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ABSTRACT

Labour supply when tax evasion is an option is analysed within a discrete choice framework which incorporates random parameters and Box-Cox functional forms, using mixed logit models. Deviates in parameters and, in some cases, correlation between alternatives in the evasion group are found to be significant.

The models utilized yield good predictions in terms of labour supply and taxes paid by non-evaders. The goodness of fit and quality of prediction is improved by the introduction of correlation between random coefficients.

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Keywords: Labour supply, tax evasion, mixed logit model.

1 Introduction

This paper analyzes empirically the supply of labour when tax evasion, i.e. work in the irregular sectors, is an option. The analysis utilizes a random utility discrete choice model within the theoretical approach introduced by Jørgensen, Ognedal and Strøm (2005).

The model is defined as discrete since labour supply choice is limited to a finite set of alternatives[1]. The underlying assumption is that individuals face only jobs with a limited number of hours, both in the regular and irregular sectors. The combination of

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[1] Van Soest (1995) introduces discrete choice model to analyze labour supply. He states that labour supply can be discretized since individuals face a limited number of options. The advantage of this approach is to avoid problems with nonlinear budget set.

these all possible amounts of hours in the regular and irregular sectors, yields all the possible alternatives the individual may choose.

A clear distinction occurs between alternatives with full tax reporting and exclusive participation in the regular sector of the economy and choices that imply a participation in the irregular sector. The first one belongs to the "honest" group H, the second one to the "evading" group E.

The discrete nature of choice set does not imply any kind of loss of information since it reflects the nature of the data available. Respondents give information on all the relevant quantitative variables, i.e. income, working hours, hourly wage etc., selecting the broad category where these values fall in. The empirical analysis is conducted on data from a randomized survey of Norwegian population whose responses contain individuals' beliefs in acceptability of tax evasion and personal attitudes towards tax evasion.

The contribution of the paper is an extension of the above mentioned model. Random parameters and correlation between alternatives through mixed logit specification are introduced. This approach leads to the estimation of significant deviations of individuals' tastes and in some cases, differently from previous works[2], of significant random coefficients into the utility function gives the opportunity to test an important aspect of tax evasion and labour supply issues underlined by many theoretical and empirical works, that is the presence of heterogeneity in the slope of labour supply curve[3] which determines participation in the irregular sector. To this aim I use the mixed logit estimation procedure to test the existence of correlation between random coefficients of consumption and the random nest-specific coefficient for alternatives in the evasion group. The latter parameter represents the random taste of individuals for "cheating".

The use of random parameters is combined with a flexible Box-Cox specification of utility in leisure and consumption and with the inclusion of non-economic variables as

[2] Jørgensen, Ognedal and Strøm (2005), Andresen (2005).
[3] This of course is the result of the interaction between substitution and income effect.

additional determinants of evading behaviour. Moreover, as in Jørgensen, Ognedal and Strøm (2005) and Andresen (2005), the specification of random utility incorporates variables that reflect the existence of social norms.
Therefore the estimation results from specification with different assumptions on the functional forms and stochastic nature of parameters are compared.

The main finding of the paper is that the stochastic nature of the model increases the flexibility of the model and improves its goodness of fit. However, as in many studies on labour supply, the probabilities of part time alternatives are over-predicted since the model does not explain the peaks in the distribution of hours of the jobs present in the market.

The paper is organized as follows. Section 2 summarizes briefly the state of literature and underlines the role of social norms in the determination of evading choice. Section 3 illustrates the reasons and advantages that motivate the use of random parameters and of mixed logit approach. Section 4 provides a description of the dataset and describes the main characteristics of evaders. The model is explained in section 5. Section 6 summarizes mixed logit estimation procedure, and section 7 presents the estimation results and their interpretations. Section 8 concludes.

2 Literature Review

Many theoretical works have highlighted the uncertainty beneath the decision to evade. The pioneering work of Allingham and Sandmo (1972) describes the choice of evading as a kind of lottery where the evasion represents a more gainful but, at the same time, more risky asset. Cowell (1985, 1990) extends this framework treating the labour supply variable as endogenous and introducing therefore a double evaluation at margin: the conventional one between leisure and consumption and a "portofolio" choice between safe hours of work in the regular sector and more remunerative, but at the same time more risky, hours of work in the irregular sector. Jørgensen, Ognedal and

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Strøm (2005) utilize agents' utility maximizing behaviour under uncertainty in a discrete choice framework.

This study follows Jørgensen, Ognedal and Strøm (2005) but also takes into account the findings of many empirical works that accompanied the development of theoretical models and suggested the existence of other important determinants of evasion. The first models, however, by assimilating evasion decision to a portfolio choice, leaded to a strong over prediction of honest behaviour. Later, some authors underlined or formalized theoretically[4] the presence of moral and social factors or norms. In these models the risk of being caught by tax audits could represent sources of anxiety for the individual. Possible forms of anxiety proved by the individual when evading or the risk of being judged as an evader by the community where the individual lives, are elements that may induce honest tax reporting.

