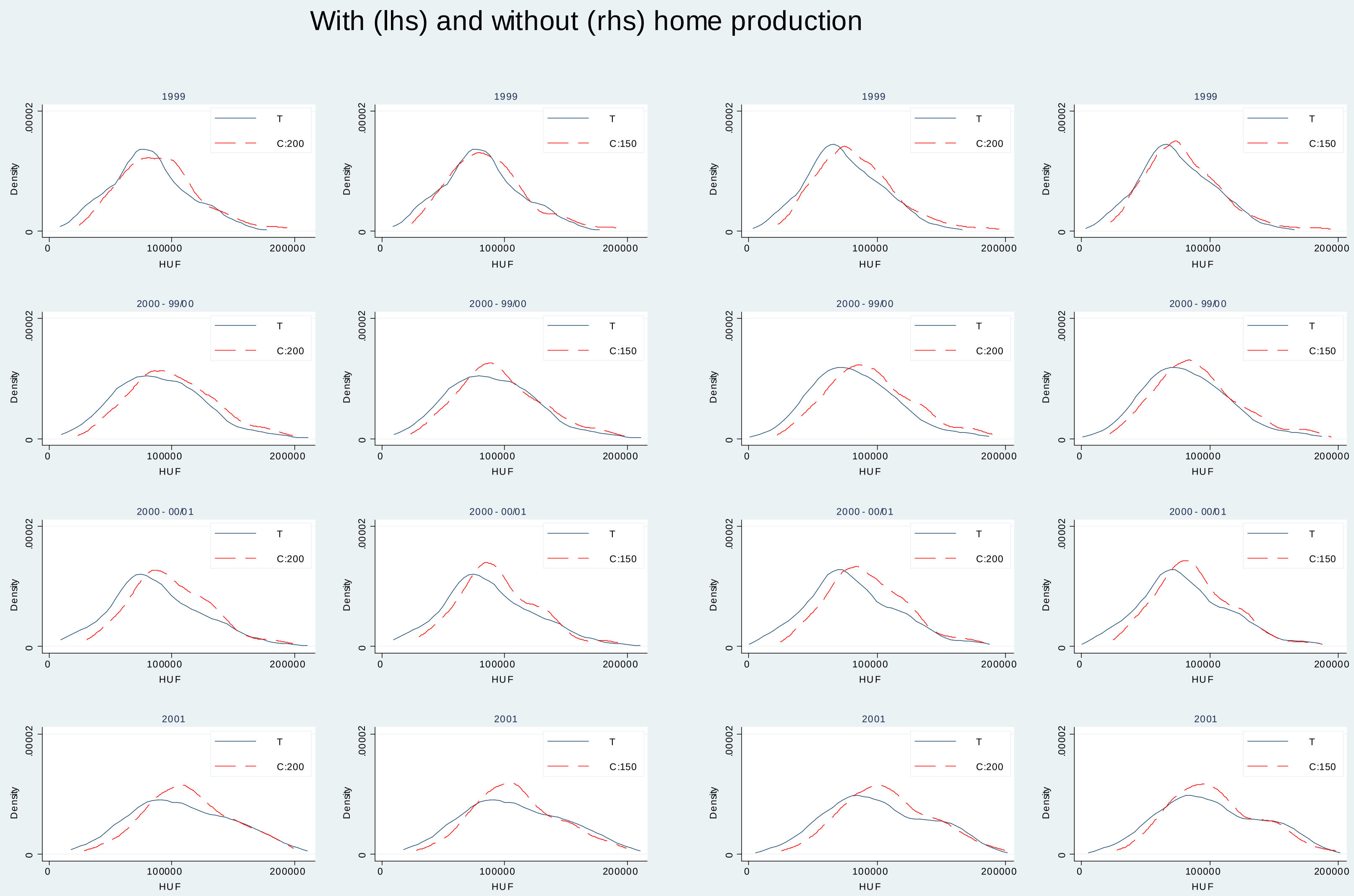


Figure 3.2: Earnings from main activity

Y-axis: fraction; X-axis: HUF - The vertical dot lines indicate the MW in 1999 (22500), 2000 (25500) and 2001 (40000)

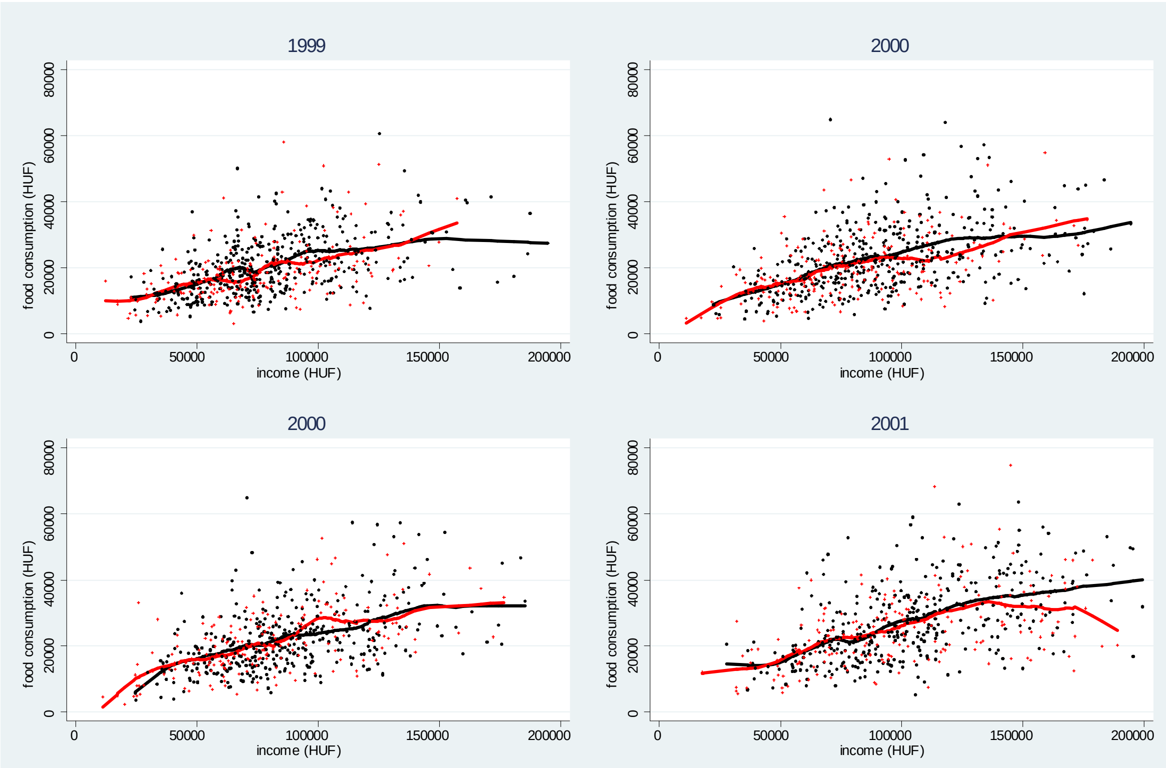
Positive earnings below 200000 HUF; bin size: 1000

Figure 3.3: Household total net income - "Potential treatment"



T - treatment group; C:200 - control group using 200% MW as upper bound; C:150 - control group using 150% MW as upper bound;
Kernel density estimation (epanechnikov); HH with positive net income below 200000 HUF in both years;

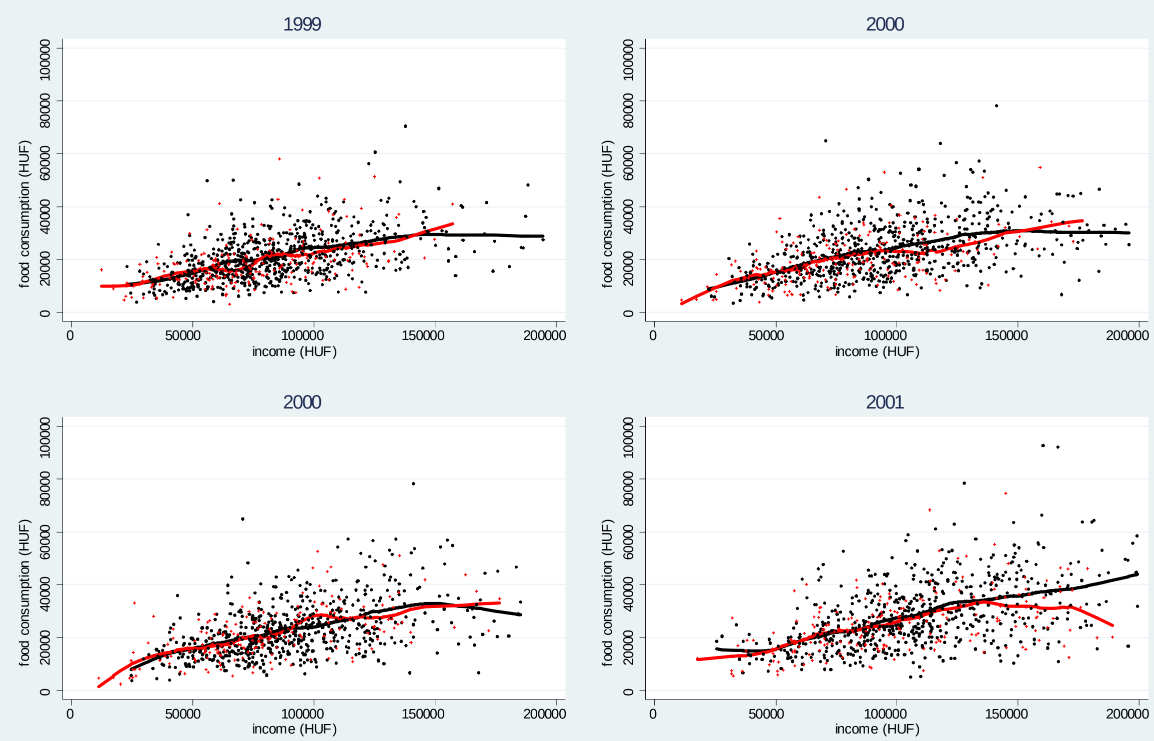
Figure 3.4: Relationship between market food consumption and income - "Potential treatment" - Narrow control group



Lowess smoothing (bandwidth: 0.25); HH with positive net income below 200000 in both years

Red: treatment group; Black: narrow control group

Figure 3.5: Relationship between market food consumption and income - "Potential treatment" - Large control group



Lowess smoothing (bandwidth: 0.25); HH with positive net income below 200000 in both years
Red: treatment group; Black: large control group

Figure 3.6: Household total net income - "Actual treatment"

