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ABSTRACT

Unreported Labour*

Unreported labour by one worker in a firm increases the probability of detection for his fellow workers, not only for himself. The firm takes this external effect into account. As a consequence, unreported work becomes rationed by the firms demand, rather than determined by demand equal supply. The gap between supply and demand increases with firm size. An empirical analysis on survey data supports theses theoretical predictions. Using a bivariate probit model, we find evidence of excess supply of unreported work in firms. We also find that the gap between supply and demand increases with firm size.

JEL Classification: H26, J20, J22, J23, J24

Keywords: tax evasion, hidden labour market

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1. Introduction

The most common opportunity for tax evasion is unreported work. A puzzle in the tax evasion literature is why this opportunity is used so little. People evade less tax than the standard framework for optimal tax evasion predicts. For example, Feinstein (1998) claims that the standard model, pioneered by Allingham and Sandmo (1972), is “theoretically appealing, but … unable to explain real-world reporting behaviour. In particular, it greatly overpredicts the amount of cheating”. The reason is that the expected penalties for tax evasion are so low that the taxpayers would like to evade more than they actually do. Most explanations of the puzzle focus on factors, such as social norms, that are not included in the standard model. We suggest that the explanation is not that the standard model overvalues what individuals want to evade, but rather that the individuals cannot evade as much as they want. Our claim is that tax evasion is rationed by the firms’ demand for unreported work, and we defend this claim both theoretically and empirically below.

In this paper we first demonstrate how unreported work in will be rationed by the firms’ demand, rather than determined by demand equal supply. Why do firms ration unreported work? The evidence that leak to the tax agencies often reveal all unreported work in the firm, not only that of an individual worker. As a consequence, the unreported work of one employee affects the probability of being detected and penalized for all tax evaders in the firm, not only himself. [2] While an individual has no incentive to take this external effect into account, the firm has, since it pays at least a part of the expected penalties through higher wages. As a result, it may be optimal for the firm to limit unreported work. In addition, the firm wishes to reduce the number of workers who have evidence on the tax evasion in order to reduce the number of whistle blowers. This has the cost of limiting the competition to participate. In other words, the secret nature of a market for unreported work gives bargaining power to those who participate. We show how the combination of the

[2] *In most models of tax controls, such as Reingaum and Wilde (1985 and 1986) and Erard and Feinstein (1994), the control agency uses the reported income of the taxpayer to decide whether to audit him or not. Information on the firm where the individual is employed plays no role. Consequently, the individual’s probability of being detected and penalized depends only on his own evasion.*

external effect of unreported work and the bargaining power of those who do it, may lead to rationing of two types: First, there is an excess supply of workers who wants to do unreported work. Second, there is excess supply of unreported work hours among those who are offered unreported work.

Our model also predicts a negative correlation between firm size and the fraction of the employees that does unreported work. When the probability that the firm is audited depends on the amount of pre-audit evidence that leaks to the control agency, we show that the firms' demand for unreported work does not increase as they increase their employment. Consequently, the fraction of workers that do unreported work declines with firm size. This prediction is supported by the empirical analysis.

If unreported work in firms were limited to the cases where the firm was actively involved in the employees' tax evasion, it might be dismissed as a marginal phenomenon in many countries. However, our model also applies to cases where the firm is not directly involved, but controls the employees' gain from unreported work by accommodating it or not. Thus, an important part of unreported work in firms is the so-called "moonlighting", where the employees take unreported jobs after their regular workday is over. The firm may have an incentive to facilitate moonlighting for its employees to make its regular work more attractive, thereby lowering the gross wage necessary to attract employees. Thus, the firm can "demand" unreported work by allowing the workers to do it on the firm's premises and with the firm's equipment. A firm may also allow the worker to use its lists of clients, and to use the firm's name when they present themselves to clients. To maximize its gain from moonlighting, the firm takes into account that one worker's moonlighting affects the probability of being caught for all workers.

Starting with the pioneer studies by Allingham and Sandmo (1972) and Sandmo (1981), most theoretical studies of tax evasion focus on the individual taxpayer's supply of unreported work.[3] The effects of policy changes on unreported work are usually studied by their effect on supply, as in the survey by Andreoni, Erard and Feinstein (1998). Empirical studies of unreported labour based on survey data, such as

[3] Firm characteristics play a role in these models, but only through exogenous effects on parameters such as wage rates and the probability of detection.

Lacroix and Fortin (1992), Lemieux, Fortin and Frechette (1994) and Jørgensen, Ognedal and Strøm (2005), estimate unreported labor by estimating the supply. One implication of our framework is that studying the supply of unreported work may not give good predictions of the actual unreported work, since the actual unreported work may be rationed by demand. For example, an estimate of the supply of unreported labor may overstate the actual amount. Also, policy changes that reduce the supply of unreported work may not be as effective to reduce the actual amount.

The empirical part of this paper uses data from two surveys on unreported labor in Norway (1980 and 2003). The surveys include a question about the willingness to receive unreported income as well as a question about actually performed unreported work last year. We use a similar modeling strategy as Oosterbeek (1998), who analyses the market for firm-provided training. We use the question about willingness to receive unreported income as an indicator of supply, and the question about actual performance as an indicator of the market outcome. Both the willingness to receive unreported income and the actual performance of unreported work are analyzed in a bivariate probit-model, allowing for selection. The aim of the empirical part is to sort out which factors affect supply and which factors affect demand. We obtain estimates of the notional demand and supply equations, as well as of the rationing in the market for unreported labor.

The claim that unreported work is rationed is supported by the empirical analysis. The fraction of workers willing to take unreported income is much higher than the fraction that ends up doing it. This is not only true on average, but for all industries considered separately. While the willingness to do unreported work seems to be constant across firms and industries, the actual level of unreported work varies with firm size and industry.

The paper is organized as follows: In the next section we analyze the probability of being detected and penalized for unreported work in firms. We derive the expected penalty of an individual employee as a function of the number of workers that does unreported work and the amount of unreported income for each of these. In section 3 we develop a model of both supply and demand for unreported work in firms, and derive implications that are tested in section 4 through 6. Section 4 discusses the empirical strategy used to disentangle the supply and demand factors in the market for unreported labor. The data are presented in section 5 and the empirical results in section 6. Section 7 concludes the paper, and discusses some of its implications.

2. A model of detection and conviction

In this section, we discuss how the expected penalty of an employee depends on the amount of unreported labour in the firm. We assume that the control agency knows the expected level of unreported work in the firm, but needs to audit the firm to prove the evasion of each individual employee. However, auditing without any prior clue to how the unreported work is organized and hidden in the firm can be very costly. The control agencies therefore rely on pre-audit evidence on the firm; from whistle blowing and hearsay to information from accounts and tax reports. The amount of pre-audit evidence is stochastic and exogenous to the control agency. The pre-audit evidence lowers the cost of auditing to find proof. With a sufficient amount, the cost of an audit becomes low enough to make an audit worthwhile. The probability that the control agency gets sufficient evidence to audit is higher with more unreported work in the firm.