As in previous works[5], the model in this paper assumes that agents maximize their utilities under uncertainty. However, differently from Lacroix et al. (1992) and Lemieux et al. (1994), this specification does not use marginal criteria and it is able to deal with non-convex budget sets. Like in Jørgensen, Ognedal and Strøm (2005) the labour choice is discretized and random utilities with extreme value distribution are assumed. The combination of regular and irregular hours that characterizes each alternative, determines the consumption available and the leisure of the individual. The complete structure of tax function is taken into account in the computation of the available consumption level in each alternative, and thus the maximizing procedure results are much simpler.

Utility of an individual is composed by a deterministic part and a stochastic one. The first consists of a function of leisure and consumption and of a nest specific constant (for alternative in group E) and variables related to social norms interacted with it.

The stochastic part takes account of the presence of random deviates of parameters and of an additional random error that induces correlation between alternatives in the same groups.

[4] See for instance Elster (1989), Gordon (1989), Myles et al.(1990) and Erard et al.(1994).

[5] See for instance Lacroix et al. (1992) and Lemieux et al. (1994)

3 Motivation of random parameters

The mixed logit approach in this paper is utilized mainly for two reasons: the possibility to mimic different pattern of correlation among the alternatives[6], and the possibility to account for a random taste variation over choice characteristics. Preferences over attributes - or in this case over Box-Cox transformation of the attributes - are in fact characterized by random coefficients.

The introduction of correlation between alternatives in the same group becomes important when there are unobserved factors that affect utility of group of alternatives.
In the case of group of alternatives that shares the same unobserved attributes, the substitution pattern reflects this similarity and thus IIA property is ruled out. This means that the ratio of probability of an alternative *m* in group H and a generic alternative *n* of group E does not remain the same after changes that make a third alternative (in E or in H) more attractive. Therefore individuals who select an "evading" alternative are more likely to select another "evading" alternative if some attributes' changes made their first choice no longer the most attractive.

Random parameters in turn, by inducing deviation in tastes, also help to avoid IIA property. For instance, correlation among alternatives can be induced by setting the parameter of Box-Cox transformation of leisure as random, as I actually do in the estimation. A significant variation in this parameter implies that an individual with a high evaluation of consumption would always prefer choices with high level of consumption when the variance of the deviates is greater than zero.
These deviations in tastes play an important role especially if we consider the importance of heterogeneity of agents in labour supply models. As many theoretical studies show[7] the effect of government instruments (i.e. marginal tax, probability of

[6] McFadden and Train (2000) prove that mixed logit can approximate any random utility model.
[7] See, for example, Pencavel (1979) and Cowell (1985,1990).

detection and penalty) on labour supply in the irregular sector when labour supply is endogenous are ambiguous. The sign of comparative static results depends mainly on the slope of labour supply curve of individuals.

Since consumption indirectly reflect utility from labour by allowing its coefficient to be random, I also take into account the taste variation of labour supply, and thus add a form of flexibility in the model that makes the model closer to reality.

Moreover, the mixed logit approach, as it will be shown in section 5, gives the possibility to introduce correlation between consumption (or leisure) random parameter and the individual attitude towards tax evasion.

4 Data Description

The empirical analysis is conducted on a data set constructed by a private survey bureau in Norway, the MMI. In 2003 this polling institute carried out a randomized survey of the Norwegian population. Participants included individuals above 15 years old who were asked if they wished to participate in the survey.

The individual who accepted to participate received a questionnaire by post and was required to fill it in and mail it back with the guarantee of full anonymity.

The response rate is moderately high. 73% of people who accepted the interview answered all the questions. The percentage of initially contacted individuals who completed the survey procedure is 62%.

As for all surveys possible biases in the answers due to the selection bias in participation in the survey and respondents' "agenda" problem may exist. It might be in fact that only people really involved in the issue agreed to participate, or that participants voluntarily gave untrue answers.

However, the overall interview procedure consisted of two-stages and allowed for some control of the selection problem. In fact previous studies[8] that used the same type of

[8] Isachsen,Klowland and Strøm(1982), Goldstein,Hansen, Ognedal, Strøm(2002)

surveys in Norway found out that the sample characteristics were not deviating significantly from the population ones.

The answers to the questionnaire convey demographic information on the respondents, such as age, gender, marital status, non labour income, type of the job and labour supply.

Moreover, participants were asked about the amount of hours in the regular sector and the amount of income earned in the irregular sector of the economy. The individual amounts of weekly hours in the regular sector are divided in five brackets: 0-20, 20-30, 30-45, more than 45. The categories for annual hours in the black economy are represented by the brackets 0-10, 10-24, 25-49, 50-99,100-199,200.399, 400-599,600-799,800-999, more than 1000. The possibility not to participate at all in the irregular sector is also included. In order to define the two amounts of hours in each alternative I use the midpoints of the two series of categories described above.

The questionnaire investigated also the beliefs of respondents about the functioning of the tax enforcement system. Respondents expressed their beliefs over the probability of being detected, and the fine in case of detection of evasion. These are the subjective values utilized by the individual in her decisional procedure.

Some questions of the survey were targeted to measure the attitude of respondents towards tax evasion. The respondents answered about the social acceptability of tax evasion and about their propensity to evade when the opportunity for such behavior exists.