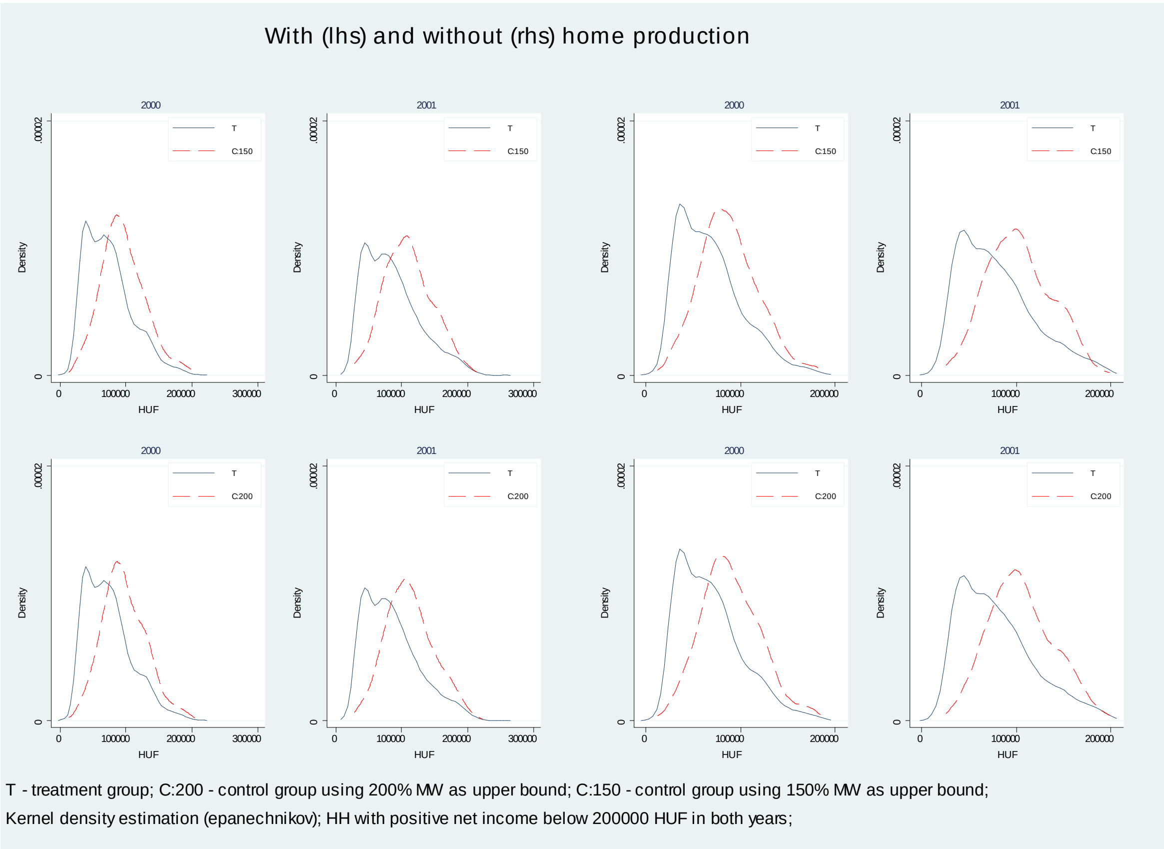
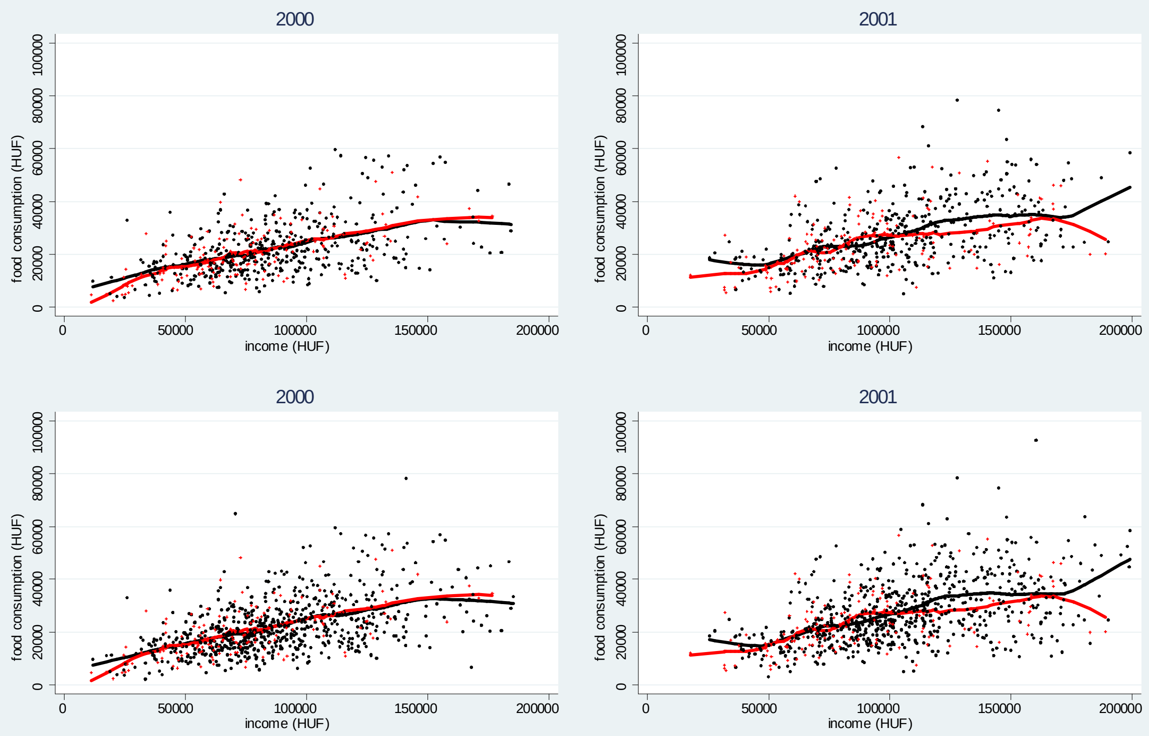


Figure 3.7: Relationship between market food consumption and income - "Actual treatment"



Lowess smoothing (bandwidth: 0.25); HH with positive net income below 200000 in both years
Red: treatment group; Black: control group; Upper half: narrow control group; Lower half: large control group;

Chapter 4

In-Work Benefits in Search Equilibrium*

1 Introduction

In-work benefits are becoming an increasingly relevant labour market policy. Programmes including some type of benefit or tax credit conditioned on labour income have been introduced or are in the "policy pipeline" in several countries (e.g. Belgium, Canada, Finland, France, Ireland, the Netherlands, New Zealand and Sweden). Yet other countries have progressively extended the scope of existing programmes, which were originally targeted at a very small section of the labour force. For instance, the Earned Income Tax Credit (EITC) in the US, which was introduced more than 30 years ago, is now the largest cash transfer programme for low income families at the federal level and, in 2003, about twenty million families received a total of $34 billion in benefits from it[1] . Moreover, the United Kingdom has a more than 25-year history of in-work benefits and has seen a gradual increase in their scope.

The expansion of this type of programmes makes it increasingly relevant to account for their general equilibrium effects. Moreover, since a number of less market oriented economies have recently followed the US and the UK in introducing various kinds of in-work benefits with the aim of decreasing unemployment and increasing

* This is joint work with Ann-Sofie Kolm. We want to thank John Hassler, Bruce Meyer, and seminar participants at Umeå University and Växjö University. Financial support from Jan Wallander's and Tom Hedelius' Research Foundations is gratefully acknowledged.

[1] See Eissa and Hoynes (2005).

labour force participation, it is particularly important to take involuntary unemployment and search effort into consideration.

The aim of this paper is to study the equilibrium impact of in-work benefits in a simple analytical framework displaying involuntary unemployment. Using a search model a la Pissarides (2000), we show that the introduction of in-work benefits reduces equilibrium unemployment, moderates wages and boosts participation and search effort. Total employment increases as a result. We show that accounting for the general equilibrium effects actually reinforces the impact of benefits on labour market variables. Another contribution of the paper is to look at the issue of financing. With the expansion of benefit programmes, the resources needed to finance them are not negligible and their impact should be accounted for.

Research has almost exclusively been concerned with the supply-side effects of in-work benefits. On the empirical side, the effect of in-work benefits on labour supply has been extensively evaluated by exploiting the expansions of the programmes in the US and the UK. The evaluations show that these programmes have been quite successful in terms of increasing labour supply. Eissa and Liebman (1996) compare the labour supply responses of single women with children to the responses of single women with no children when the earned income tax credit expanded in 1986. They show that between 1984-1986 and 1988-1990, single women with children increased their relative labour force participation by up to 2.8 percentage points. Meyer and Rosenbaum (2001) estimate that 63 percent of the increase in labour force participation of single families in the US between 1984 and 1996 can be credited to the expansion of the EITC. Moreover, Fang and Keane (2004) estimate the most important explanation for the 11 percentage point increase in labour force participation in the US between 1993-2002 to be the EITC. In addition, the evaluations show that it seems to be the participation decision rather than the hour decision that is affected by the EITC.[2]

The theoretical research on the impact of EITC policies is also supply-side oriented. Standard labour supply theory serves as the basis for predicting the effects of the EITC on work hours (See Meyer, 2002, Eissa and Hoynes, 2005). In addition, a number of papers have also accounted for labour supply responses on the exten-

[2] Moreover, the evaluations of the Working Family Tax Credit (WFTC) in the UK show that the programme has had positive net-effects on labour supply (see Brewer and Browne, 2006, and Blundell, 2006).

sive (participation) margin when considering the effects of EITC policies; see, for example, Saez (2002).

Considering that an important aim of an EITC type of policy is to increase employment, which is an equilibrium outcome involving both supply-side and demand-side factors, the limited number of studies that have accounted for the demand side of the market might be surprising. Some recent empirical papers have raised the question of how the EITC is likely to affect wages, and have tried to estimate the incidence of the EITC on wages in different ways. Leigh (2004) uses variations in US state EITCs to examine the effect of the policy on pre-tax wages. The study by Rothstein (2007) uses the federal expansion of the EITC in the mid-1990s to estimate the effects on wages of the policy. While Leigh (2004) finds that wages are significantly reduced by the state EITC, Rothstein (2007) finds that women at the lower end of the skill distribution may, in fact, face higher gross wages due to the federal expansion of the EITC. Making a review of the literature, Eissa and Nichols (2005) stress the importance of a better understanding of the role of the EITC in wage determination when evaluating the overall effectiveness of the EITC against that of alternative policies.

Some recent model analyses of in-work benefits incorporate unemployment. Boone and Bovenberg (2004) stress the importance of in-work benefits in order to alleviate distortions in terms of an inefficiently low search effort among the unemployed. Moreover, the study by Boone and Bovenberg (2006) provides an explanation for why in-work benefits can be demanded for both in countries with generous welfare benefits (such as many European countries) and countries with low welfare benefits (such as the US). In countries with relatively low levels of social assistance, in-work benefits are aimed at poverty alleviation. In contrast, countries with generous social assistance need in-work benefits in order to maintain workers in the labour force. Although these two studies account for unemployment in their models, unemployment is exogenously imposed. Thus, when investigating the impact of an in-work benefit, there will be no effect on wages and unemployment as they are fixed by assumption[3] .

[3] Another feature that may be of potential importance for the success of an EITC policy is a country's degree of wage compression. The study by Immervoll et al (2007) considers the potential effects of in-work benefits in European countries using a micro simulation model. They consider both the effect of such a reform on work hours and labour force participation, accounting for the fact

Two studies that account for adjustments in wages while allowing for unemployment to be endogenously determined are Boeter et al (2006) and Lise et al (2005). Boeter et al (2006) simulate the general equilibrium effects of a social assistance reform in Germany. They use a union wage bargaining framework and find that a cut in the minimum income guarantee for those able to work, combined with a reduction in effective marginal tax rates at the lower end of the income distribution, entails a decrease in unemployment. Accounting for the general equilibrium wage reactions mitigates labour supply effects. Lise et al (2005) simulate the general equilibrium effects of the Self Sufficiency Project (SSP) in Canada, using a search framework to model the specific institutional details. Their simulation results also imply that accounting for equilibrium effects reduces the impact of the policy. Moreover, unemployment increases and employment decreases following the introduction of SSP.

In this paper, we account for involuntary unemployment and wage adjustment using a model with search frictions and worker-firm wage bargains (see Pissarides, 2000) and show analytically that the introduction of an in-work benefit moderates wages, boosts participation and search effort, thus reducing equilibrium unemployment and increasing total employment. Allowing for general equilibrium effects through wage adjustment actually boosts the impact of the policy on labour market variables. This is due to the effect on job creation and underlines the importance of taking the demand side into consideration.

The results are derived in a simple and stylized model in sections 2 and 3. In section 4, we show that these results are robust to various extensions such as the inclusion of unemployment benefits, the endogenous determination of work hours and wage indexation of in-work benefits. We show that in some cases, employment mainly increases through job creation. Section 5 considers the case when the in-work benefit is financed with payroll taxes or proportional income taxes. Analytical results are derived for the case when benefits are fully financed by a fiscal imposition on beneficiaries while the partial financing case, in which part of the workforce is ineligible to benefits but contributes to their financing, is investigated in the

that the earnings distribution may be more or less compressed in different countries. They show that in-work benefits will be less desirable in countries with a compressed earnings distribution. This follows as a given redistribution when earnings are equal induces larger deadweight losses. The labour market is treated as perfectly competitive in their analysis.

simulation section. Section 6 elaborates on the case when there is downward wage rigidity, whereas section 7 simulates the model to decompose and quantify the effects of an in-work benefit on labour market outcomes. Section 8 concludes.