Let $F(x;u,m)$ be the cumulative distribution function for the amount of pre-audit evidence x that leaks to the control agency. m is the number of employees who do unreported work and u is the average unreported income among them. Both the number of employees who do unreported work and their average unreported income is potential sources of leakages to the control agency. Hence, we assume that both an increase in m and an increase in u shift the distribution function to the right, i.e. towards higher x-values. Formally, $F_u(x;u,m)<0$ and $F_m(x;u,m)<0$. Moreover, we assume that $F_{uu}(x;u,m)<0$, $F_{mm}(x;u,m)<0$ and $F_{um}(x;u,m)<0$.

The tax agency maximizes its net revenue from proving and penalizing evasion. The revenue per dollar they can prove is the penalty tax rate τ. The cost per dollar the agency proves is $c(x)$. As argued above, the unit cost of proving evasion is decreasing in the amount of pre-audit evidence, i.e. $c'(x)<0$. The revenue per dollar proven in an audit is $\tau - c(x)$. Since the revenue is independent of the amount proven, the agency will audit and prove the entire evasion if $\tau \geq c(x)$, and will not audit the firm if $\tau < c(x)$. Hence, the amount of evidence that triggers an audit is given by $\tau = c(\bar{x})$.[4]

The probability of an audit is the probability that the amount of pre-audit evidence that leak to the control agency is above $\bar{x}$, i.e.

$$1 - F\left(\bar{x}; u, m\right) \equiv Q(u,m) \tag{1}$$

Since $F\left(\bar{x}; u, m\right)$ is decreasing in *u* and *m*, the audit probability Q is increasing in *u* and *m*. Moreover, $Q_{uu}(u,m) > 0$, $Q_{mm}(u,m) > 0$ and $Q_{um}(u,m) > 0$. Since the leakage of pre-audit evidence is stochastic, the probability of an audit is also stochastic. Consequently, firms with a lot of unreported work may escape being audited while firms with only a little unreported work are audited.

If the firm is audited, all unreported income is revealed, and each employee *i* is charged a penalty tax τu_i. Hence, the expected penalty of an employee is $Q(u,m)\tau u_i$, where $u = \frac{1}{m}\sum_{j=1}^{m} u_j$. His expected penalty is increasing in his own evasion u_i, but also in the number of workers who do unreported work (*m*) and their average evasion (*u*). It follows that if worker *i* increases his unreported income, this raises the expected penalty for all his fellow workers, since the average unreported income *u* goes up, and thereby also the probability of an audit.

In our model, only the employees are held liable and penalized for their tax evasion. In reality, the firm may also be held liable and penalized. To what extent, depends on how involved the firm has been and how much it has gained. Although it may be interesting to study the effect of how penalties are shared, it distracts from the main

[4] Our cost structure is extremely simplified and several variables that may have an effect on the cost of revealing and proving evasion are not included: For example, we have not taken into account that the unit cost c may be affected by the fraction of workers who participate in evasion or by evasion per worker. Although including these variables may make the formulation more realistic, it makes the exposition more complicated, without adding insight or changing the main results.

problem we want to discuss. We therefore focus on the case where the workers pay the entire penalty.

3. Demand and supply of unreported work in firms

First, we derive the firm's demand for unreported work. The firm's incentive to let some of its workers do unreported work is that they may be willing to accept a lower gross wage. The lower gross wage implies that the firm gets a share of the gain from tax evasion. We assume that only the employees are penalized if their tax evasion is revealed. The firm's demand for unreported labour is determined by what minimizes the firm's total wage expenses. Second, we demonstrate that the individual's supply of unreported labour will be higher than the firm's demand.

The firm determines the number of workers m that is allowed to do unreported work, hereafter called the evaders. The firm's total employment is n. The n-m non-evaders report all their income from the firm.[5] The number of work hours is fixed and the same for all employees. After the m evaders are selected, they negotiate with the firm over their wage y and the fraction of their income λ that is not reported for taxation.[6] The remaining n-m workers are offered the market wage y_0. Workers are risk neutral and indifferent between reported and unreported work, as long as the expected net wage rate is the same.

We analyse the two-step problem of (i) choosing m evaders and then (ii) negotiating y and λ with the evaders, by backward induction: First, we derive the wage y and the unreported fraction λ from the negotiations between the evaders and the firm, for a given the number of evaders. Second, we derive the optimal number of evaders, m.

With gross income y and tax rate t, a worker's expected net income when a fraction λ of his income is not reported for taxation is

[5] As discussed above, the firm's demand for unreported work may be moonlighting that is facilitated by the firm. In this case, the firm facilitates moonlighting for the m selected workers only. The remaining n-m workers may do unreported work on their own, but since the firm does not facilitate this, it does not affect their gross wages.
[6] Normalizing the fixed number of work hours to one, y is also the gross income.

$$V = (1-t)(1-\lambda)y + \left[1 - Q(\lambda y, m)\tau\right]\lambda y \tag{2}$$

Using that $\lambda y = u$, *V* can be written as

$$V = (1-t)y + u(t - Q(u,m)\tau) \tag{2)′}$$

If the negotiations break down, the parties resort to the “white” wage contract: the worker is paid the market wage y_0, reports the entire income and receives the net income $(1-t)y_0$. The Nash bargaining solution is then given by the values of *y* and *u* that maximizes the following product

$$\left[y_0 - y\right]^{\beta}\left[(1-t)y + \left(t - Q(u,m)\tau\right)u - (1-t)y_0\right]^{1-\beta} \tag{3}$$

This gives us the two first order conditions

$$t = Q(u^*, m^*)\tau - u^* Q_u(u^*, m^*)\tau \tag{4}$$

$$y^* = y_0 - \beta \frac{u^*\left(t - Q(u^*, m^*)\tau\right)}{1-t} \tag{5}$$

The total wage expenses of the firm can now be written as

$$Y = ny_0 - \beta m u^*\left(t - Q(u^*, m)\tau\right) \tag{6}$$

Minimizing *Y* with respect to *m* gives us the optimal number of tax evaders. The first order condition for minimum of *Y* is

$$t = Q(u^*, m^*)\tau + m^* Q_m(u^*, m^*)\tau \tag{7}$$

Since $Q_{uu}(u,m) > 0$ and $Q_{mm}(u,m) > 0$ the second order conditions are satisfied.