Individuals below 20 and over 60, i.e. too young people or retired people, are excluded from the sample. Then, the amount of hours supplied in the regular sector of economy by the retained individuals is always greater than zero. The participation in the black economy for these individual seems thus to have the characteristics of a side job.

Table 1 presents demographics characteristics of the sample and tax reporting decisions.

Descriptive statistics in Table 1, 2 and Table 3 reveal some interesting aspects. Female and older people evade less. This result is consistent with the great majority of empirical studies on this issue[9]. The differences between the subjective probability of being caught when evading and the perceived fine of evasion are minimal between evaders and non-evaders.

An apparently surprising result is that average hourly wage of evaders is lower than hourly wage of non-evaders. Evaders also supply more hours of work in the regular sector than non evaders[10]. The higher average wage makes however the gross labor income of non-evaders higher.

5 Model

5.1 Definition of variables

Leisure and consumption level have different definitions depending on whether alternative *j* belongs to group H or group E. Each alternative is characterized by a combination of weekly hours in the regular sector h_{pH} and annual hours in the irregular sector, h_{lE}, $p=1,..,P$ $l=1,..,L$. The alternatives that include hours in the irregular sector belong to the "evasion" group (E); the alternatives that consist only of hours in regular sector are in the "honest" group (H).

Leisure is computed as:

$$l_j = (8760-h_j)/8760 \qquad [1]$$

that is, as the difference between the total amount of available annual hours in alternative *j* minus h_j, i.e. the total annual amount of work of individual *n* if she chooses alternative *j*.

[9] See for instance the results from the experiment of Baldry (1987) and estimated on real data by Clotfelter (1983). See also Andreoni et al. (1998) for an excellent survey on the subject.
[10] The two latter results are however consistent with finding from other surveys, Lemieux et al. (1994), and may be interpreted by theoretical models, see for instance Cowell (1985,1990).

The difference in definition of leisure between the two groups simply consists of the definition of annual amount of labour h_j.

$$h_j = h_{pH} \quad [2]$$

i.e. annual hours in the regular sector for alternative in group H.

$$h_j = h_{pH} + h_{lE} \quad [3]$$

That is the sum of amount of annual regular hours h_{pH} plus the amount of annual hours in the irregular sector h_{lE}.

The definition of consumption levels differs for alternatives in the two groups.

The consumption level for alternatives in group H is:

$$C_{jH} = R_{pH} + I - T(R_{pH}, I) \quad j = 1,..,J \quad [4]$$

where $R_{pH} = w_{pH} h_{pH}$ is the pre-tax annual wage income, with w_{pH} as wage in the regular sector. I is the annual non labor income. $T(R_{pH}, I)$ is the amount of taxes paid computed with a step-wise linear function of annual wage income and non-labor income.

The available consumption when alternative j includes hours in the irregular sector, depends on the realized state of nature related to tax enforcement activity of government. Therefore, consumption available when government detects evasion with probability p is different from consumption level when evasion is uncovered.

In case of non detection consumption is:

$$C_{jE,NT} = R_{pH} + R_{lE} + I - T(R_{pH}, I) \quad [5]$$

Individual does not pay taxes on the amount of wage income $R_{lE} = w_{lE} h_{lE}$ from the irregular sector, with w_{lE} being the wage in the irregular job.

In case of detection, consumption is defined as follows:

$$C_{jE,T} = R_{pH} + R_{lE} + I - T(R_{pH} + R_{lE}, I) - \tau(R_{lE}) \quad [6]$$

That is, individuals pay taxes on the overall amount of labor income plus non-labor income. In addition, they pay a fine τ on the amount of non-reported irregular income.

5.2 Utility specification and functional form

As is usual in random utility approaches, individual n chooses alternative j that maximizes her utility. The utility for individual's *n* alternative *j* is defined as follows:

$$U_{njs} = u_{njs} + \theta_{nj} + \varphi_{nj} + \varepsilon_{nj} \qquad n=1,..,N;\ j=1,..,J;\ s=E,H. \qquad [7]$$

where ε_{nj} is the usual iid extreme value used in standard logit models. u_{njs} is the function of consumption and leisure level available in alternative *j*. θ_{nj} contains stochastic components that induce correlation between alternatives belonging to the same group (H,E).

φ_{nj} consists of interaction of personal characteristics and believes with a nest constant equal to one for alternatives in group E. This group of variables is meant to capture the effect of social norms.

Due to the hazardous nature of the choice of evading, the utilities of "honest" and "dishonest" alternatives are built in two different ways. As already mentioned, in the case of evading strategy there are two possible states of the world: the case of detection and consequent sanction for evasion behavior, and the case when irregular hours are not uncovered. The expected utility is:

$$u_{njE} = qu(c_{j;ET},..,X) + (1-q)u(c_{jE;NT},..,X) \qquad [8]$$

That is the sum of utilities in the two possible states of nature weighted by the respective probabilities. q is the perceived probability of detection expressed by the individual in the questionnaire.