2 The Model

The economy consists of a population that is fixed in size which is, without loss of generality, normalized to unity. The size of the labour force is endogenous. An individual chooses to participate in the labour force if the return of participation exceeds the return of non-participation. Individuals are heterogeneous with respect to the value of leisure that they enjoy when non participating. A worker who decides to participate in the labour force is either employed or searching for a job.

The economy is characterized by trading frictions due to the costly and time-consuming matching of workers and firms. The matching process of vacancies and unemployed job searchers is captured by a concave and constant-returns-to-scale matching function, $X = h(v, su)$, where v is the vacancy rate and u is the unemployment rate. The rates are defined as the number of vacancies and the number of unemployed workers relative to the labour force. The search intensity by an average worker is denoted by s. su defines the number of job searching workers in terms of efficiency units.

The rate at which a specific unemployed worker finds a job depends on the individual search effort, s_i, in relation to the average search effort of the unemployed, s. Thus, the transition rate of the unemployed individual i into employment is given by $s_i X/su = s_i h(\theta, 1) = s_i \lambda(\theta)$, where $\theta = v/su$ denotes labour market tightness. Firms fill vacancies at the rate $X/v = h(1, 1/\theta) = q(\theta)$. Higher labour market tightness θ increases workers' probability of finding a job, but reduces the probability of a firm finding a worker, i.e., $\lambda'(\theta) > 0$ and $q'(\theta) < 0$.

2.1 Workers and Firms

Let E, U, and N denote the expected present values of employment, unemployment, and non participation. The flow value functions for an individual worker can be written as:

$$rE_i = w_i + IWB - \phi\left(E_i - U_i\right), \tag{4.1}$$

$$rU_i = -\sigma\left(s_i\right) + s_i\lambda\left(\theta\right)\left(E - U_i\right), \tag{4.2}$$

$$rN_i = l_i, \tag{4.3}$$

where r is the exogenous discount rate, w is the wage, and ϕ the exogenous separation rate. $\sigma\left(s\right)$ captures the search costs of the unemployed, where $\sigma_s\left(.\right), \sigma_{ss}\left(.\right) > 0$. The term IWB represents the in-work benefit which is received only when employed. l is the per period real value of leisure if not participating in the labour force which is assumed to be distributed in the population according to the cumulative distribution function $F\left(l\right)$.

The unemployed worker chooses search effort, s_i, so as to maximize the discounted value of unemployment, U_i, taking search effort by other unemployed workers, s, as well as other market variables, as given. This yields:

$$\sigma_{s_i}\left(.\right) = \lambda\left(\theta\right)\left(E - U_i\right). \tag{4.4}$$

Thus, the unemployed worker chooses search effort so as to equalize the marginal return of search with the marginal cost of search.

The economy consists of a large number of small firms that employ one worker only. Let J and V denote the expected present values of an occupied and a vacant job, respectively. The asset equations of a specific occupied job and a vacant job can be written as:

$$rJ_i = y - w_i - \phi\left(J_i - V\right), \tag{4.5}$$

$$rV = -k + q\left(\theta\right)\left(J - V\right), \tag{4.6}$$

where y is worker productivity and the vacancy cost is denoted by k.

2.2 Wage determination

Matching frictions create quasi-rents for any matched pair providing a scope for bilateral bargaining after a worker and an employer meet. The baseline wage specification assumption found in the literature on search equilibrium is the generalized axiomatic Nash bilateral bargaining outcome with a 'threat point' equal to the option of looking for an alternative partner. The threatpoint for the worker is given by the value of unemployment. Note that the value of unemployment is at least as high as the value of non participation for workers in the labour force. Thus, employed workers do not consider the option of dropping out of the labour force as a threat when bargaining over wages.

Assuming that the worker has bargaining power β, the solution to the Nash bargaining problem satisfies the following first-order condition:

$$\frac{\beta}{1-\beta}J = E - U, \tag{4.7}$$

where we have imposed a symmetric equilibrium. From (4.7), we get the wage rule:

$$w = \beta\left(y + ks\theta\right) - \left(1-\beta\right)\left[IWB + \sigma\left(s\right)\right]. \tag{4.8}$$

We derive the job creation curve by imposing the free-entry condition $V = 0$ in (4.5) and (4.6)

$$\frac{k}{q\left(\theta\right)} = \frac{y-w}{r+\phi}, \tag{4.9}$$

and using (4.8) to substitute for the wage, we get tightness conditional on search effort. Similarly, search effort in equilibrium is derived conditional on tightness by imposing $s_i = s$ in (4.4) and using the free-entry condition $V = 0$ in (4.6) together with (4.7). This yields the following two equations determining search effort and tightness in equilibrium:

$$\frac{k\left(r+\phi\right)}{q\left(\theta\right)} = \left(1-\beta\right)\left[y + IWB + \sigma\left(s\right)\right] - \beta sk\theta, \tag{4.10}$$

$$\sigma_s\left(s\right) = \frac{\beta k\theta}{1-\beta}. \tag{4.11}$$

2.3 Labour force participation

A worker enters the labour force into the state of unemployment by choosing to conduct search. It will be worthwhile to enter the labour force if the return from entering exceeds the return from not entering. In equilibrium, the following condition determines the value of leisure of the worker who is indifferent between entering and not entering the labour force:

$$rU = rN\left(\hat{l}\right),$$

where $\hat{l}$ denotes the value of leisure of the marginal worker. Workers with a value of leisure higher than $\hat{l}$, i.e., $l_i > \hat{l}$, will choose non-participation, whereas workers with a value of leisure lower than $\hat{l}$, i.e., $l_i \leq \hat{l}$, will choose participation. The participation condition can be written as $s\lambda(\theta)(E-U) - \sigma(s) = \hat{l}$ by using the flow equations in (4.2) and (4.3) in symmetric equilibrium. Using the free-entry condition $V = 0$, together with equations (4.6) and (4.7) and the cumulative distribution function for leisure, we have the labour force given by:

$$LF = F\left(\frac{s\beta k\theta}{1-\beta} - \sigma(s)\right). \tag{4.12}$$

2.4 Employment

In equilibrium, the flow into unemployment equals the flow out of unemployment, i.e., $\phi(1-u)LF = s\lambda(\theta)uLF$. The equilibrium unemployment rate is then given by:

$$u = \frac{\phi}{\phi + s\lambda(\theta)}, \tag{4.13}$$

which depends positively on the separation rate and negatively on tightness and search intensity. The total number of employed workers is given by:

$$Employment = (1-u)LF. \tag{4.14}$$

3 Effects of in-work benefits

This section derives the effects of in-work benefits on wage formation, search effort, unemployment and employment in equilibrium. Section 5 will deal with the generalization of these results when proportional income or payroll taxation is used to finance the in-work benefit. We summarize the results in the following proposition:

Proposition 4.1 *An in-work benefit will reduce wages and increase tightness and search effort. Moreover, the equilibrium rate of unemployment falls, and labour force* *participation and employment increase, with an in-work benefit.*

Proof. Differentiation of (4.10) with respect to θ and IWB yields $\frac{\partial\theta}{\partial IWB} = \frac{(1-\beta)}{s\beta k\left(1-k(r+\phi)\frac{q'}{s\beta kq^2}\right)} > 0$. To get the equilibrium effect on tightness, we need to account for the fact that s is a function of θ through (4.11). However, as search is optimally determined by workers, the effects working through search effort in (4.10) will have no impact on tightness. Using how IWB affects tightness and the fact that search is optimally determined, we can show the following for search effort, wage, income from work, labour force participation, the unemployment rate, and employment: $\frac{\partial s}{\partial IWB} = \frac{\beta k}{\sigma_{ss}(s)(1-\beta)}\frac{\partial\theta}{\partial IWB} > 0$ from (4.11), $\frac{\partial w}{\partial IWB} = -(1-\beta)\left[1-1/\left(1-k(r+s)\frac{q'}{s\beta kq^2}\right)\right] < 0$ from (4.8), $\frac{\partial(w+IWB)}{\partial IWB} = -(1-\beta)\left[1-1/\left(1-k(r+s)\frac{q'}{s\beta kq^2}\right)\right] + 1 > 0$, $\frac{\partial LF}{\partial IWB} = F'(.)\frac{s\beta k}{(1-\beta)}\frac{\partial\theta}{\partial IWB} \geq 0$ from (4.12), $\frac{\partial u}{\partial IWB} = -\frac{\phi}{\phi+s(\theta)\lambda(\theta)}\left(\frac{\partial s}{\partial\theta}\lambda(\theta) + s\frac{\partial\lambda}{\partial\theta}\right)\frac{\partial\theta}{\partial IWB} < 0$ from (4.13), and $\frac{\partial Employment}{\partial IWB} = -\frac{\partial u}{\partial IWB}LF + (1-u)\frac{\partial LF}{\partial IWB} > 0$ from (4.14). ■

An in-work benefit which, by definition, is conditioned on work, makes it relatively more attractive to have a job, so it tends to reduce wage demands. As wage demands fall, it becomes more profitable to open vacancies in relation to the number of efficient job searchers in the unemployment pool, which induces tightness to increase. As the expected unemployment spells become shorter, the return to job search increases, which induces unemployed workers to devote more time to search. The equilibrium rate of unemployment falls both because unemployed workers search more intensively for a job and because there are more posted vacancies relative to the number of efficient job searchers. An in-work benefit will also induce more workers to choose participation instead of non-participation. The shorter expected unemployment spells simply increase the return to participation. Consequently, total employment increases both because the equilibrium rate of unemployment falls and because more workers choose to participate in the labour market.

4 Extensions

In order to illustrate the effects of an in-work benefit on wage formation and employment in equilibrium, we used a simple model set-up which disregarded the presence of unemployment benefits and how work hours are determined. Moreover, the in-work benefit was considered to be fixed. In many countries, the in-work benefit is instead indexed to labour income, as is the case for the EITC in the US. This section takes a first step towards including such features in the model analysis.

Including a fixed level of unemployment benefits, B, in the present model will not modify the results in the proposition put forth in section 3, nor will the assumption of unemployment benefits that are indexed to the wage, i.e. $B = bw$. However, when benefits are indexed to the wage, an increase in the in-work benefit (IWB) tends to have a larger effect on wage demands. This follows as the wage moderation entails a reduction in unemployment benefits, which further reduces the wage demands. In fact, the take home pay when employed, $w + IWB$, may fall in this case. However, despite the fact that labour income may fall with an increase in the in-work benefit, search effort and participation increase as the expected unemployment spell becomes shorter. This illustrates a case when the employment increase caused by an in-work benefit is solely driven by job creation.

Previous literature evaluating the impact of the EITC has been concerned with the potentially negative incentive effects of such policy on individual work hours. However, evidence supporting that the EITC reduces work hours is difficult to find, although this has been the focus of numerous empirical studies. Instead, the empirical evaluations have consistently found the labour supply responses to be concentrated along the participation (extensive) margin, rather than along the work hour (intensive) margin (see Meyer, 2002, Eissa and Hoynes, 2005, and Meyer 2007). The choice to focus on the participation margin in this paper, rather than on the hour margin, thus seems more natural. However, we have also considered an extension of the model that accounts for endogenous determination of work hours. Both cases when work hours are determined by the worker and when work hours are determined through bargaining are investigated. The following separable utility function is used to capture disutility of work, $u = I - \varphi(h)$, where I denotes income. This utility function will only allow us to capture substitution effects of the policy in focus. It is straightforward to show that the results proposed in proposition 1 will remain also if we let work hours be endogenously determined in this way. It also follows that work hours are unaffected by an increase of the in-work benefit in case hours are determined through bargaining but will, in fact, fall if hours are determined by the worker. A more elaborate analysis of the effects of an in-work benefit on work hours also accounting for the impact of income effects should be considered for future work.

Finally, we can conclude that the results in proposition 4.1 remain if we assume that the in-work benefit is indexed to the wage, i.e., $IWB = \gamma w$ in the phase-in region, and $IWB = IWB_{MAX} - \delta w$ in the phase-out region. A steeper phase-in rate or a less steep phase-out rate then captures an increase in the in-work benefit. However, analysing the impact of a phase-in and a phase-out region becomes more relevant when workers eligible for the benefit are heterogenous in terms of productivity. Such an extension is considered for future work.