The two first order conditions (5) and (7) determines the values of *u* and *m* that maximizes the total gain from tax evasion, $um\left(t - Q(u,m)\tau\right)$. The total gain is maximized when the marginal gain from tax evasion, by increasing *u* and by increasing *m*, equals the marginal cost. The marginal gain is the tax rate *t*. The marginal cost is the increase in expected penalties, given by the two terms on the right hand side of (5) and (7). The first term ($Q\tau$) is the increase in the penalty tax as *u* or *m* is increased. The second term is the increase in the expected penalty from the increased probability of and audit when *u* and *m* goes up.

Equation (6) says that the negotiated gross wage equals the market wage y_0 minus the firm's part of the total gain from tax evasion. Since β measures the firm's bargaining power, it follows from (6) that the negotiated wage *y* is lower the higher the firms' bargaining power. If the worker has all the bargaining power ($\beta = 0$), the negotiated wage equals the market wage y_0, which is also the wage for non-evaders. In this case, the *m* evaders capture the entire gain from tax evasion. If the firm has all the bargaining power ($\beta = 1$), the negotiated wage *y* is such that an evader's expected net income equals his reservation income $(1-t)y_0$, which is the same as the net income of a non-evader. In this case, the workers are indifferent between being an evader or not. For $\beta < 1$, the expected net income of an evader is higher than the net income of a non-evader. Since the workers are identical, this implies that unreported work is rationed in the firm in the sense that the *n-m* non-evaders strictly prefer the contract of the evaders. Proposition 1 sum up the result.

Proposition 1. Excess supply of evaders:
When the employer controls tax evasion in the firm, the fraction of employees who are willing to take unreported income is higher than the fraction of employees who actually do it.

When the evaders have some bargaining power, the negotiated expected net income for an evader will be above the net income of a non-evader. At the same time there is excess supply of workers who want to be among the evaders at the negotiated contract (y,λ). The reason for this paradoxical outcome is that contracts about unreported work must be kept secret, or at least they are not publicly admitted, since tax evasion is illegal. When the information about the contracts cannot be verified, a difference between supply and demand does not necessarily lead to changes in the wage. Even if the non-evaders know that the evaders' expected net income is above their own net income; they are not able to compete for a contract by bidding down wages with evasion since the firm may not even admit to have such contracts.

In addition to the excess supply workers who wants to do unreported work, we can show that each of the *m* evaders prefer more unreported work than the firm allows him:

Proposition 2. Excess supply of unreported work hours among the evaders:
If the employer controls unreported work in the firm, the supply of unreported work for each of the m evaders exceeds the employer's demand for such work. At the negotiated wage, each worker would like to report a lower fraction of his income than the firm allows him to.

Proof:
Assume that y, u and m take the optimum values given by (4), (5) and (7), but that we give the individual worker the opportunity to choose what fraction λ_i of his income he wants to leave unreported. The worker's net expected income should then be written as

$$V_i = (1-t)(1-\lambda_i)y + \left[1 - Q\left(\frac{1}{m}\sum_{j=1}^{m}\lambda_j y, m\right)\tau\right]\lambda_i y \tag{8}$$

Differentiating V with respect to λ_i, and evaluating $dV_i/d\lambda_i$ at the optimum gives us

$$\frac{dV_i}{d\lambda_i} = y\left[t - Q(u^*, m^*)\tau - \frac{1}{m^*}u^* Q_u(u^*, m^*)\tau\right] \tag{9}$$

where $u = \frac{1}{m}\sum_{j=1}^{m} y\lambda_j = \frac{1}{m}\sum_{j=1}^{m} u_j$. From the first order condition (5), we know that $t - Q(u^*, m^*)\tau = u^* Q_u(u^*, m^*)\tau$. By inserting this into (9) and rearranging , *dV/dλ*$_i$ can be written as

$$\frac{dV}{d\lambda_i} = \frac{m^* - 1}{m^*} u^* Q(u^*, m^*) > 0 \qquad (9)'$$

Hence, the worker prefers to take more of his income unreported than the employer wants him to at the negotiated contract.

It follows from (9)´ that the difference between the worker's and the firm's marginal gain from evasion is the effect on the audit probability for the *m-1* other evaders. The explanation for why an evader would prefer to leave more of his income unreported than the employer wants him to is the following: When a worker increases his fraction of unreported work he increases the probability of an audit, and thereby the expected penalty, for all workers in the firm. However, he only takes into account the effect on his own expected penalty, which is *1/m* of the total effect. He ignores the effect of an increased expected penalty on the other workers, which is the term $\frac{m^* - 1}{m^*} u^* Q_u(u^*, m^*)\tau$ in Equation (9)´. This external effect is internalised by the firm, since the firm minimizes its wage payment by maximizing the expected sum of net gains from tax evasion. Consequently, the individual worker is not allowed to work as much unreported as he would like to.

If the individual employees were allowed to choose the fraction of unreported income, each of them would choose a higher fraction than the firm prefers. As a consequence, the expected penalty from tax evasion would be higher and the total gain from tax evasion lower than when the firm controls the evasion. No matter how the gain from tax evasion is shared between workers and firm, the evaders as a group benefit from the firm's control of the amount evaded.

Separate wages for reported and unreported work

One might think that the difference between supply and demand would be eliminated if the negotiations allowed for different wages for reported and unreported income. This is not necessarily the case. Let y_r be the wage rate for the reported work and $y_u = (1-\theta)y_r$ the wage rate for unreported work. Hence, $r \equiv (1-\lambda)y_r$ and $u \equiv \lambda y_u = \lambda(1-\theta)y_r$. The employers wage payment for each of the *m* evaders is then $r+u$, and the worker's expected net income is

$$V = (1-t)r + \left[1 - Q\left(u,m\right)\tau\right]u$$

Consequently, negotiations over y_r,y_u and λ are equivalent to negotiations over *r* and *u*. The Nash bargaining solution to the negotiations over *r* and *u* is given by

$$t - Q(u,m)\tau - uQ_u(u,m)\tau = 0 \tag{10}$$

$$(1-t)r + \left[1 - Q\tau\right]u - u(1-\beta)(t - Q\tau) - (1-t)W_0 = 0 \tag{11}$$

The two first order conditions (10) and (11) determines r^* and u^*. The optimal number of evaders is still given by (7). Since Equation (10) is identical to Equation (5), u^* and m^* does not depend on whether or not there are different wages for reported and unreported work. It is easily confirmed that there are many combinations of y_r and y_u that satisfies (10) and (11) as long as $r^* = (1-\lambda)y_r$ and $u^* = \lambda y_u$ holds. One of these combinations of y_r and y_u makes the demand for unreported work equal supply. However, neither the firm nor the worker has any incentive to choose this combination over the other, since this does not matter for their net incomes.