The utility given by alternative j under honest strategy is:

$$u_{njH} = u_n(c_{njH},..,X_{nj}) \qquad [9]$$

The functional form of the utility is the same used by Jørgensen, Ognedal and Strøm (2005), and is specified as follows:

$$u_{nj}(c,l,X) = \alpha_{0n}\left(\frac{(c_{nj}/10000)^{\lambda}-1}{\lambda}\right) + (\beta_{0n} + \beta_1 X_{n1} + \beta_2 X_{n2})\left(\frac{l_{nj}^{\ \gamma}-1}{\gamma}\right) \qquad [10]$$

where l_{nj} and c_{nj} are leisure and available consumption defined above[11].

X_1 represents age and X_2 is a dummy that is equal to one for women. As indicated by the descriptive statistics these two variables seem to have a significant effect on evasion choices. They are thus allowed to affect individual utility through an interaction with the Box-Cox transformation of leisure[12].

The Box -Cox functional form $\left(\frac{x^{\theta}-1}{\vartheta}\right)$ for leisure and income is equivalent to the logarithm when ϑ is zero and equal to the linear case when ϑ becomes one. The advantage of this specification is that quasi-concavity can easily be tested.

However, this specification differs from Jørgensen, Ognedal and Strøm (2005) since I consider the possibility that α_{0n} and β_{0n} are random parameters.

These parameters consist of a mean and a deviation σ from this mean. For example, $\beta_{0n} = \beta_0 + \sigma_{\beta}\eta_{0n}$ where β_0 is the population mean and η_0 is a stochastic deviation which is meant to capture the variation of tastes between individuals (respectively $\alpha_{0n} = \alpha_0 + \sigma_{\alpha}\pi_{0n}$).

This specification thus differs from a standard logit model with Box-Cox functional forms due to the presence of two additional stochastic components in the utility function i.e.:

$$\eta_{0n}\left(\frac{(c_{nj}/10000)^{\lambda}-1}{\lambda}\right) \text{ and } \pi_{0n}\left(\frac{l_{nj}^{\ \gamma}-1}{\gamma}\right) \qquad [11]$$

These two stochastic components relax the IIA assumption of standard logit model since they induce another source of correlation over alternatives.

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[11] Consumption and leisure are rescaled. Consumption level is divided by 10000 in equation [10]; leisure is divided by 8760 in equation [3.1]. The aim of rescaling is to reduce the log of condition number and consequently to avoid the precision lost in computing Hessian inverse and to speed the maximum likelihood estimation procedure.

[12] For a detailed discussion and proof of the properties of Box-Cox transformation see Dagsvik and Strøm(2005).

As anticipated, the mixed logit approach offers also the possibility to test whether the two stochastic components are correlated[13]. The term θ_{nj} in equation [7] introduces iid deviates to mimic correlation pattern similar to nested multinomial logit. This term is equal to:

$$\theta_{nj} = \delta_0 d_{nj}^E + \mu_s' \, z_{nj} \qquad [12]$$

where d_{nj}^E are dummies equal to one if alternative j belongs to the group of evading choices. δ_0 thus reflects a constant equal to one for all the alternatives of the "evasion" group. $\mu_{ns}' z_{nj}$ can be considered as an error component:

$$\mu_{ns}' z_{nj} = \sum_{s=H,E}^{K} \mu_{ns} d_j^s \qquad [13]$$

with $z_{nj} = (d_{nj}^E, d_{nj}^H)'$ and s=H,E. μ_{ns} is a vector of iid deviates such that $V(\mu)$ is diagonal with elements $\sigma_s, s = H, E$. These deviates are assumed to be normally distributed, $N(0, \sigma_s)$.

$\mu_{ns}' z_{nj}$ induces correlation between alternatives in the same nests. If, for instance, alternatives q and t belong to nest H (E) we have that $Cov(\theta_{nq}, \theta_{nt}) = E\left[(\mu_{sq}' z_{nq} + \varepsilon_{nq})(\mu_{st}' z_{nt} + \varepsilon_{nt})\right] = \sigma_H \; (\sigma_E)$ with s=H (E) while it is equal to zero if q and t belong to different nests.

In this way I test the presence of correlation between alternatives belonging to the "honest" strategy and correlation of alternatives in the "evasion" strategy group. Differently from nested logit models the mixed logit framework does not impose homoskedasticity[14]. This higher flexibility has however a disadvantage: as shown by Ben-Akiva et al. (2001) and Munizaga et al. (2001) in the case of two mutually exclusive nests the variance of one must be normalized to an arbitrary value (for instance to one).

[13] As it will be shown later on this occurs through Cholesky factorization.
[14] Nested logit by construction is homoskedastic. Homoskedasticity can however be imposed in mixed logit.

In the present case, since there is a dummy for alternative in group E plus a stochastic component interacted with it, the coefficient of evading feature may be considered as random.

The variables in φ_{nj} reflect the effect of social norms on individual choices.

$$\varphi_{nj} = g_1 d_j^E Z_{n1} + g_2 d_j^E Z_{n2} + g_3 d_j^E Z_{n3} \qquad [14]$$

d_j^E is a dummy variable equal to one when alternative *j* belong to E nest.