5 Financing of the in-work benefit

In this section, we study the effects of in-work benefits when their financing through proportional income taxation is taken into account. In particular, wages are taxed at the proportional rate, t [4] . The flow value function for employment (4.1) becomes

$$rE_i = w_i\left(1-t\right) + IWB - \phi\left(E_i - U_i\right),$$

while (4.2), (4.3), (4.5), and (4.6) remain unchanged. The first-order condition for wage determination in (4.7) becomes

$$(1-t)\frac{\beta}{1-\beta}J = E - U, \tag{4.15}$$

and the wage rule corresponding to (4.8) becomes

$$w = \beta\left(y + ks\theta\right) - \frac{1-\beta}{1-t}\left[IWB + \sigma\left(s\right)\right]. \tag{4.16}$$

It can be noted that a higher tax rate will have a direct negative effect on wage demands given by (4.16). The reason for this is that IWB is not taxed and the marginal value of an additional unit of wage is $(1-t)$. Thus, a higher tax rate works as an increase in the IWB when formulating (gross) wage demands.

In-work benefits are financed by taxing wages. We study two cases. First, we derive analytical results for the case when benefits are fully financed by taxing the beneficiaries. Then, we deal with the case when the whole workforce is taxed to

[4] The IWB being financed by payroll taxation would yield the same results.

finance benefits for which only part of the population is eligible. For this case, labelled "partial financing", we here derive the main equations, while the simulation results are discussed in section 7.

5.1 Full financing

As only employees receive the benefits, a balanced budget implies [5]

$$IWB = tw. \tag{4.17}$$

Substituting (4.17) into (4.16) and rearranging, we get the wage as an expression of the tax rate

$$w = \frac{\beta(1-t)}{1-\beta t}(y + ks\theta) - \frac{1-\beta}{1-\beta t}\sigma(s). \tag{4.18}$$

Substituting (4.18) into the job creation curve (4.9), we get the expression for equilibrium tightness corresponding to (4.10):

$$\frac{k(r+\phi)}{q(\theta)} = \frac{1-\beta}{1-\beta t}[y + \sigma(s)] - \frac{\beta(1-t)}{1-\beta t}ks\theta. \tag{4.19}$$

In the (θ, w) space, increasing the tax rate shifts the wage curve (4.18) downward and clockwise while leaving the job creation curve (4.9) unchanged, thus clearly reducing the equilibrium wage and increasing tightness, i.e.

$$\frac{\partial w}{\partial t} < 0, \frac{\partial \theta}{\partial t} > 0.$$

Note that changes in t working through s will have no effect on these expressions as s is optimally chosen. Thus, we can state that an increase in proportional taxes used to finance in-work benefits reduces wages and increases tightness. It is also straightforward to formally verify this by differentiating (4.19) and (4.18) with respect to t,

[5] When unemployment benefits are also accounted for, the analysis of financing becomes more complex, as the tax rate necessary to finance a given level of in-work benefits and unemployment benefits (or a given replacement rate) depends on the equilibrium level of unemployment. In this case, an increase of in-work benefits is likely to be partly financed by reduced unemployment benefits and, if unemployment benefits are also taxed, by higher tax revenues from unemployed. If we also consider some kind of social assistance available to non participants, also the size of the labour force is of importance.

θ, and w [6] .

The relationship between the tax rate and the in-work benefits may not be monotonic. For a given wage, an increase in t increases IWB. However, in equilibrium the tax rate has a moderating impact on wages, with a higher t corresponding to a lower w. Thus, the effect of an increase in the tax rate on tax revenues, i.e. on in-work benefits, may be dominated by the reduction in the tax base, i.e. the reduction in wages due to a tax hike[7] . There may thus be some sort of "Laffer curve", but as far as the economy is on the side of the curve where an increase in the tax rate increases total revenues, i.e. $\frac{\partial IWB}{\partial t} > 0$, the derivatives w.r.t. t have the same sign as the derivatives w.r.t. IWB, thus

$$\frac{\partial w}{\partial IWB} < 0, \frac{\partial \theta}{\partial IWB} > 0.$$

Search intensity is given by (4.4). Using the free-entry condition $V = 0$ in (4.6) together with (4.15), we get

$$\sigma_s(s) = (1-t)\frac{\beta k\theta}{1-\beta}. \tag{4.20}$$

For search intensity to grow as the tax rate increases, we need the following condition to hold:

$$(1-t)\frac{\partial \theta}{\partial t} - \theta > 0. \tag{4.21}$$

The labour force is given by

$$LF = F\left((1-t)\frac{s\beta k\theta}{1-\beta} - \sigma(s)\right), \tag{4.22}$$

[6] Differentiating (4.19) with respect to t and θ yields $\frac{\partial \theta}{\partial t} = \frac{(1-\beta)[y+ks\theta+\sigma(s)]}{(1-\beta t)sk(1-t)[1+z]} > 0$, where $z = -\frac{(r+\phi)q'}{q^2}\frac{(1-\beta t)}{(1-t)s\beta} > 0$. Then, differentiating (4.18) with respect to w and t accounting for θ being affected by t, yields: $\frac{\partial w}{\partial t} = -\frac{\beta(1-\beta)[y+ks\theta+\sigma(s)]}{(1-\beta t)^2}\left[1-\frac{1}{1+z}\right] < 0$. Once more, note that changes in t working through s will have no effect on these expressions as s is optimally chosen by the individuals.

[7] Using (4.18) in (4.17) and differentiating wrt, t we get $\frac{\partial IWB}{\partial t} = \frac{\left(\beta t^2-2t+1\right)\beta[y+ks\theta+\sigma(s)]}{(1-\beta t)^2} + \frac{\beta kst(1-t)}{1-\beta t}\frac{\partial \theta}{\partial t} - \sigma(s)$. The first term is positive iff $t \in \left[0, \frac{1-\sqrt[2]{1-\beta}}{\beta}\right] \supset [0, \frac{1}{2}]$. The second term is always positive as $\frac{\partial \theta}{\partial t} > 0$. So, for $\sigma(s)$ small enough and t not too high $\frac{IWB}{\partial t} > 0$. Substituting the expression for $\frac{\partial \theta}{\partial t}$ we get $\frac{\partial IWB}{\partial t} = \frac{\beta[y+ks\theta+\sigma(s)]}{1-\beta t}\left[(1-t) - \frac{t(1-\beta)}{(1-\beta t)}\left(1-\frac{1}{1+z}\right)\right] - \sigma(s)$. Notice that at $t = 0$, $\frac{\partial IWB}{\partial t} = w > 0$.

which increases with t iff $(1-t)\frac{\partial\theta}{\partial t}-\theta>0$. Unemployment is given by (4.13). If search intensity increases with t, then unemployment certainly decreases with t. Employment is given by (4.14). If (4.21) holds, then employment also increases with t. Thus, (4.21) is a sufficient, but not necessary, condition for unemployment and employment to increase with the tax rate.

When is it the case that $(1-t)\frac{\partial\theta}{\partial t}-\theta>0$? Substituting the expression for $\frac{\partial\theta}{\partial t}$ into (4.21), the condition is equivalent to

$$\frac{(1-\beta)\left[y+ks\theta+\sigma(s)\right]}{1-\beta t}>\theta sk\left[1-\frac{(r+\phi)\,q'}{q^2}\frac{1-\beta t}{(1-t)\,s\beta}\right].$$

Using the equilibrium expression for tightness (4.19) and rearranging, we get

$$\eta\left(\theta\right)<\frac{1-t}{1-\beta t}\beta, \tag{4.23}$$

where $\eta\left(\theta\right)=-\frac{q'}{q}\theta$ is the elasticity of the expected duration of a vacancy w.r.t. tightness. With $t=0$ the condition is $\eta\left(\theta\right)<\beta$. We know that because of trading externalities, equilibrium search intensity and participation are generally too low from the point of view of society and, when $\beta>\eta(\theta)$, equilibrium unemployment is above the socially efficient rate (Pissarides, 2000). What we show is that under these circumstances, there is room for in-work benefits to improve labour market efficiency by increasing search intensity, labour force participation, employment, and reducing unemployment, even when financing is taken into account.

Proposition 4.2 *Proposition 4.1 holds also when the in-work benefits are financed through proportional taxes on wages, provided that the tax rate is such that a higher tax rate implies higher fiscal revenues and that* $\eta\left(\theta\right)<\frac{\beta(1-t)}{1-\beta t}$.

The intuition behind this result is the following. Equilibrium tightness and search when in-work benefits are financed through proportional taxation at the rate t are given by equations (4.19) and (4.20), while the wage is given by equation (4.18). We get exactly the same expressions when substituting β with

$$\beta'\equiv\frac{\beta\left(1-t\right)}{1-\beta t}<\beta,$$

and $IWB=0$ into equations (4.10), (4.11), and (4.8) that characterize the equilibrium when financing of benefits is not taken into account. This means that the equilibrium of a model with in-work benefits financed through a proportional tax on wages t and with workers' bargaining power β is isomorphic to the equilibrium of a model without in-work benefits and with workers' bargaining power $\beta' < \beta$. Thus, an increase in the tax rate used to finance in-work benefits is equivalent to reducing the "effective" bargaining power of the worker. In a search model as that used here, (constrained) efficiency is reached when workers' bargaining power equals the elasticity of the expected duration of a vacancy with respect to tightness. If instead $\beta > \eta(\theta)$, then a marginal increase in taxation moves the labour market toward efficiency, thus increasing search intensity and participation and reducing unemployment. This goes on until $\frac{\beta(1-t)}{1-\beta t} = \eta(\theta)$, after which a further increase in taxation to finance in-work benefits moves the economy away from efficiency, reducing search intensity and participation, while the effect on unemployment is ambiguous.

From (4.23), we can calculate the tax rate that gives efficiency as the solution to the system formed by equations (4.19) and (4.20) and by

$$t = \frac{\beta - \eta(\theta)}{\beta(1 - \eta(\theta))}, \tag{4.24}$$

which is easy to calculate in case of a Cobb-Douglas matching function as $t^* = \frac{\beta - \eta}{\beta(1-\eta)}$. This provides a simple condition for the level of fully financed in-work benefits needed to achieve (constrained) efficiency in a labour market characterized by search externalities.

5.2 Partial Financing

Here, we study the case when only part of the population is entitled to benefits, which are financed by the whole workforce. We assume that there are two types of agents in the population. One type, representing a share ρ of the total population, is entitled to in-work benefits, while the other type is not. This may be due to the fact that the two types have different productivities or that they differ in some other relevant dimension, like having children or not. To simplify the analysis and focus on the fiscal aspects of in-work benefits, we assume that these two types of agents are active in separate labour markets. Thus, they are solely linked through the fiscal system. In particular, all agents are subject to a tax on wages at rate t, used to finance an in-work benefit to which only a part of the population is eligible. Moreover, all structural parameters, except possibly productivity, are the same in the two labour markets. First, we characterize the equilibrium labour market outcome for the part of the population that is non-eligible to benefits, then for the eligible part. Simulation results are discussed in section 7.1. Subscripts "n" and "e" are used to indicate the two groups. The labour market outcome for the economy as a whole is determined as a weighted average of the corresponding variables for the two groups, in which weights reflect their relative size (see the Appendix for details).

Non-eligible Workers Workers of this type have their wage taxed at tax rate t, but in-work benefits are not available to them. Substituting in (4.9) the wage equation given by (4.16) with $IWB = 0$, we get the expression characterizing tightness in this labour market

$$\frac{k\left(r+\phi\right)}{q\left(\theta_n\right)} = \left(1-\beta\right)y_n - \beta k s_n \theta_n + \frac{1-\beta}{1-t}\sigma\left(s_n\right).$$

Search intensity s_n is given by expression (4.20), while the participation rate, the unemployment rate and the employment rate are given by expressions (4.13), (4.14), and (4.22), respectively. To get the absolute number of participants and employed, we need to account for the fact that these agents represent a fraction $(1-\rho)$ of the total population. The total fiscal resources collected from this group of workers are given by

$$b = \left(1-\rho\right)e_n t w_n,$$

where e_n is the employment rate and w_n the equilibrium wage.