This combination of y_r and y_u that makes demand of unreported work equal supply can be derived as follows: The expected net income of a worker *i* when a fraction λ_i of his income is unreported for taxation is

$$V = (1-t)(1-\lambda_i)y_r + \left[1 - Q\left(\frac{1}{m}\sum_{j=1}^{m}\lambda_j y_u, m\right)\tau\right]\lambda_i y_u \tag{12}$$

Maximizing V_i with respect to λ_i, inserting $y_u = y_r(1-\theta)$ and rearranging gives us the first order condition

$$\left[t - Q(u,m)\tau - \frac{1}{m} u Q_u(u,m)\tau \right] - (1-t)\frac{\theta}{1-\theta} = 0 \qquad (13)$$

The higher $1-\theta$ is, i.e. the higher y_u / y_r is, the higher is the income u that the worker wants to leave unreported. Hence, (13) gives us the individual supply of unreported work as a decreasing function of $1-\theta$. It follows from (5) that the employer's demand for unreported work, measured by u^*, is independent of θ. Equation (5) can be rewritten as

$$t - Q(u^*,m^*)\tau - \frac{1}{m^*} u^* Q_u(u^*,m^*)\tau - \frac{m^*-1}{m^*} u^* Q_u(u^*,m^*)\tau = 0 \qquad (14)$$

Comparing (13) and (14), we find that the value of θ that makes demand equal supply for unreported work equals

$$\theta^* = \frac{\frac{m^*-1}{m^*} u^* Q^*_u \tau}{\left[1 - Q^*\tau - \frac{1}{m^*} u^* Q^*_u \tau \right]} \qquad (15)$$

Even when the value of θ is such that the supply of unreported work equals demand, unreported work is rationed in the following sense: If the worker could leave one more dollar unreported without involving the employer, he would benefit. His gain from keeping one more dollar unreported if he did not involve the employer equals the gain from increasing λ_i when $y_r = y_u = y$, i.e. when $\theta = 0$. As shown above, the supply of unreported work exceeds demand in this case.

Tax evasion and firm size

It follows from (5) and (7) that the optimal values of both u and m do not depend on the employment level n. Consequently, as n is increased, the fraction of evaders (m/n) goes down. Since total unreported income mu is unchanged, the unreported income as a fraction of total wage payments goes down. To sum up:

Proposition 3. Unreported work and firm size:

The fraction of workers who has unreported income is decreasing in the number of workers in the firm. The number of evaders and the unreported income per evader is unchanged.

One implication of Proposition 3 is that if a productivity increase makes it optimal to increase the employment, it also makes it optimal to decrease the fraction that is involved in tax evasion. Hence, we would expect a negative relation between firm productivity and unreported work.

4. Empirical strategy

In our sample 16 percent of the respondents say that they have actually performed unreported work during the last 12 months. At the same time 65 percent of the respondents report that they are willing to take unreported income[7]. This observation indicates rationing in the market for unreported work. In figure 1a) we show that actual performance of unreported work varies with the size of the firm where the worker has his regular employment. The percentage of workers who are willing to receive unreported income, however, does not appear to vary systematically with firm size. Figure 1a) thus gives a clear impression of an increasing level of rationing with firm size. In figure 1b) we show the same figures by industry. We find that actual performance varies considerably more by industry than willingness do. Industries with low levels of unreported work (education and health) have less than one quarter of the level of actual performance than in the construction industry, where the level of unreported work is high. However, the level of willingness in education and health is about three quarters of the level of willingness in construction. Hence, the impression

[7] See details about the data and definitions below.

is that unreported work in low-level industries is low because of industry characteristics, not because of low willingness to supply unreported labour.

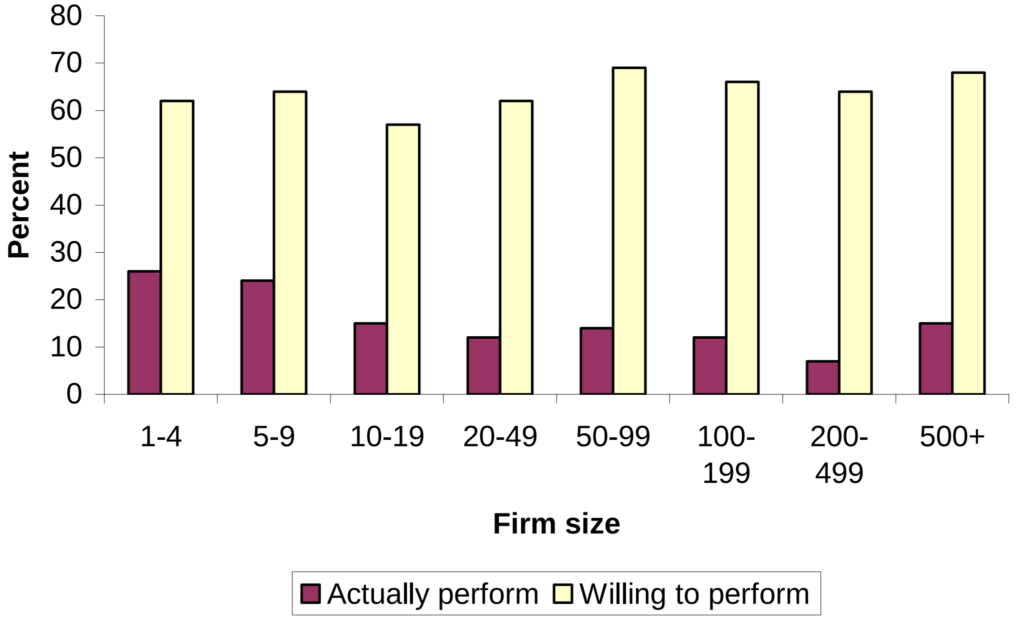

Figure 1a: The percentage that actually performed unreported work and the percentage that was willing to in firms of different size.