The remaining Z variables are all interacted with this dummy. These variables are individual characteristics or beliefs that affect behaviour and reflect features that may signal the presence of social norms. The sign of these coefficients represent their effects on the probability of choosing an alternative in group E.

The questionnaire includes various variables that may be interpreted as aspects of social norms. In particular, I use the belief of individuals on social acceptability of tax evasion, Z_{n1} equals one if the respondent believes that tax evasion is socially accepted. Another variable is the tendency of the individual to evade, i.e. Z_{n2} equals one if the respondent expresses his willingness to evade when such an opportunity exists. I consider also the salaried status of the worker, Z_{n3} equals one if the respondent is salaried[15]. These variables are interacted with the dummy d_j^E equal to one if alternative j includes hours of irregular work. This approach takes into account the role of social norms in a fashion that is not so different from the g(Z) function used by Jørgensen, Ognedal and Strøm (2005).

Here the effect of norms enters the specification of expected utility in the form of nest-specific attributes. The Z variables are in fact interacted with the dummy variables d_i^E so that their parameters can be identified. Their effect on H alternatives is

[15] As suggested by most of the studies on real data employed workers evade less than self-employed. This variable therefore represents rather a different level of the opportunity of evasion than the effect of social norms. As note by Pestieau et al (1991) individuals might self-select into self-employment or salaried job according to their level of risk aversion.

normalized to zero; otherwise, since the Z-variables do not change over alternatives - being individual specific - they could not be identified.

In Jørgensen, Ognedal and Strøm (2005) specification, the g(Z) function was used as a multiplicative factor of the expected value of the maximum of the utility from alternatives in the evasion group. It could, however, be considered as a nest specific attribute of the evasion choice[16].

The overall utility of alternative *j* for individual *n* can thus be written in a compact form.

$$U_{nj} = (\boldsymbol{\alpha}_j + L\boldsymbol{\mu}_{nj})' * X_{nj} + \varepsilon_{nj} \qquad [15]$$

$$\text{where } \boldsymbol{\alpha}_j = \begin{pmatrix} \alpha_0 \\ \beta_0 \\ \delta_0 \\ 0 \\ \beta_1 \\ \beta_2 \\ g_1 \\ g_2 \\ g_3 \end{pmatrix}, \quad \boldsymbol{\mu}_{nj} = \begin{pmatrix} \pi_{0n} \\ \eta_{on} \\ \mu_E \\ \mu_H \\ 0 \\ 0 \\ 0 \\ 0 \\ 0 \end{pmatrix}, \text{L=} \begin{pmatrix} s_{11} & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 \\ s_{21} & s_{22} & 0 & 0 & 0 & 0 & 0 & 0 & 0 \\ s_{31} & 0 & s_{33} & 0 & 0 & 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & s_{44} & 0 & 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 \end{pmatrix} \qquad [16]$$

[16] Setting for instance g(Z)=exp(lng(Z)) we can see that this term has the same role of the multiplicative factor used by Jørgensen, Ognedal and Strøm (2005) .

$$X_{nj} = \begin{pmatrix} \left(\frac{(c_{nj}/10000)^{\lambda} - 1}{\lambda} \right) \\ \left(\frac{l_{nj}{}^{\gamma} - 1}{\gamma} \right) \\ d_{nj}^{E} \\ d_{nj}^{H} \\ X_{1n} \left(\frac{l_{nj}{}^{\gamma} - 1}{\gamma} \right) \\ X_{2n} \left(\frac{l_{nj}{}^{\gamma} - 1}{\gamma} \right) \\ Z_{n1} \\ Z_{n2} \\ Z_{n3} \end{pmatrix} \quad [17]$$

L is a lower triangular Cholesky factorization, such that $LL' = \Omega$. In such a way, even utilizing iid deviates μ it is possible to induce any correlation pattern between stochastic components. Correlation between random parameters may therefore be tested. I focus in particular on the possible correlation between the error component of α_{on} parameter with the "nest" deviate μ_E. I want to test if the individuals who place a higher value on utility of consumption have also a higher (or lower) evaluation of the negative impact of the "cheating" nature of alternatives in group E.

Since from [15] we have that:

$$\begin{pmatrix} \varepsilon_{\alpha 0n} \\ \varepsilon_{\beta 0n} \\ \varepsilon_E \\ \varepsilon_H \end{pmatrix} = \begin{pmatrix} s_{11} & 0 & 0 & 0 \\ s_{21} & s_{22} & 0 & 0 \\ s_{31} & 0 & s_{33} & 0 \\ 0 & 0 & 0 & s_{44} \end{pmatrix} \begin{pmatrix} \pi_{0n} \\ \eta_{0n} \\ \mu_E \\ \mu_H \end{pmatrix} = \begin{pmatrix} s_{11}\pi_{0n} \\ s_{21}\pi_{0n} + s_{22}\eta_{0n} \\ s_{31}\pi_{0n} + s_{33}\mu_E \\ s_{44}\mu_H \end{pmatrix} \quad [18]$$

the correlation between α_{0n} and μ_E can be defined as follows:

$$Cov(\varepsilon_E, \varepsilon_{\alpha 0n}) = s_{11}s_{31}. \quad [19]$$

Similarly, it is possible to verify the correlation between taste variation in the utility of leisure with taste variation in the utility of consumption.