Eligible Workers This group of workers has the wage taxed at rate t and is eligible to an in-work benefit. The analysis is similar to the case with full financing, where the per capita amount of benefits implied by a balanced budget is given by

$$IWB = t w_e + \frac{b}{\rho e_e}. \tag{4.25}$$

The first term, tw_e, is the "self-financing" part, while the second term represents the part financed by ineligible workers, which depends on the total fiscal resources collected, b, and the number of eligible workers among which these resources must be split, ρe_e. Substituting (4.25) into the wage equation given by (4.16) we get

$$w_e = \frac{\beta(1-t)}{1-\beta t}(y_e + ks_e\theta_e) - \frac{1-\beta}{1-\beta t}\left[\frac{b}{\rho e_e} + \sigma(s_e)\right],$$

which substituted in (4.9) gives

$$\frac{k(r+\phi)}{q(\theta_e)} = \left(\frac{1-\beta}{1-\beta t}\right)\left[y_e + \frac{b}{\rho e_e} + \sigma(s_e)\right] - \frac{\beta(1-t)}{1-\beta t}ks_e\theta_e,$$

where e_e depends on θ_e. Search intensity, participation rate, unemployment rate and employment rate are given by expressions (4.20), (4.13), (4.14), and (4.22), respectively.

6 Fixed Wages

As seen in the previous sections, the introduction of in-work benefits results in a fall in equilibrium wages. Here, we assume wages to be fixed, however. Therefore, even after the introduction of in-work benefits, wages remain at the level $\tilde{w}$ observed when no benefits are present. In section 7.1, using simulations, we contrast the resulting equilibrium with the equilibrium in which wages adjust. In this way, we can determine the impact on labour market outcomes of accounting for equilibrium wage adjustments in the analysis of in-work benefits.

When the financing of benefits is not taken into account, with wages fixed at the pre-benefit level $\tilde{w}$, tightness is the same as in the pre-benefit equilibrium, given by

$$\frac{k(r+\phi)}{q(\theta)} = y - \tilde{w}.$$

The behavioural equation giving search effort is still (4.4). However, (4.7) no longer holds. Combining (4.1) and (4.2), we obtain

$$E - U = \frac{\tilde{w} + IWB + \sigma(s)}{r + \phi + s\lambda(\theta)},$$

so that, using (4.4), search effort is determined by

$$\sigma_s(.) = \lambda(\theta)\frac{\tilde{w} + IWB + \sigma(s)}{r + \phi + s\lambda(\theta)}. \tag{4.26}$$

Conversely, labour force participation is given by

$$LF = F\left(s\lambda(\theta)\frac{\tilde{w} + IWB + \sigma(s)}{r + \phi + s\lambda(\theta)} - \sigma(s)\right), \tag{4.27}$$

while the expressions for unemployment and employment are unchanged.

When in-work benefits are fully financed by taxing the beneficiaries, wages fixed at the pre-benefit level $\tilde{w}$ imply that the income of a worker when employed, $\tilde{w}(1-t)+IWB$, always equals $\tilde{w}$, so that the equilibrium with or without in-work benefits is the same.

7 Calibration

To calibrate the model, we assume the matching function to be Cobb-Douglas, so that

$$X = h(v, su) = mv^{1-\eta}(su)^{\eta} \quad \text{where} \;\; m > 0; \eta \in (0,1). \tag{4.28}$$

The convex search cost function is assumed to be a power function and therefore

$$\sigma(s) = s^{\alpha}, \text{ where } \;\alpha > 1. \tag{4.29}$$

The month is the basic time unit. Productivity y is normalized to 1. Worker bargaining power β is set to the standard value in the literature of 0.5, while the real interest rate r is 0.005. Following Christensen et al. (2005), parameter α equals 2, implying a quadratic search cost[8] . In the baseline specification, η equals 0.4, while parameters k, ϕ, and m are set to replicate an unemployment rate of 0.06, an average duration of unemployment of three months, and an average duration of a vacancy of one month in the absence of in-work benefits, giving $k = 4.5616$, $\phi = 0.0213$, and $m = 0.6807$. Finally, we assume the per period value of leisure to

[8] Christensen et al. (2005) structurally estimate a model with on-the-job search using Danish microdata. A quadratic function is also the preferred specification in Yashiv (2000), who structurally estimates a model with search only by the unemployed using Israeli aggregate time-series data.

be distributed according to an exponential function with parameter μ, calibrated so that the participation rate without in-work benefits equals 0.7. See the Appendix for details. The table below summarizes the baseline parametrization.

y	β	k	r	ϕ	m	η	α	μ
1	0.5	4.5616	0.005	0.0213	0.6807	0.4	2	0.631

When simulating the model with partial financing, we also consider the case where the productivity of non-eligible workers is double the productivity of eligible ones.

7.1 Numerical results

Figure 4.1 describes the effects on the main labour market variables of introducing in-work benefits up to the equivalent of half of labour productivity, when financing is not taken into account. The continuous line represents the case where wages are flexible, while the dotted line represents the case with fixed wages.

As predicted by theory, the introduction of in-work benefits implies an increase in tightness and a fall in wages when wages are flexible, while these two quantities do not move when wages are fixed. The quantitative impact on unemployment and employment is significantly stronger when the effect of benefits on wages is taken into account. For instance, compared to an unemployment rate of 6% without in-work benefits, the introduction of benefits equivalent to 40% of productivity implies a decline in unemployment to 4.97% when wages are fixed and to 4.41% when they are flexible, while employment increases by an additional 0.62% with flexible wages as compared to the case with fixed ones. Moreover, the impact on search intensity and labour force participation is stronger when wages are allowed to move but quantitatively, the difference is very small.

Figure 4.2 investigates the effects on the main labour market variables of introducing fully-financed benefits up to the equivalent of half of labour productivity[9] . The continuous line represents the case when wages can adjust, while the dotted line represents the case with fixed wages. As stated in the previous section, when benefits are fully financed by taxing beneficiaries and wages are downward rigid, in-work benefits do not have any effect. When wages can adjust, tightness increases and

[9] The tax rate corresponding to $IWB = 0.5$ is approximately 60%. In the baseline parametrization, the maximum attainable amount of benefits with wage flexibility is 0.64, achieved at a tax rate of 88%.

gross wage decreases. Notice that in this setting, gross wage is equivalent to total income, as fiscal revenues are entirely used to finance benefits. The comparison of figures 4.1 and 4.2 reveals that both tightness and wage respond more strongly when benefits are financed through taxation on beneficiaries' wages as compared to the case when an identical amount of in-work benefits is a "windfall", financed through other sources. This is due to the additional wage moderation stemming from taxation. As predicted by the theory, with full financing the response of search intensity and labour force participation is hump-shaped, initially increasing with the level of benefits (and taxes) and then declining. In the baseline parametrization, the tax rate at which both quantities reach their peak is, from (4.24), $t = 1/3$, corresponding to $IWB \approx 0.28$, at which (constrained) efficiency is achieved. Further increases in fully financed benefits take the labour market away from efficiency. However, search intensity and participation stay above the level they have when no benefits are paid until $IWB \approx 0.47$ ($t \approx 56\%$). Unemployment declines in the whole range, falling, for instance, from 6% to 4.15% when benefits are equivalent to 40% of productivity. Total employment increases, reaching approximately 67.2% of the population when $IWB = 0.4$, as compared to 65.8% with no benefits.

We look at three scenarios in the "partial financing" case, where the share of the population eligible for benefits financed by the whole workforce is 25%, 50%, and 75%, respectively. To make the comparison easier, we focus on the case when both eligible and non-eligible workers have the same productivity. However, the case with non-eligible workers having higher productivity is also investigated.

Figure 4.3 reports the main labour market indicators for eligible workers as a function of in-work benefits in the three scenarios. For comparison, indicators with "no financing" and "full financing" are also depicted. As could be expected, the "partial financing" cases lie between the two polar ones, moving toward the "full financing" equilibrium as the share of eligible workers increases. The corresponding figure for non-eligible workers is 4.4. For this group of workers, given the share of eligibles in the population, an increase in benefits just represents an increase in taxation. An increase in the share of eligible workers, given a level of benefits, also represents an increase in taxation. Thus, increasing benefits or increasing eligibility reduce wages, search intensity, labour force participation, and employment of non-eligible workers, while tightness and unemployment increase. The impact of benefits on the labour market as a whole is presented in figure 4.5, that includes the "full financing" case for reference, and in table 4.1. Unemployment decreases with the introduction of benefits, and the impact on it is stronger as benefits increase and as the share of eligible workers increases, with the equilibrium smoothly converging to the "full financing" case. The behaviour of labour force participation and employment is more complex. Their response to benefits is hump-shaped, first increasing and then decreasing as benefits increase. The response to an increase in eligibility is also non-linear. For a given level of benefits, labour force participation and employment may decrease with the share of the population eligible for benefits rising from 25% to 50%, but then bounce back with a further increase to 75%. While improving labour market conditions for eligible workers, the negative impact of increased taxation on non-eligible ones implies that in-work benefits above a relatively low level do not improve participation and employment in the labour market as a whole. This no longer happens if the productivity of non-eligible workers is set to double the productivity of eligible ones (see table 4.2). In this case, labour market conditions improve with the introduction of benefits even at relatively high levels. The analysis of the partial financing case done here is just preliminary, but indicates the importance of accounting for the financing of benefits when evaluating their impact on the labour market as a whole.

8 Conclusions

In-work benefits are becoming increasingly popular among policy-makers due to their success in the American and British contexts. Whether they can be successfully adopted in other countries and help solve some of the problems characterizing their labour markets is an open issue. This paper represents a first step towards addressing this question. We analyse the impact of in-work benefits on some of the main labour market indicators in a search framework, taking into account the general equilibrium effects. We find that introducing or increasing in-work benefits increases labour force participation, employment, and search intensity by unemployed, while wages and the unemployment rate decline. This result is robust to various extensions.

Considering in-work benefits in a general equilibrium setting reveals that their impact on job creation is an important factor behind employment growth, in contrast to the existing literature that mainly looks at their impact on labour supply via a higher take-home pay. In fact, in-work benefits may even reduce the take-home pay as wage demands are moderated[10] . However, the lower wages boost job creation which reduces unemployment. The shorter expected unemployment spell, in turn, encourages job search and labour force participation which reinforces the increase in employment. Our model suggests that the job creation dimension should be taken into account in evaluating ex ante the impact of introducing such benefits in a European country. The risk is, otherwise, to miss a very important link.

The analysis of financing reveals the conditions under which benefits that are financed through proportional taxation on wages increase labour force participation, employment, and search intensity of the targeted group.

Both these aspects of in-work benefits, their impact on job creation and their financing, have mostly been overlooked by the existing literature, but become increasingly relevant as the scope of programmes including benefits or tax credits conditioned on labour income is extended.

[10] This was concluded in section 4, where unemployment benefits were indexed to the wage which induced additional wage moderation which could actually reduce the take-home pay.

Bibliography

[1] Blundell, R. (2006), "Earned income tax policies: impact and optimality", *Labour Economics* 13(4), pp. 423-443.

[2] Boeter, S., Schnabel, R., and Gurtzgen, N. (2006), "Reforming social welfare in Germany; An applied general equilibrium analysis", *German Economic Review*, vol. 7(4), pp. 363-388.

[3] Brewer, M., and Browne, J. (2006), "The effect of the working families' tax credit on labour market participation", BN No 69, the Institute for Fiscal Studies.

[4] Boone J., and Bovenberg, L. (2004), "The optimal taxation of unskilled labour with job search and social assistance", *Journal of Public Economics*, vol. 88, pp. 2227-2258.

[5] Boone J., and Bovenberg, L. (2006), "Optimal welfare and in-work benefits with search unemployment and observable abilities", *Journal of Economic Theory*, vol. 126, pp. 165-193.

[6] Christensen, B. J., Lentz, R., Mortensen, D. T., Neumann, G. R., and Wervatz, A. (2005), "On the job search and the wage distribution", *Journal of Labor Economics*, vol. 23(1), 31-58.

[7] Eissa, N., and Hoynes, H. (2004), "Taxes and the labour market participation of married couples; The earned income tax credit", *Journal of Public Economics*, vol. 88, 9-10, pp. 1931-1958.