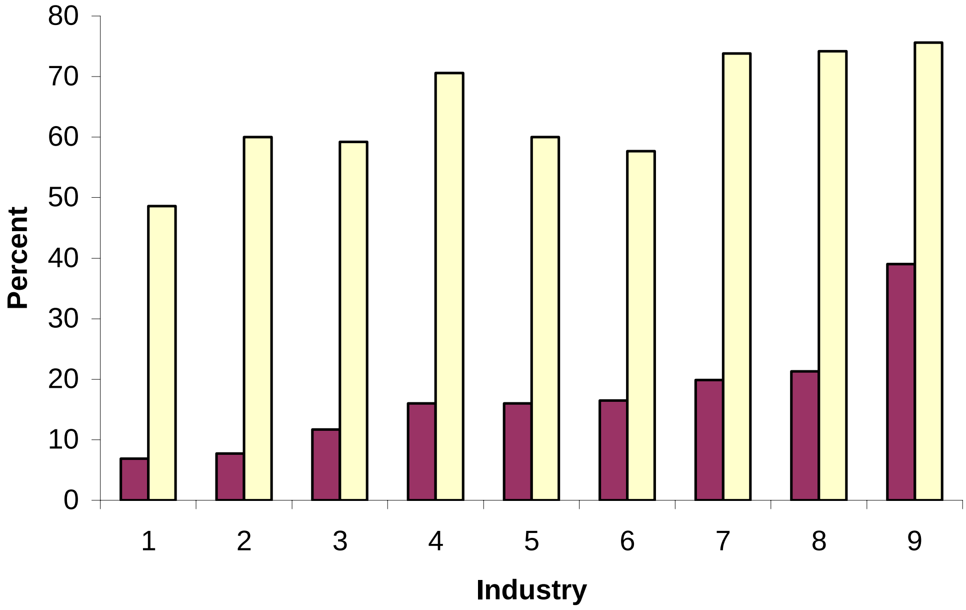

Figure 1b: The percentage that actually performed unreported work and the percentage that was willing to in different industries.

Of course these raw averages may be influenced by other characteristics of the respondents, or by the environment they operate in, and the two dimensions illustrated in figure 1 may interact in different ways. We thus need to know if these stylised facts survive careful scrutiny in a multivariate framework, including several other important controls, such as education, norms, gender and beliefs about the probability of being found out.

In our data we have observations of individuals and their tax evasion behaviour. We do not observe firms directly, but use variables related to the employment relation of workers as firm specific indicators. As in most empirical studies in economics, we do not observe supply and demand, but observe market outcomes only. Furthermore we need to deal with issues of rationing and selection in our empirical framework, since our model is not a market clearing one. We thus start out by presenting a simple index model of *latent* supply and demand, and then go on to explain how they are related to the observations in our data.

An index model of supply and demand

Consider the following simple index model of demand and supply for a single worker's unregistered work. Worker i's *latent supply* of unreported work is given by:

$$y_s* = \alpha + x_s\beta + u_s \tag{10}$$

where subscript *i* is suppressed for convenience. The vector x_s includes factors that affect the supply of unreported labour. This vector includes factors like the perceived probability of being caught, the punishment for tax evasion, norms and so on. The index function is normalized such that the worker is willing to supply unreported work if $y_s^* > 0$ and unwilling to supply this kind of work if $y_s^* < 0$.

The novel feature of our paper is to introduce the demand side of the market. Consider the firm's *latent demand* for unreported labour from worker *i*:

$$y_d* = a + x_d b + u_d \tag{11}$$

where the x vector now include factors that influence the agreed wage, like the probability that the firm is caught and the expected punishment. We use industry indicators as proxies for differences in technology and organisational design affecting the net benefits of using unreported labour. According to Proposition 3, the fraction of workers that does unreported work is negatively related to firm size. The demand equation should therefore include firm size. The firm demands unregistered labour from worker i, if $y_d^* > 0$ and do not demand unreported labour if $y_d^* < 0$.

We assume that $E(u_i|x) = 0$ and $Var(u_i) = 1$ for $i= d, s$ and that $Cov(u_d, u_s) = \rho$. This means that we allow for a correlation between the error terms in the two equations. Correlation may arise from several factors. For instance, we do not observe the implicit wage for unreported work that would have been realised if the parties had reached an agreement. Stochastic components of this implicit wage would enter positively into the supply equation and negatively into the demand equation. On the other hand, if "willing" individuals are selected into occupations in which the demand for unreported work is higher than in other occupations, there will be a positive component in both error terms, and a positive correlation occurs. The sign of the correlation is thus entirely an empirical question and of course also dependent on what factors are included in the observed x-vectors.

Disentangling demand and supply factors

We estimate the latent demand and supply indexes using the following two questions from the surveys[8]:

"If possible, would you be willing to take income without reporting it to the tax authorities" Willing = [Y, N]

"Have you, during the last 12 months, performed work where the income is not (or will not be) reported to the tax authorities?" Unreported Work = [Y,N]

We use the first question to estimate the parameters of the supply index and the second question to estimate the parameters of the demand equation. Since there are

[8] See the below data description.

four possible combinations of the two observed variables, there are four possible outcomes of the two latent variables. The relationship between the latent variables and the observations may be classified as follows:

1. $y_s^* > 0$ and $y_d^* > 0$. Both parties find unreported work worthwhile. We find W = Y and UW = Y. Unreported work occur.
2. $y_s^* > 0$ and $y_d^* < 0$. The worker is willing to do unreported work, but the firm does not demand unreported work. W = Y but since unreported work does not occur UW = N.
3. $y_s^* < 0$ and $y_d^* > 0$. The firm is willing, but the worker is not. We find W = N but again UW = N since unreported work does not occur.
4. $y_s^* < 0$ and $y_d^* < 0$. Neither party finds unreported work worthwhile. We find W = N and UW = N. Unreported work does not occur.

Obviously, our data is censored, since we cannot observe the demand when the worker is unwilling to supply unreported labour. Our modelling strategy[9] is to use the contrast between situations 1 and 2 to estimate the demand function, and to use the contrast between situations 1, 2 and 3, 4 to estimate the supply function. Since the data is censored, we use a bivariate probit model with censoring to estimate the demand function. In our data, we may distinguish between three situations: [1] $y_s > 0$ & $y_d > 0$, [2] $y_s > 0$ & $y_d < 0$ and [3] $y_s < 0$. The log likelihood function thus takes the following form:

$$\text{Log L}= \sum_{i:[1]} \log \Phi_2 (x_s\beta, x_d b, \rho) + \sum_{i:[2]} \log \Phi_2 (x_s\beta, -x_d b, -\rho) + \sum_{i:[3]} \log \Phi (-x_s\beta) \qquad (12)$$

Where the numbers in [ ] refer to situations 1-3, Φ_2 is the distribution function of the bivariate normal and Φ is the distribution function of the univariate normal distribution[10].

Identification

[9] See Osterbeeck (1998) who uses a similar modelling strategy to analyse the market for firm-provided training.
[10] We use the “heckprob” procedure in stata v. 8.0 to estimate the model.

Since we also want to estimate the correlation coefficient between the two equations, we need some exclusion restrictions. We use four variables reflecting individual norms[11] as well as the individual's reported marginal tax rate in the supply equation only. This means that our model is not identified by functional form only, and we are furthermore able to identify the correlation coefficient between the error terms of the two equations. If the correlation coefficient is not significantly different from zero, the most efficient procedure is to estimate the model by separate probit analyses, the parameters of the supply equation on the full sample and the parameters of the demand equation on the sample of willing workers.