In this case the correlation induced by the lower triangular matrix L is:

$$Cov(\varepsilon_{\alpha 0n}, \varepsilon_{\beta 0n}) = s_{11}s_{21}. \qquad [20]$$

6 Mixed logit[17] estimation procedure

As shown in equation [7], the random utility specification includes two different kinds of stochastic components: the iid extreme value distributed ε_{nj} and the random components $\boldsymbol{\mu}_n$. The existence of stochastic components in $\boldsymbol{\mu}_{nj}$ makes the standard logit formula no more sufficient to determine the choice probabilities. However, since the extreme value distributed unobserved error term ε_{nj} is independent of $\boldsymbol{\alpha}_{nj}$ and X_{nj}, it is possible to integrate out this random part of the utility and to compute the probability of individual n choosing alternative j conditional on a value of parameter $\boldsymbol{\alpha}_{nj}$. This probability is still represented by a standard logit formula:

$$P_{nj}(\alpha_{nj}) = \frac{e^{\alpha'_{nj}X_{nj}}}{\sum_{k=1}^{K} e^{\alpha'_{nk}X_{nk}}} \qquad [21]$$

Therefore, the mixed logit probabilities can be computed as a sum of these conditional standard logit probabilities weighted by the probability of observing the conditioning value of parameter $\boldsymbol{\alpha}_{nj}$. That is, the unconditional probability is computed as the integral of the conditional probability over all the possible values of $\boldsymbol{\alpha}_{nj}$.

$$P_{nj} = \int \frac{e^{\alpha'_{nj}X_{nj}}}{\sum_{k=1}^{K} e^{\alpha'_{nk}X_{nk}}} f(\alpha_{nj})d\alpha_{nj} \qquad [22]$$

The value of the integral depends on the distribution of $\boldsymbol{\alpha}_n$ and on the parameter that determines it (in general, the mean and the variance). The distribution function of $\boldsymbol{\alpha}_n$ is called the mixing distribution.

[17] For an exhaustive explanation of mixed logit see Train (2002) and Revel and Train (1998).

Simulation method is used to solve the integral in equation [22]. The first step of the procedure consists of drawing R values of $\boldsymbol{\alpha}_n$ from its distribution function. For each of these R values the conditional probabilities in equation [21], now defined as $L_{nj}(\alpha_{nj}^{r})$, can be simulated. That is:

$$L_{nj}(\alpha_{nj}^{r}) = \frac{e^{\alpha_{nj}'^{r} X_{nj}}}{\sum_{k=1}^{K} e^{\alpha_{nk}'^{r} X_{nk}}} \quad \text{r=1,..,R} \qquad [23]$$

Taking the averages of these conditional probabilities the simulated probability of alternative j may be computed as:

$$\hat{P}_{nj} = \frac{1}{R}\sum_{r=1}^{R} \frac{e^{\alpha_{nj}'^{r} X_{nj}}}{\sum_{k=1}^{K} e^{\alpha_{nk}'^{r} X_{nk}}} \quad \text{r=1,..,R} \qquad [24]$$

The simulated probabilities $\hat{P}_{nj}$ are unbiased estimator of the true unconditional probabilities P_{nj} and have other desirable properties[18].

Hence, by substituting these values in the log-likelihood, a simulated log-likelihood is defined as follows:

$$SLL = \sum_{n=1}^{N}\sum_{k=1}^{K} d_{nk} \ln \hat{P}_{nk} \qquad [25]$$

where d_{nj} equals one if the k is the alternative selected by individual n.

Usual numerical maximum likelihood procedure is implemented to find the MSLE estimator θ that maximizes SSL. This vector contains the estimates of fixed parameters and the means and variances of the random ones.

To estimate the mixed logit I used a modification of Kenneth Train's Gauss program[19]. The changes in the code consist of the inclusion of Box-Cox specifications and the introduction of correlation of the random parameters.

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[18] The variance reduces as R increases. $\hat{P}_{nj}$ is a smooth simulator and this fact makes easier the computation of derivatives, and consequently the numerical optimization.

[19] The GAUSS program is available at http://emlab.berkeley.edu/users/train/software.html.

In order to generate simulated probabilities I use 125 Halton draws. These randomly generated numbers posses some properties of coverage and covariance[20] that reduce the number of draws for MSLE estimation[21].

7 Estimation results

This section discusses the results from estimation of models with different specification of the utility function, different number of random parameters and with various correlation patterns between these random components.

Table 4 shows estimates obtained assuming that the utilities of leisure and of consumption have a Box-Cox functional form. These estimates help to understand the shape of the functional form of utilities of leisure and consumption. Model 1 does not contain any random parameter. Utility function estimated in model 2 has a random coefficient for α_0.