[8] Eissa, N., and Hoynes, H. (2005), "Behavioral responses to taxes; Lessons from the EITC and labour supply", forthcoming in *Tax Policy and the Economy.*

[9] Eissa, N., and Liebman, J. (1996), "Labor supply responses to the earned income tax credit", *Quarterly Journal of Economics*, vol. 111(12), pp. 605-637.

[10] Eissa, N., and Nichols, A. (2005), "Tax-Transfer Policy and Labor Market Outcomes", *American Economic Review. Papers and Proceedings*, vol. 95(2), pp. 88-93.

[11] Fang, H., and Keane, M. (2004), "Assessing the Impact of Welfare Reform on Single Mothers", *Brookings Papers on Economic Activity*, vol. 1, pp. 1-116.

[12] Immervoll, H., Kleven, H., Kreiner, C.T. and Saez, E. (2007), "Welfare reform in European countries: A micro simulation analysis", *Economic Journal*, vol. 117, pp. 1-44.

[13] Leigh, A., 2004, Who Benefits from the Earned Income Tax Credit? Incidence Among Recipients, Coworkers and Firms, ANU CEPR Discussion Paper 494.

[14] Lise, J., Shannon, S., and Smith, J. (2005), "Equilibrium policy experiments and the evaluation of social programs", IZA Working Paper 758.

[15] Meyer, B., and Rosenbaum, D. (2001), "Welfare, the earned income tax credit and the labour supply of single mothers", *Quarterly Journal of Economics*, vol. 116, pp. 1063-1114.

[16] Meyer B. (2002), "Labor Supply at the Extensive and Intensive Margin, the EITC, Welfare and Hours Worked", *American Economic Review. Papers and Proceedings*, vol. 92(2), pp. 373-379.

[17] Meyer B. (2007), "The Earned Income Tax Credit, the U.S. Welfare Reform, and the Well-Being of Families", forthcoming in *Swedish Economic Policy Review.*

[18] Michalopoulos C., Robins, P.K., and Card, D. (2005), "When Financial Work Incentives Pay for Themselves; Evidence from a Randomized Social Experiment for Welfare Recipients", *Journal of Public Economics*, vol. 89, pp. 5-29.

[19] Pissarides, C. (2000), *Equilibrium unemployment theory*, MIT Press, Boston, MA.

[20] Rothstein, J. (2004), "The Unintended Consequences of Encouraging Work: Is the EITC As Good As an NIT?", mimeo.

[21] Saez, E. (2002), "Optimal Income Transfer Programs: Intensive Versus Extensive Labor Supply Responses", *Quarterly Journal of Economics*, vol. 117 (3), 1039-1073.

[22] Yashiv, E. (2000), "The determinants of equilibrium unemployment", *The American Economic Review*, vol. 90(5), pp. 1297-1322.

Appendix

A1 Expressions and calibration

The expressions we used in the calibration are derived in this appendix.

No financing Using (4.29) in (4.11), we get

$$s = \left[\frac{\beta k\theta}{\alpha\left(1-\beta\right)}\right]^{\frac{1}{\alpha-1}}, \tag{4.30}$$

that, substituted into (4.10) and together with (4.28), gives

$$\frac{k\left(r+\phi\right)}{m\theta^{-\eta}} = \left(y+IWB\right)\left(1-\beta\right) - \left(1-\frac{1}{\alpha}\right)\frac{\left(\beta k\theta\right)^{\frac{\alpha}{\alpha-1}}}{\left[\alpha\left(1-\beta\right)\right]^{\frac{1}{\alpha-1}}}, \tag{4.31}$$

which implicitly determines equilibrium tightness as a function of parameters. Equilibrium search is given by substituting equilibrium tightness into (4.30). Given that θ and s are determined by (4.30) and (4.31), we can derive the wage, the unemployment rate, the labour force and employment in the following way. From (4.8) we get the equilibrium wage

$$w = \beta\left(y+ks\theta\right) - \left(1-\beta\right)\left[IWB+s^{\alpha}\right],$$

and from (4.13) the equilibrium unemployment rate

$$u = \frac{\phi}{\phi+sm\theta^{1-\eta}}. \tag{4.32}$$

From (4.12) and the assumption that the per period value of leisure is distributed according to an exponential function with parameter μ, we get the labour force

$$LF = 1-\exp\left(-\frac{\left(\alpha-1\right)}{\mu}\left[\frac{\beta k\theta}{\alpha\left(1-\beta\right)}\right]^{\frac{\alpha}{\alpha-1}}\right), \tag{4.33}$$

and, finally, from (4.14) we can derive the equilibrium employment.

With financing Using (4.29) in (4.20), we get

$$s = \left[\frac{(1-t)\beta k\theta}{\alpha(1-\beta)} \right]^{\frac{1}{\alpha-1}}, \tag{4.34}$$

which, substituted into (4.19) and together with (4.28), gives

$$\frac{k(r+\phi)}{m\theta^{-\eta}} = \frac{1-\beta}{1-\beta t} \left[y + (1-\alpha) \left(\frac{(1-t)\beta k\theta}{\alpha(1-\beta)} \right)^{\frac{\alpha}{\alpha-1}} \right], \tag{4.35}$$

that implicitly determines equilibrium tightness as a function of parameters. Equilibrium search is given by substituting equilibrium tightness into (4.34). Given that θ and s are determined by (4.34) and (4.35), we can derive the wage, the unemployment rate, the labour force and employment in the following way. From (4.18), we get the equilibrium wage

$$w = \beta\left[y + ks\theta + s^{\alpha}\right] \frac{1-t}{1-\beta t} - s^{\alpha},$$

and from (4.17), the corresponding in-work benefits, IWB. Labour force participation is given by (4.22)

$$LF = 1 - \exp\left(-\frac{(\alpha-1)}{\mu} \left[\frac{(1-t)\beta k\theta}{\alpha(1-\beta)} \right] \right),$$

while the expressions for unemployment and unemployment are the same as in the case without financing.

Partial Financing For non-eligible workers, tightness is given by

$$\frac{k(r+\phi)}{m\theta_n^{-\eta}} = (1-\beta)\, y_n - (\alpha-1)\frac{1-\beta}{1-t} \left[\frac{(1-t)\beta k\theta_n}{\alpha(1-\beta)} \right]^{\frac{\alpha}{\alpha-1}},$$

and the wage is given by

$$w_n = \beta\left(y_n + ks_n\theta_n\right) - \frac{1-\beta}{1-t} s_n^{\alpha},$$

while the other expressions are the same as in the total financing case.

For eligible workers, tightness is given by

$$\frac{k\left(r+\phi\right)}{m\theta_e^{-\eta}}\left(\frac{1-\beta t}{1-\beta}\right)=\left(y_e+\frac{b}{\rho}\frac{1+\phi\left[\frac{(1-t)\beta k\theta_e}{\alpha(1-\beta)}\right]^{-\frac{1}{\alpha-1}}m^{-1}\theta_e^{\eta-1}}{1-\exp\left(-\frac{\alpha-1}{\mu}\left[\frac{(1-t)\beta k\theta_e}{\alpha(1-\beta)}\right]^{\frac{\alpha}{\alpha-1}}\right)}\right)+(1-\alpha)\left[\frac{(1-t)\beta k\theta_e}{\alpha\left(1-\beta\right)}\right]^{\frac{\alpha}{\alpha-1}}.$$

The wage is given by

$$w_e=\frac{\beta\left(1-t\right)}{1-\beta t}\left(y_e+ks_e\theta_e\right)-\frac{1-\beta}{1-\beta t}\left[\frac{b}{\rho e_e}+s_e^{\alpha}\right],$$

while the other expressions are the same as in the total financing case. The labour force participation rate for the economy as a whole is given by

$$LF=\rho LF_e+\left(1-\rho\right)LF_n,$$

while total employment is given by

$$E=\rho e_e+\left(1-\rho\right)e_n.$$

The unemployment rate for the economy as a whole is

$$u=\frac{\rho LF_e u_e+\left(1-\rho\right)LF_n u_n}{LF},$$

and the average wage is

$$w=\frac{\rho e_e w_e+\left(1-\rho\right)e_n w_n}{E}.$$

Fixed wages Expression (4.26) becomes

$$m\theta^{1-\eta}(\alpha-1)s^{\alpha}+\alpha s^{\alpha-1}\left(r+\phi\right)-m\theta^{1-\eta}\left(\tilde{w}+IWB\right)=0,$$

while expression (4.27) is given by

$$LF=1-\exp\left(-\frac{1}{\mu}sm\theta^{1-\eta}\frac{\tilde{w}+IWB+s^{\alpha}}{r+\phi+sm\theta^{1-\eta}}+\frac{1}{\mu}s^{\alpha}\right).$$

Calibration Parameters k, ϕ, m are set to replicate an unemployment rate of $\bar{u}$, an average duration of unemployment of d_u months, and an average duration of a vacancy of d_v months in the absence of in-work benefits. Unemployment is given by (4.32), so that

$$\frac{\phi}{\phi + sm\theta^{1-\eta}} = \bar{u}.$$

Expected duration of unemployment is given by

$$\frac{1}{s\lambda(\theta)} = \frac{1}{sm\theta^{1-\eta}} = d_u.$$

Expected duration of a vacancy is given by

$$\frac{1}{q(\theta)} = \frac{1}{m\theta^{-\eta}} = d_v.$$

Substituting the value of the expected duration of unemployment in the expression for unemployment, we pin down the value of ϕ:

$$\bar{u} = \frac{\phi}{\phi + \frac{1}{d_u}} \iff \phi = \frac{\bar{u}}{d_u(1-\bar{u})}.$$

Taking the ratio of the expected duration of unemployment and of a vacancy we have

$$\frac{d_v}{d_u} = s\theta.$$

Substituting from (4.30) we get

$$\frac{d_v}{d_u} = \left[\frac{\beta k}{\alpha(1-\beta)}\right]^{\frac{1}{\alpha-1}} \theta^{\frac{\alpha}{\alpha-1}} \iff \theta = \left(\frac{d_v}{d_u}\right)^{\frac{\alpha-1}{\alpha}} \left[\frac{\alpha(1-\beta)}{\beta k}\right]^{\frac{1}{\alpha}}.$$

Taking (4.31) with $IWB = 0$ and substituting we get

$$\theta = \frac{\alpha(1-\beta)^{\frac{1}{\alpha}}}{\beta k} \left[\frac{y(1-\beta) - k(r+\phi)d_v}{\alpha - 1}\right]^{\frac{\alpha-1}{\alpha}}.$$

The two expressions together imply

$$k = \frac{(1-\beta)}{\left(1-\frac{1}{\alpha}\right)\beta\left(\frac{d_v}{d_u}\right) + (r+\phi)d_v} y.$$

The corresponding tightness is given by substituting k into one of the two above expressions, i.e.

$$\theta = \left(\frac{d_v}{d_u}\right)^{\frac{\alpha-1}{\alpha}} \left[\frac{(\alpha-1)\,\beta\left(\frac{d_v}{d_u}\right) + \alpha\,(r+\phi)\,d_v}{\beta y}\right]^{\frac{1}{\alpha}},$$

while m, the matching function scale parameter, is given by

$$\frac{1}{m\theta^{-\eta}} = d_v \Longleftrightarrow m = \frac{\theta^{\eta}}{d_v},$$

and s, search intensity, by

$$s = \frac{d_v}{\theta d_u}.$$

The chosen parameter values plus the calibration of an unemployment rate of 0.06, an average duration of unemployment of three months, and an average duration of a vacancy of one month in the case without in-work benefits imply a separation rate $\phi = 0.0213$ (equivalent to an annual separation rate of 0.255), a vacancy cost $k = 4.5616$, with the corresponding tightness $\theta = 0.3823$, the scale parameter of the matching function $m = 0.6807$, while search is given by $s = 0.8719$. Using (4.33), we get the distribution parameter as

$$\mu \ s.t. \ F\left(\frac{s\beta k\theta}{(1-\beta)} - s^{\alpha};\mu\right) = \bar{L}$$

which, in case of an exponential distribution, is equivalent to

$$\mu = \frac{1}{\ln\left(\,1-\bar{L}\right)}\left(\frac{s\beta k\theta}{(1-\beta)} - s^{\alpha}\right)$$

and gives a value of $\mu = 0.631$ for a labour force participation without in-work benefits equal to 0.7.