Inference on the censored observations

Both sides of the market may be constrained. Workers who are willing to do unreported work may not face willing firms, and firms who demand unreported work may not face willing workers. This is a likely result of a thin market where information flow may be hampered by the illegal nature of the potential transactions. Using the results from our estimated demand and supply functions, we may draw some inferences on the possible behaviour also of the censored observations. Below we calculate the predicted demand probabilities for the individuals that are not willing to supply unreported labour. The estimated probabilities provide us with a measure of the constraints also at the censored side of the market. As shown in Proposition 2, we expect workers to be more likely to be constrained than firms.

5. Data

The data are from two representative Norwegian surveys of individuals from 1980 and 2003, labelled the Survey of the Hidden Labour Market (SHLM). The focus in both surveys is on unreported or "black-market" work. Since our theoretical model is focused on firm's behaviour, it is unfortunate that we only have data from surveys on individuals. However, for individuals employed in regular employment, we have some information on the firm in which they work, since we know firm size (the number of employees) as well as industry affiliation[12] of their regular job. We thus

[11] The questions reflect attitudes towards the financing of the welfare state as well as towards income inequality. See the data section for details.

[12] The following industry classification is used: Construction, Manufacturing, Trade, Transport, Education, Health, Public adm., Finance, Other Services and Other industries.

limit the samples to individuals with regular employment. We have 1104 observations altogether of employed individuals between the ages of 20 and 65 with non-missing values on the covariates used in the models.

In the surveys, individuals are asked about standard human capital variables in addition to some questions on norms, the perceived risk of not reporting income, tax-rates as well as on the willingness to take unreported income and about actual unreported work the last 12 months, as described above. With respect to the willingness to take unreported income, there is a problem of comparison between the two surveys, since "do not know" was an option in 2003 and not in 1980. In the empirical analysis, we allocated the "don't know"-group in 2003 randomly[13] to willing/unwilling to increase comparability. We also have information about their pay in their regular job. Table A1 in the appendix reports some summary statistics of the variables used in the analyses.

Measures of human capital and wages

In addition to the survey responses, we have calculated a measure of individual human capital. From a separate survey, the Level of Living Survey (LLS) in 1995, we have estimated a standard Mincer-wage-equation, augmented with a firm size variable as well as industry dummies. We then impute the variable: *Individual productivity component* from the observation of human capital variables in the SHLM. The human capital variables are (Mincer-) experience, experience square, gender and two dummies for education. We also report results from specifications where we use the underlying human capital variables instead of the imputed productivity components.

We have a measure of the wage rate in regular employment from the SHLM. Since this variable is likely to be highly endogenous, it is omitted in most specifications below. However, we do report results from specifications including this variable as

[13] 50/50 allocation is very close to the proportion in the 2003 sample that did reveal a preference (51/49). As a robustness check, we have run the all the models reported in Table 1 and 2 below, excluding the "don't know" category in 2003 from the analysis. The results below also holds when we use this limited sample, with the exception of some of the level comparisons between 2003 and 1980 which may obviously be affected. We retain the full sample in the analysis in order to make the comparison between the two years as good as possible. Results for the limited sample are available from the authors on request.

well, to show that our results regarding firm size is not simply a “wage effect” (see below).

Individual’s norms

In the supply equation, we use some measures of individuals’ norms towards tax-financing and income inequality as proxies for individual norms. In 1980 the respondents were asked if they agree that the present level of taxes is necessary to finance the welfare state and if it is understandable that people do unreported work. In 2003 the respondents were asked if they agree that income inequalities should be small and that income inequalities due to factors outside ones own control should be removed. These variables are included as dummy variables, taking the value of 0 in the year they were not asked. We also include a year dummy in the equation, which ensures that the coefficients get the correct interpretations. However, because of this design we do not report the coefficient for the year dummy in the tables, since it cannot be interpreted without considering the set of year specific norm-dummies. We report the p-value of the joint test of the norm-dummies in all equations where they are used.

In both years the respondents were asked what they believe is people’s general attitude towards unreported income was: “accepted” or “not accepted”. They were also asked about the probability of being detected if income was not reported to the tax authorities. Both of these indicators are used in the analysis below.

Table A1 report the average value of the key variables in sample. We also report average values for each of the years 1980 and 2003. We note that both the willingness to do unreported work and the actual performance of such work has decreased from 1980 to 2003. At the same time, the share of women has increased as well as the share of employees with higher education. In line with changes in the tax system, people also report a lower marginal tax in 2003 than in 1980. They also report a higher average score on the probability of being controlled. While the individual productivity component has increased over this period, the firm specific productivity component has not changed. This is also reflected in the relatively stable level of firm size.

6. Results

The first two columns of Table 1 report the results from probit regressions of *Unreported work* and *Willing.* The two models both include all variables and are estimated on the full sample. We should thus view these two models as preliminary reduced form equations. We find that firm size is significantly negatively related to doing unreported work, but not significantly related to being willing to take unreported income. This observation shows that there is no significant variation across the firm specific variables in the willingness to take unreported income, but there is significant variation in the probability of actually having done unreported work over the last 12 months. We take this as a strong indication that the demand side matters in the determination of the volume of trade in the market for unreported work.

We find that individual productivity affects the probability of both outcomes negatively. The same holds for being a woman. The perceived probability of being caught reduces the probability both of being willing and of actually performing unreported work, while the attitude that tax evasion is generally accepted increases the probability of both outcomes. The norms used in the supply equation affect the willingness significantly (chi square of 35 with 4 degrees of freedom), but do not show up as significant in the reduced form performance equation. The main result is that the joint effect of firm size and industry is highly significant in the unreported work regression and not significant at all in the willing-regression. The results from these two reduced form equations are broadly consistent with existing evidence on the probability of performing unregistered work in Norway (see e.g. Goldstein et al 2001 who use the same data from 1980 as we do in addition to another data set from 2001).

Sorting out demand versus supply factors

The next two models of Table 1 report results from the bivariate probit analysis with selection. The first two columns report the model specification where supply and demand equations differ only in that the set of norms (four variables, see the data section) is present only in the supply equation. We find that the impact of firm size on the demand equation is stronger than in the previous probit specification estimated on the full sample, an observation that is consistent with the observation that firm size does not have a significant effect in the supply equation.

It appears that the individual productivity component tends to reduce both supply and demand. We have kept both gender and the probability of being caught as well as the beliefs about other's attitudes towards tax evasion in both equations since they appear to have a significant impact on both. The interpretation of these variables in the supply equation is obvious. The interpretation of these variables in the demand equation is likely to be related to occupational factors and to the unobserved wage level for unreported work. The main conclusion is that industry dummies and firm size has a negative impact on demand, but does not appear to affect the supply of unreported work.