Results from both models suggest that utility of consumption has a logarithmic functional form. The coefficient for π_{0n} is not significantly different from zero at 1 % level. The coefficient γ is significant at 1% level and negative. However the beta-coefficients, β_0 β_1 β_2, are not significant. The constant for evading alternatives δ_0 and proclivity to evade Z_2 are significant at 1% level and respectively positive and negative.

This means that the risky nature of evading choice reduces the utility of these alternatives and that those individuals who are inclined to evade, when possible, give a higher utility to alternatives that contain hours of irregular work.

Both in model 1 and model 2 the variable Z_3, i.e. being salaried, does not affect significantly the probability of choosing an alternative in group E. Similarly, the effect of considering evasion acceptable is not significantly different from zero. The beta-

[20] See Train(1999) .

[21] In order to obtain efficient and consistent MSLE estimator the number of draws must increase faster than the square root of the umber of observations. Therefore, by taking 125 Halton draws, I am much more above the required threshold.

coefficients, i.e. the constant β_o and the interaction of age, β_1, and sex , β_2, with Box-Cox transformation of leisure are not significant.

We use these estimates to compute the predicted probabilities P_H and P_E of being honest and a tax evader, the predicted amounts of hours supplied in the two sectors and the respective tax revenues. L_H is the expected total amount of hours supplied in the regular sector. $L_H|H$ is the expected amount of hours supplied in the regular sector conditional on being honest. Similarly L_E is the expected total amount of hours in the irregular sector and $L_E|E$ is the expected amount of irregular hours conditional on being an evader. T is the predicted total tax revenue, T|H is the expected revenue tax conditional on being honest. T|E is the average tax paid by evaders and $T_H|E$ is the average true amount of tax evaders should pay.

Table 5 shows predictions from models 1 and 2. Both models over predict hours in the irregular sector and consequently tax evasion. The interesting result is that model 2 leads to higher over-prediction of evading behavior even if it is improving the likelihood, as it is possible to elicit from the mean log-likelihood value in Table 4. The introduction of additional random terms with full support unfortunately increases also the probability of less attractive alternatives, since even for these options this random term has positive values. This, however, is a common characteristic of many studies on labour supply which face the problem of explaining the lower demand for part-time jobs. Both models yield predicted amounts of hours in the regular sector that are quite accurate.

Table 6 shows the results from models where the utility of consumption has a logarithmic functional form and the utility of leisure a Box-Cox form. Model 3 does not contain random parameters. Model 4 has one random parameter attached to the logarithm of consumption. Model 5 has two random parameters: the coefficient α_{0n} of consumption utility level and the coefficient β_{0n} of leisure utility level. Model 6 has the same random parameters as Model 5 but in addition allows for a correlation between them.

The constant δ_0 for evading alternatives is significant at 1% and negative in all the four models. The effect of proclivity to evade on the probability of choosing an evading strategy is positive and significant at 1%.

The coefficients α_0 and γ are significant at 1% and are, respectively, positive and negative in all models of Table 6.

The coefficients for the deviates of the consumption parameter α_0, i.e. π_{0n} , is significant in all models (4,5,6) where the corresponding coefficient is made random.

The beta coefficients are all insignificant in model 3 and model 4. In model 5, where β_{0n} is random, β_0 and η_{0n} are significant, respectively at 10% and 1% level. The coefficient of the interaction of leisure with the dummy for female, β_{2n}, is positive and significant at 10% level.

Deviates of β_0, i.e. η_{0n}, are not significant in model 6, which contains a correlation term between the random component of the utility of consumption and the random component of the utility of leisure. The term s_{21} is found to be significant at 10% level, however the covariance between α_{0n} and β_{0n}, as shown in equation [18], is equal to the product $s_{11}s_{21}$. By applying derivative rule (see Revelt and Train (1998)) this product is found to be insignificant.

As in the case of model 1 and model 2 the introduction of random parameters increases the likelihood but, as can be verified from Table 7, the predicted level of hours of work in regular and irregular sectors and the predicted amount of tax evasion are much higher than the true ones. The more random terms with full support are introduced, the higher will be the probabilities of the less attractive alternatives[22] in the E group and the higher will be the over-prediction of cheating behavior.

The estimates of models 7,8,9,10 are shown in Table 8. These models contain specification with random parameters of utility and random parameters for nest. The latter induce correlation between the alternatives that belong to one of the two groups, E and H.

[22] These alternatives are represented by the choices characterized by a part-time supply of work in the regular sector.

As in the previous models, the constant for evading alternatives and the variable for the proclivity to evade are significant at 1% and are respectively, negative and positive in all the models of table 8.

The empirical results from these models confirm the Box-Cox specification for utility from leisure and the logarithm form for utility of consumption, i.e. γ is negative, α_0 is positive and both are significant at 1%. In all four models, however, the coefficient β_0 and its deviates η_{0n} are not significantly different from zero.

Concerning the correlation between alternatives in the same group, the results differ in the four models. As already mentioned, the variance μ_H of the error component for alternatives in the H group is normalized to one[23].

The variance parameter μ_E (or more precisely its square root) for the evasion group is not significant in model 7, where the α_{0n} coefficient is not random, but is significant in model 8,9 and 10, where α_{0n} is allowed to vary. Hence, in addition to the effect of social and moral norms, there still exists a part of unobserved error component which captures the correlation between the two groups of alternatives.