Figure 4.1: No financing (variables as a function of in-work benefit - solid line: flexible wage; dotted line: fixed wage)

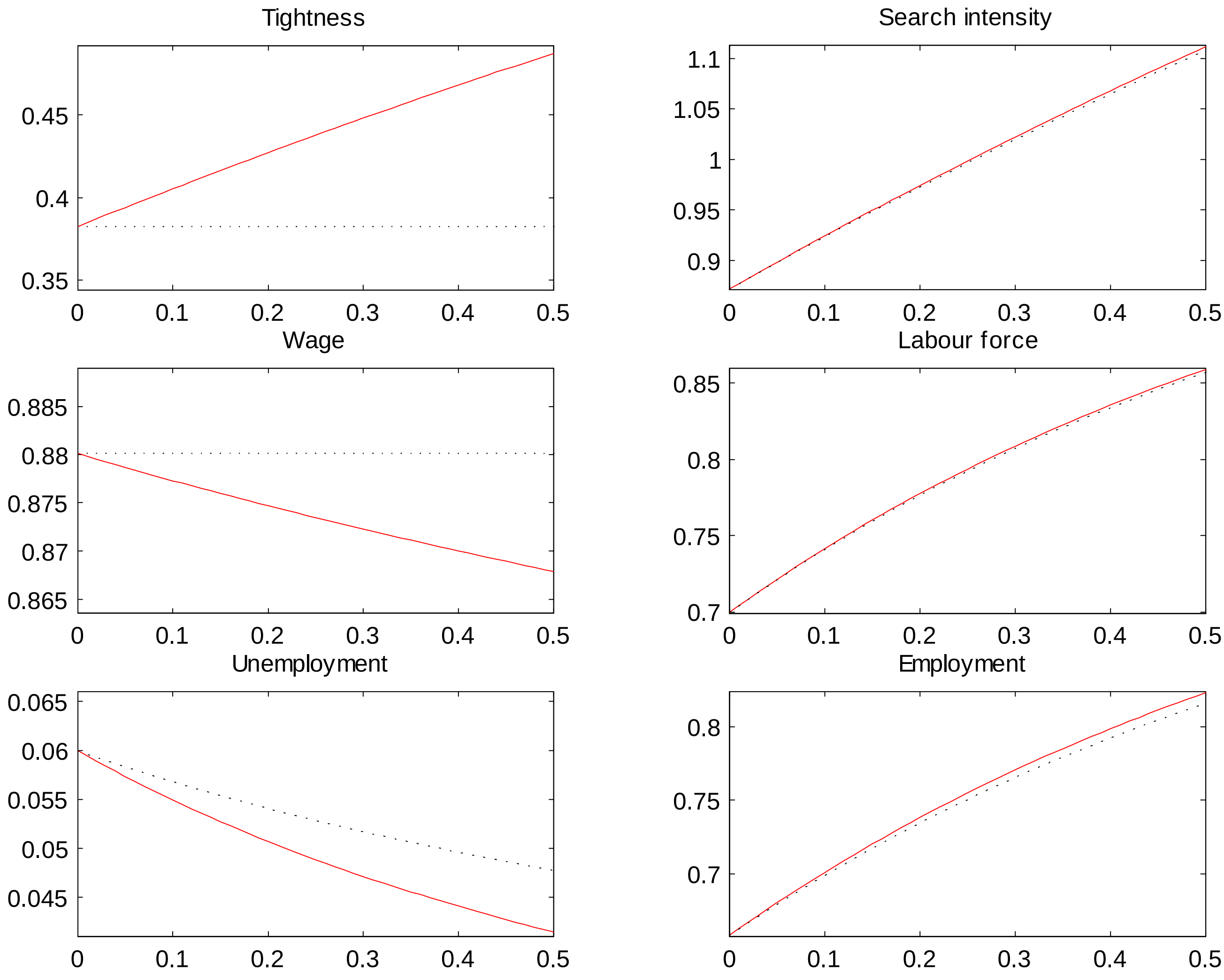


Figure 4.2: Full financing (variables as a function of in-work benefit - solid line: flexible wage; dotted line: fixed wage)

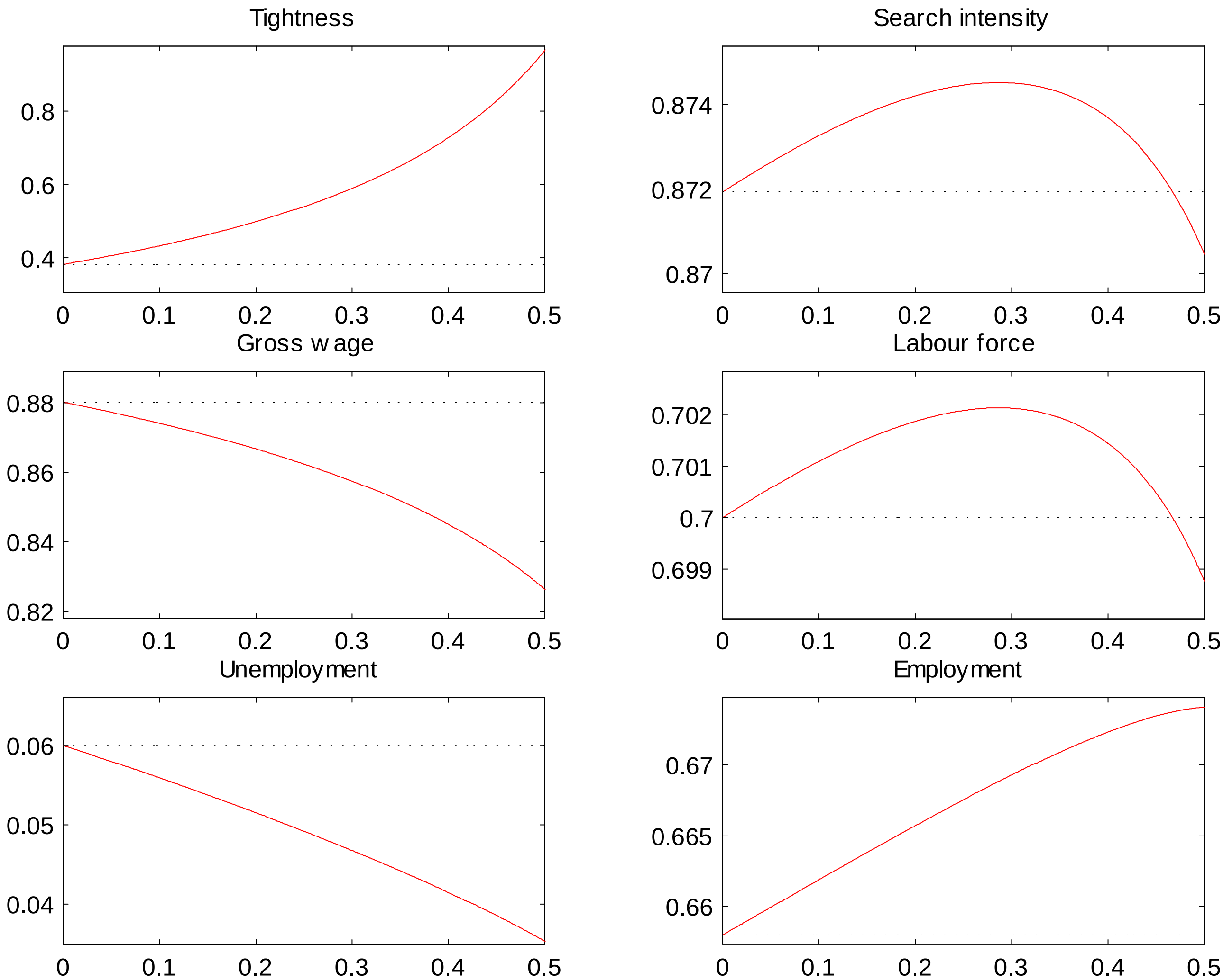


Figure 4.3: Partial financing - Eligible workers (variables as a function of IWB - dashed: ρ=0.25, dashdot: ρ=0.5, dotted: ρ=0.75, solid: no financing and full financing).

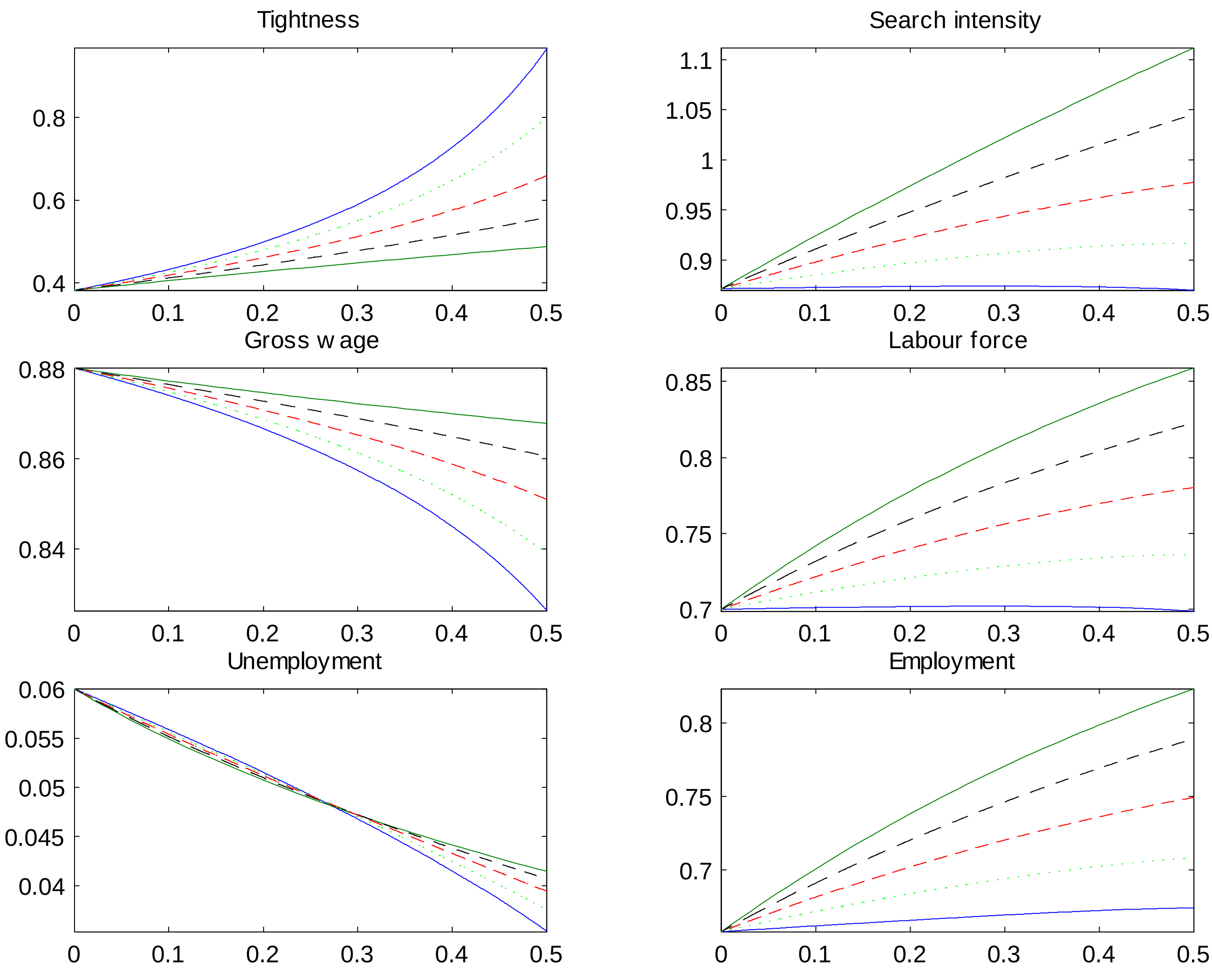


Figure 4.4: Partial financing - Non-eligible workers (variables as a function of IWB - dashed: ρ=0.25, dashdot: ρ=0.5, dotted: ρ=0.75)