ρ measures the correlation between the error terms in the two regressions. Since ρ is not significantly different from zero, we do not spend too much effort discussing the underlying causes of this correlation. When there is no significant relationship between the error terms in the two equations, running separate probit equations, one (Willing) on the full sample and one (Unreported Work) on the truncated sample where willing=1, is more efficient. We thus return to such probit equations below. First, however, we present a more parsimonious model in the last two columns, mainly to check if our result with respect to the impact of industry dummies and firm size as well as the significance of ρ. We find support for all our above conclusions with a more parsimonious model as well, and thus go on to run separate probit equations.

Table 1.
Demand and Supply for Unreported Work.

	Reduced form		Demand	Supply	Demand	Supply
Dependent variable	Unreported work last 12 months	Willing to take unreported income	Unreported work last 12 months	Willing to take unreported income	Unreported work last 12 months	Willing to take unreported income
Sample	All		All		All	
Method	Probit		Bivariate probit with selection		Bivariate probit with selection	
Firm size (log)	-0.1203*	0.0317	-0.1417*	0.0313	-0.1458*	
	(0.0307)	(0.0248)	(0.0349)	(0.0249)	(0.0335)	
Individual productivity	-2.1575*	-2.1074*	-1.9822*	-2.1326*	-1.9833*	-2.1862*
	(0.5247)	(0.4170)	(0.6005)	(0.4170)	(0.6000)	(0.3674)
Woman	-0.9586*	-0.6440*	-0.8993*	-0.6494*	-0.9103*	-0.7333*
	(0.1634)	(0.1272)	(0.1801)	(0.1275)	(0.1843)	(0.1071)
Prob. of being caught	-0.0110*	-0.0130*	-0.0100*	-0.0131*	-0.0099*	-0.0131*
	(0.0026)	(0.0019)	(0.0033)	(0.0019)	(0.0034)	(0.0019)
Unreg. Work accepted	0.6782*	0.7338*	0.5830*	0.7355*	0.5814*	0.7416*
	(0.2201)	(0.1291)	(0.2883)	(0.1291)	(0.2862)	(0.1270)
Industry controls & firm size P-value	0.0000	0.4222	0.0000	0.4236	0.0000	
Year dummy	Yes	Yes	Yes	Yes	Yes	Yes
Norms Chisq (4)	4.01	34.95		35.15		33.55
p-value	0.4041	0.0000		0.0000		0.0000
ρ			0.3247		0.3113	
			(0.4340)		(0.4028)	
Pseudo R2	0.2122	0.1911				
No of censored obs.			393		393	
N	1107		1107		1107	

In Table 2 we first report results from a demand and supply equation estimated by separate probit analyses. The demand equation is estimated on the sample of willing respondents only. The results are very similar to those given in the bivariate probit model. We find a strong significant negative effect of firm size on the demand for unreported work. Furthermore we may reject a hypothesis of no joint effect of the industry and firm productivity variables. Employer characteristics matter for the probability of unreported work among those who are willing to do it. The supply equation confirms that individual productivity characteristics reduce the probability of being willing to take unreported income. Since the results for the other variables do not differ significantly from the results in Table 1, we do not report all the coefficients. The probability of being caught, the attitudes of acceptance as well as the norms all have significant influence on the willingness to take unreported income. The remaining six columns report some sensitivity tests.

What if the firm size effect is merely a wage effect, i.e. that the firm-size effect just reflects differences in individual wages? To check for this possibility, the next column gives the results from a specification where we include both the wage level in the individual's regular job and the marginal tax rate in the model. We find that the effect of firm size remains when we also control for the wage level and marginal tax. The equation performs only slightly better with these two variables included, and since the wage level is likely to be endogenous, we prefer the results from the equation without wages included. However, it seems clear that our results with respect to firm productivity characteristics are not driven by the wage level in the individual's regular employment.

In the next column, we interact firm size and individual productivity variables with a public sector dummy. Judging from the signs of the coefficients, both firm size and individual productivity matter less in the public than in the private sector. However, the differences between the sectors are small and statistically insignificant, and we thus resort to the first equation.

Table 2.

Demand and Supply for Unreported work
Separate probit and sensitivity analysis

	Demand	Supply			Demand Sensitivity tests			
Dependent variable	Unreported work last 12 months	Willing to take unreported income			Unreported work last 12 months			
Sample	Willing = 1	All			Willing=1			
							1980	2003
Firm Size (log)	-0.1470* (0.0334)		-0.1335* (0.0340)	-0.1553* (0.0374)	-0.1477* (0.0334)			
Firm size. Interact. w/ public sector				0.0362 (0.0843)				
Individual productivity	-1.7534* (0.5667)	-2.1555* (0.3654)	-1.5841* (0.6159)	-1.7600* (0.5712)		-1.8993* (0.5704)	-3.040* (0.9095)	-1.0141 (0.7674)
Individual prod Interact. w/ public sector				0.0443 (0.1251)				
Size group 2						-0.4852* (0.1697)	-0.7361* (0.2670)	-0.3774[z] (0.2324)
Size group 3						-0.5428* (0.1738)	-0.8172* (0.2578)	-0.3663* (0.2491)
Size group 4						-0.7456* (0.1549)	-1.0373* (0.1549)	-0.4935* (0.2202)
High School Education					-0.0566 (0.1503)			
College Education					-0.4027* (0.1832)			
Experience					-0.0155* (0.0050)			
Indust. & firm specific variables p-value	0.0000		0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
Norms p-value		0.0000						
Log hourly wage and marginal tax rate			Yes					
Pseudo R2	0.1508	0.1847	0.1588	0.1518	0.1551	0.1558	0.1861	0.1011
N	714	1107			714		361	347 361

Our individual productivity measure is calculated from a wage equation estimated on another survey. The individual productivity component includes experience, education and gender. In this section, we report results where we use firm size, experience and education directly in the demand equation, instead of the productivity components. In this way we allow for all the variables to have independent effects. We do this mainly to increase the transparency of our results as well as to show the robustness of the results to different specifications.

In the fifth column of Table 2 we report the coefficients for log Firm size and for the three human capital variables. We find that there is a significant negative effect of firm size on the probability of doing unreported work. Furthermore, both the human capital components of experience and college education reduce the probability of doing such work. The joint significance of firm size and industry dummies is strong.

In the next model we use a specification involving four different groups of firm size. We find that there is significantly more unreported work in the small firms, and significantly less in the group of the largest firms.

The last two columns report separate regressions for each year. We find smaller effects of all variables (and pseudo R square) in 2003 than in 1980, but significant effects of firm size remains in both years. Since we have fewer observations each year, and the number of persons actually doing unreported work in 2003 is quite small, the standard errors are large. We thus prefer the results from the pooled regressions.

An overview of the market for unreported labour

According to Proposition 1 and 2, workers are more likely to be constrained in the market for unreported work than firms. Consequently, the volume of unreported work is determined mainly from the demand side of the market. In Table 3 we report some statistics calculated from the data and from the outcome of the first model in Table 2 (the separate probit models for demand). First we find that workers are constrained to a large extent. Among those who are willing to take unreported income, only 25 percent actually performed unreported work last year (Column 1, share of willing). In other words: 75 percent of those willing do not actually perform unreported work. A measure of how much firms are rationed is given by the average probability of being demanded by workers who are not willing P(Demand|Willing=0)), which is estimated to only 14 percent. It seems fair to conclude that these results support our Propositions.

There has been a considerable drop in the probability of doing unreported work from 1980 to 2003. In 1980 23 percent of the employed population had done unreported work the last year. In 2003 this number had dropped to 11 percent. Our estimations also enable us to draw some inferences on what has actually happened over this period. We find that there has been a drop in the share of workers willing to take unreported income 72 percent in 1980 to 58 percent in 2003. This observation indicates a decline in the supply of unreported labour of 19 percent over this period.

Table 3. Shares and predicted probabilities of demand and supply. Percent by year.

	All	1980	2003
Willing to take home unreported income	64,5	72,3	58,3
Performing unreported work last year Share all/share of willing	16,2 / 25,1	23,0 / 31,8	11,0 / 18,9
P(Demand)	21,3	27,5	16,3
P(Demand|Willing=1)	25,2	31,5	19,1
P(Demand|Willing=0)	14,0	17,2	12,4

Note: the two first lines report the actual shares in the data. The P( ) rows report the average probabilities from models 1 and 2 from Table 2 (probit specifications). [Preliminary version, calculated on a slightly different model than the one in table 2]

The probit model allows us to calculate the probability of doing unreported work for the whole population of employed individuals. We find that the overall demand has dropped from 28 percent to 16, a decline of more than 40 percent. In the next row we report the estimated demand for the sub-sample of willing workers. These estimates of 25, 32 and 19 percent correspond to the figures we found in the second row for the realized percentage of unreported work, when calculated as a percentage of willing workers. The last row, however, reports the estimated demand for the group of workers who are unwilling to supply unreported work. The estimated demand for this group of workers thus represents unrealised demand in this market. Hence, the reduction in the size of the market for unreported work is due both to demand and supply factors, but our results indicate that demand has declined by more than supply.

Discussion of the results and some caveats

To sum up, we have found evidence of rationing in the market for unreported work. We have established that firm-specific factors, like firm size, have statistically significant and economically sizeable effects on the level of unreported work, even after careful control for a host of relevant factors. Furthermore, we have found that these firm-specific effects arise from the demand side, rather than the supply side of the market. These results are consistent with our theoretical propositions, but not consistent with the alternative view that there is no rationing.

Our results should be interpreted with caution, since the data cannot fully provide the information needed to test the propositions from the theoretical model. One problem is that we attempt to analyse both sides of the market based on information from workers only, and with only a few indicators of the firm in which he works. However, obtaining data on illegal activities from surveys at the firm level may be even more difficult than from surveys at the individual level. Another problem is the more general question of whether surveys provide reliable information. For example, one may suspect that people underreported illegal activities such as tax evasion. Our surveys are carefully designed to avoid some of the usual problems of surveys, and have proven to provide reasonable results when compared to other studies and other types of information on the size of the hidden economy, see Goldstein el al. (2002). Finally, objections may be raised against the use of the "willing" question as an appropriate measure of supply. While "actual performance" is related to specific jobs undertaken under specific conditions, "willing" is a hypothetical and unspecified question. Consequently, we may view willing as a measure of supply involving a measurement error. However, if only the level is systematically affected by the difference between the "true" notional supply and our measure, the results that arise from shifts in supply and demand are still valid. The only results that are less meaningful are the comparisons between the levels of supply and demand. For instance, 75 percent of those willing do not perform unreported work. If willing provides a more general measure of supply than actual performance, this percentage may overstate the level of rationing in the market. However, since firm specific variables do not affect willing, but do affect actual performance, we may still conclude that firm specific variables affect demand and not supply.

7. **Concluding remarks**

We have argued that unreported work in firms is rationed by the firm's demand, rather than determined by demand equal supply. The reason is that the unreported work of an individual employee affects the probability of being revealed for all evaders in the firm. While an employee has no incentive to take this external effect into account, the employer has, since he captures a share of the gain from the tax evasion of all his employees. As a result, the firm rations unreported work. The fraction of employees who are offered unreported work is lower the higher the firm's employment. As a consequence, the gap between supply and demand increases with firm size.

Empirical analysis on survey data from Norway supports the result that unreported work is rationed. We find that the fraction of employees who are willing to do unreported work is much higher than the fraction of employees who actually do it. Moreover, while actual unreported work varies significantly with firm size and industry, the willingness among employees does not. We also find that unreported work is negatively correlated with firm size.

A crucial assumption in our model is that the firm can control the unreported work among its employees, for example by facilitating it or not. The more the employees need help from the firm to benefit from unreported work, the stronger the firm's control. The degree of control will of course vary between firms and industries, and may explain part of the differences in their level of unreported work. For example, we expect less unreported work in capital intensive activities, where expensive equipment is needed, than in labour intensive industries. Typically, we find more unreported work among employees in construction than in manufacturing.

Our results may have important implications for policies to reduce tax evasion. For example, policies that aim at reducing the supply of unreported work may not be as effective in reducing the actual level, if unreported work is rationed by the firm's demand. Hence, even if campaigns to improve people's tax morale make people less willing to evade taxes, they may not reduce tax evasion. Another example is support of voluntary efforts in the firms to reduce tax evasion. A paradoxical implication of our model is that such efforts may benefit tax evaders in the firm. The excess supply of unreported work among the tax evaders is a free-rider problem. As a group, they loose if each of them is free to choose his optimal amount of unreported work because the firm's control is too weak. As a result, voluntary efforts by the employer and the employees to reduce unreported work in the firm may not be a sign of high tax morale, but rather an attempt to limit tax evasion to the level that maximizes the total gain from evasion.

Table A1. Sample Means

	All	1980	2003
Willing	0.65	0.72	0.58
Unregstered work	0.16	0,23	0,11
Year 1980	0.44	1	0
Woman	0.43	0.36	0.47
Prob. of control	36.81	33.15	39.70
Acceptance	0.87	0.84	0.89
Ind prod comp (log)	3.79	3.75	3.82
Experience	22.28	21.16	23.16
High School	0.30	0.22	0.44
College +	0.34	0.21	0.36
Marg. Tax	44.21	49.39	40.12
Log Firm Size	3.61	3.72	3.52
N	1107	488	619

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