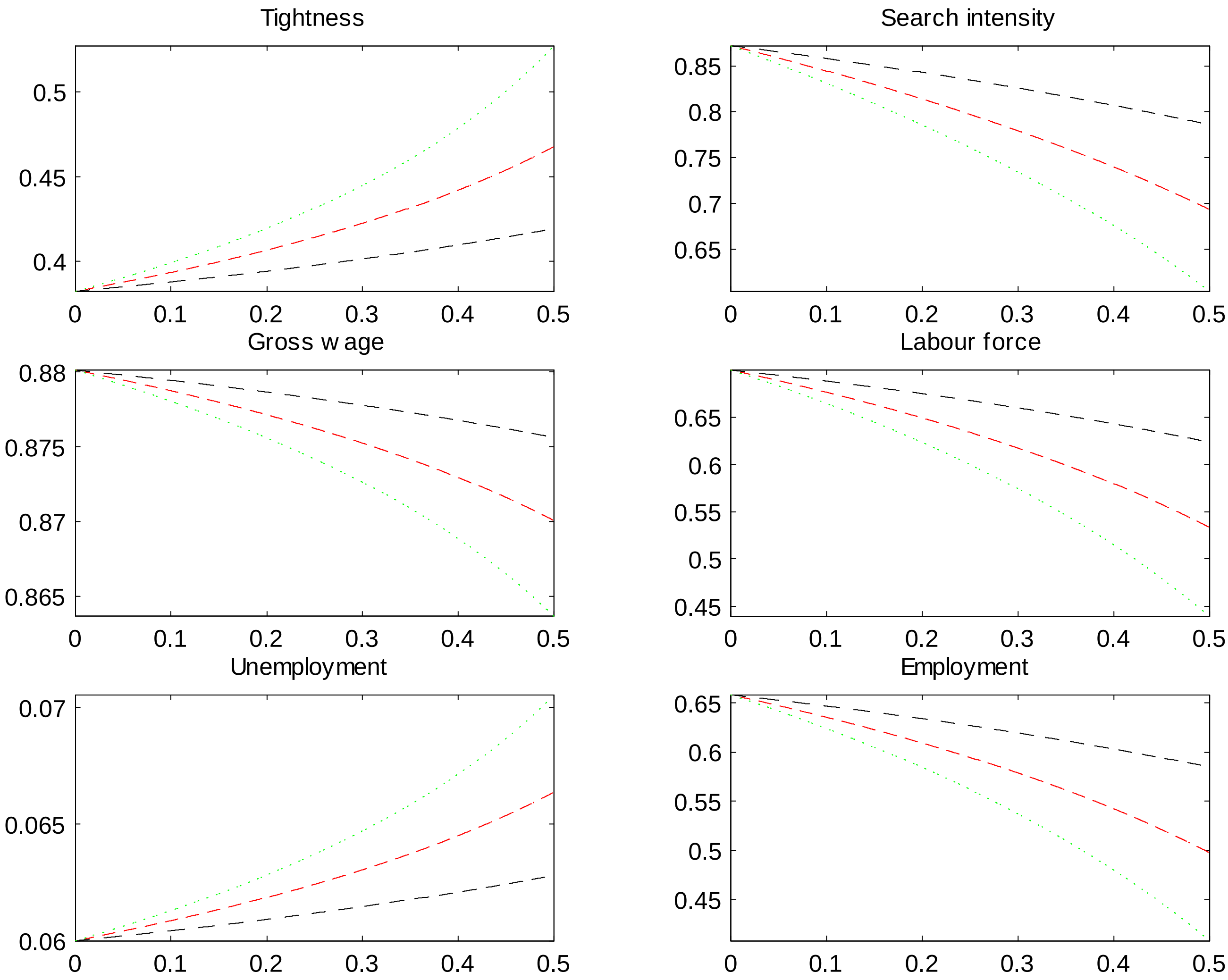


Figure 4.5: Partial financing - All workers (variables as a function of IWB - dashed: ρ=0.25, dashdot: ρ=0.5, dotted: ρ=0.75, solid: full financing)

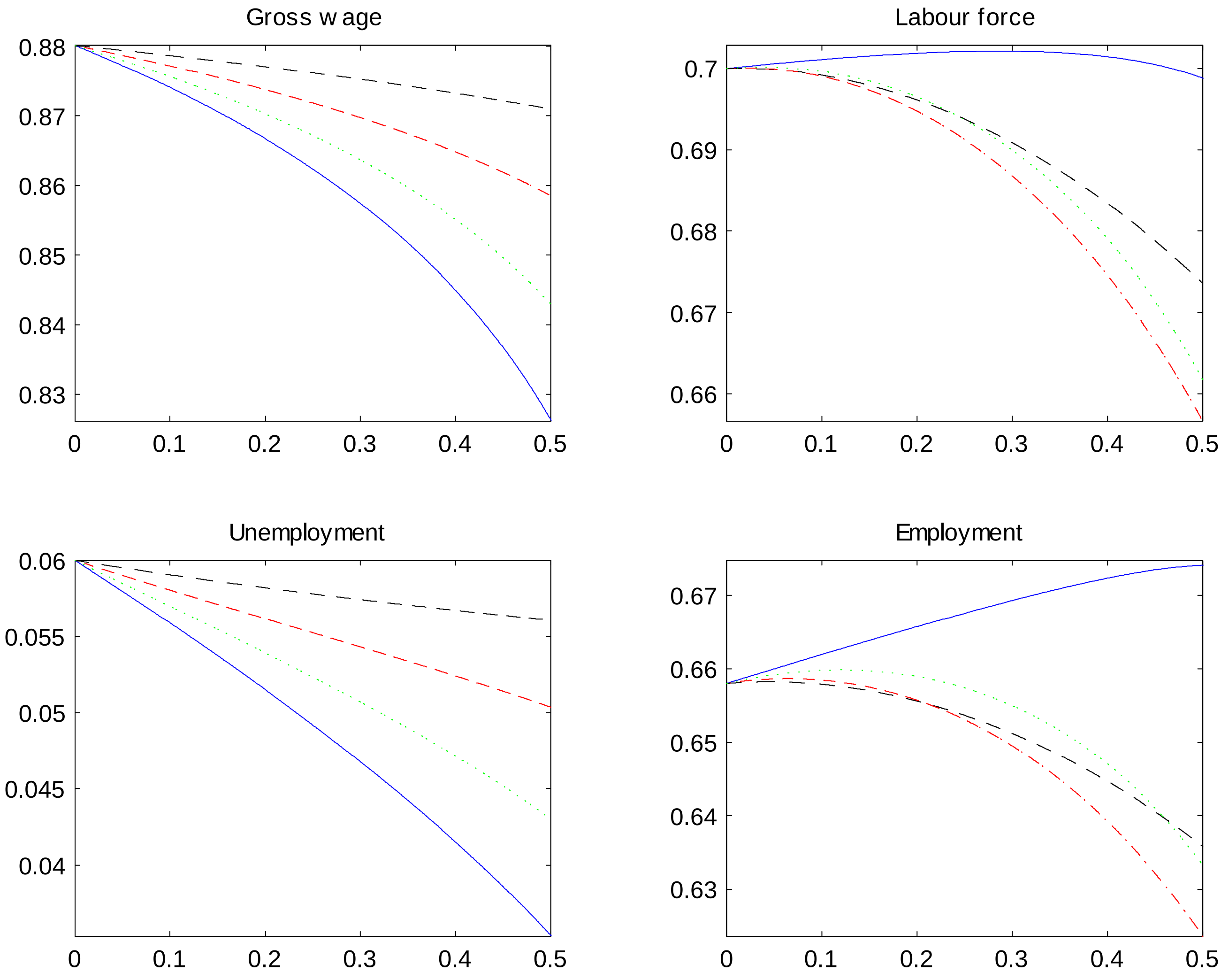


Table 4.1: Main labour market variables

		t	θ	s	w	LF	u	e
IWB=0			0.382	0.872	0.880	70.0%	6.00%	65.8%
IWB=0.2								
	no financing		0.427	0.974	0.875	77.8%	5.07%	73.8%
	full financing	23.1%	0.498	0.874	0.867	70.2%	5.15%	66.6%
IWB=0.4								
	no financing		0.468	1.068	0.870	83.6%	4.41%	79.9%
	full financing	47.3%	0.727	0.874	0.845	70.1%	4.15%	67.2%
		Partial financing - $y_n = 1$						
IWB=0.2								
	eligible		0.443	0.948	0.873	75.9%	5.10%	72.0%
$\rho = 0.25$	non-eligible	6.3%	0.394	0.843	0.879	67.5%	6.09%	63.4%
	all		–	–	0.877	69.6%	5.82%	65.6%
	eligible		0.461	0.922	0.871	74.0%	5.12%	70.2%
$\rho = 0.5$	non-eligible	12.3%	0.407	0.814	0.877	64.9%	6.19%	60.9%
	all		–	–	0.874	69.5%	5.62%	65.6%
	eligible		0.479	0.898	0.869	72.1%	5.14%	68.4%
$\rho = 0.75$	non-eligible	17.9%	0.419	0.785	0.876	62.4%	6.28%	58.4%
	all		–	–	0.870	69.7%	5.39%	65.9%
IWB=0.4								
	eligible		0.515	1.015	0.865	80.4%	4.38%	76.9%
$\rho = 0.25$	non-eligible	13.7%	0.410	0.807	0.877	64.3%	6.21%	60.3%
	all		–	–	0.873	68.3%	5.67%	64.5%
	eligible		0.575	0.963	0.859	76.9%	4.33%	73.6%
$\rho = 0.5$	non-eligible	26.6%	0.442	0.740	0.873	58.0%	6.45%	54.2%
	all		–	–	0.865	67.5%	5.24%	63.9%
	eligible		0.648	0.914	0.852	73.4%	4.25%	70.3%
$\rho = 0.75$	non-eligible	38.1%	0.479	0.676	0.869	51.5%	6.71%	48.0%
	all		–	–	0.855	67.9%	4.72%	64.7%

a. y_e= 1, y_n= 1.

Table 4.2: Main labour market variables - Partial financing - High productivity

		t	θ	s	w	LF	u	e
IWB=0								
	eligible		0.382	0.872	0.880	70.0%	6.00%	65.8%
	non-eligible		0.575	1.311	1.859	93.4%	3.22%	90.4%
$\rho = 0.25$	all				1.668	87.6%	3.77%	84.3%
$\rho = 0.5$	all				1.447	81.7%	4.41%	78.1%
$\rho = 0.75$	all				1.188	75.9%	5.14%	72.0%
IWB=0.2								
	eligible		0.434	0.964	0.874	77.0%	5.08%	73.1%
$\rho = 0.25$	non-eligible	2.6%	0.582	1.293	1.858	92.9%	3.24%	89.9%
	all		-	-	1.648	88.9%	3.64%	85.7%
	eligible		0.444	0.948	0.873	75.9%	5.10%	72.0%
$\rho = 0.5$	non-eligible	6.3%	0.593	1.267	1.857	92.1%	3.26%	89.1%
	all		-	-	1.417	84.0%	4.09%	80.6%
	eligible		0.461	0.923	0.871	74.0%	5.12%	70.2%
$\rho = 0.75$	non-eligible	12.2%	0.612	1.226	1.855	90.7%	3.31%	87.7%
	all		-	-	1.160	78.2%	4.59%	74.6%
IWB=0.4								
	eligible		0.486	1.046	0.868	82.3%	4.40%	78.7%
$\rho = 0.25$	non-eligible	5.6%	0.591	1.273	1.857	92.3%	3.26%	89.3%
	all		-	-	1.633	89.8%	3.52%	86.7%
	eligible		0.515	1.016	0.865	80.5%	4.38%	77.0%
$\rho = 0.5$	non-eligible	13.5%	0.616	1.216	1.855	90.4%	3.32%	87.4%
	all		-	-	1.391	85.4%	3.82%	82.2%
	eligible		0.570	0.966	0.859	77.2%	4.33%	73.9%
$\rho = 0.75$	non-eligible	25.7%	0.663	1.124	1.851	86.5%	3.43%	83.5%
	all		-	-	1.131	79.5%	4.09%	76.3%

a. $y_e = 1$, $y_n = 2$.