The variance of the β_0 coefficient is significant only in model 9, where the correlation between the random coefficient α_{0n} and the variance of evading choices is allowed. This correlation is found to be negative and significant at 5% level. The true correlation in fact is computed with the derivative rule[24] as the product of s_{11} and s_{31} (see [18]). This fact suggests that those individuals who place a higher value to consumption also receive a higher disutility from "evasion" alternatives. The comparative static results from theoretical models are ambiguous[25] and these empirical finding might shed some light on the true nature of labour supply when tax evasion is an option. Such a negative correlation seems to be at odds with a stylized fact in descriptive statistics and, in particular, with the higher participation of low-wage individuals in the irregular sector. Given the adopted utility specification, for these individuals the marginal utility of consumption ($dU/dC=\alpha_{0n}/C$ in the logarithmic case) should be higher. Hence, if labour

[23] Mixed logit version of nested logit in fact identifies only the sum of the two error components when the number of nest is only two.
[24] See Revelt and Train (1998).
[25] See Cowell (195,1990) and Pencavel (1979).

supply curve is forward bending[26], labour supply in the irregular sector(but also in the regular one) should be incentivated, leading to a greater level of tax evasion. Therefore, it seems counterintuitive that those individuals with a higher incentive to evade, especially if we consider that low-wage individuals actually evade more, are characterized by a higher disutility from evasion.

However, α_{0n} represents only the numerator of the marginal utility independently of the level of consumption which is common for all individuals (low and high income).

The negative correlation may thus correct predicted behaviour of all individuals with high α_{0n}. It might be that for individuals with a too high realization of α_{0n}, the level of labour supply in the irregular sector is overpredicted. This overprediction may be particularly large for low wage individuals since, due to the low level of income, the marginal utility of consumption is very high.

Another reason of the negative sign of this correlation may be related to the use of Von Neumann-Morgenstern specification of expected utility which assumes linearity in probability. This assumption, as some authors pointed out[27], is not very realistic and may create misspecification if individuals overweight the probability of sanction/detection or if probability of detection is not exogenous. It might be that individuals with a higher realization of α_{0n}, and thus with more incentives to evade, may consider detection more likely to happen. This might be true if probability of detection is an increasing function of non-reported income. Thus, to counterbalance this higher perceived probability[28] for evaders, the model estimates a negative correlation between α_{0n} and disutility of evasion.

A further reason of the existence of a negative correlation that corrects too high level of α_{0n} might be assumption of normal distribution of the parameters. As may be noted in Table 4, 6 and 8 when α_0 is made random the value of its mean increases. This depends on the fact that normal term has full support, including thus also highly negative values.

[26] This seems indeed to be the case since the evaders works more both in the regular and in the irregular sector

[27] See, for instance, Kahneman, D., & Tversky (1979) and Jørgensen, Ognedal and Strøm (2005).

[28] It worth remembering that perceived probabilities are expressed in the questionnaire by broad categories.

As a consequence, willing to avoid as much as possible negative values of the marginal utility, the mean estimated by the model increases.

As is shown in the specifications of Table 8 (in models 7,8,9,10) the higher the number of random coefficients the better is the likelihood of the estimates.

As far as predictions are concerned, I find some differences between the implications from the latter four models. Table 9 contains the predicted values from those models. Model 7 yields prediction very similar to model 3, i.e. the same model without nests. Therefore, the introduction of correlation between groups of alternatives does not worsen the predictive power.

The prediction of model 9, e.g. with correlation between α_{0n} and variance μ_E in E group, yields the level of tax evasion that is more accurate than the prediction of the same model without this correlation parameters (model 8).

Hence, due to the inclusion of correlation, a clear structure on the random components emerges, and this improves both the goodness of fit and the accuracy of predictions.

In order to solve the problem related to full support of normal distribution I estimate the model assuming a lognormal distribution for the random parameter α_{0n}[29]. Table 10 shows estimates from model 11, which contains a unique lognormal random coefficients for α_n, and from model 12, which, in addition to random α_{0n}, includes nest error terms μ_E and μ_H and allows for correlation between α_{0n} and μ_E.

Estimates from models 11 and 12 shows that when the distribution of α_{0n} is assumed to be lognormal, and thus the parameters have only positive values, the mean α_0 is lower than the value estimated by the previous models. The goodness of fit is also lower. Predictions shown in Table 11 are however similar to the ones of models 7,8,10 with normally distributed α_{0n}. However, these models yield slightly lower overpredictions of labour supply in the irregular sector and of evaded income.

[29] Uniform and triangular distributions were also assumed but the estimates of the deviates of random coefficient were found to be insignificant.

The estimates from model 12 show that when lognormal distribution is assumed the variance of nest specific error terms and correlation between α_{0n} and μ_E become insignificant.

Therefore, the most suitable models both in term of economic interpretation, prediction and goodness of fit seem to be models 5 and 6. These two models do no contain neither nest specific random components nor other correlation terms. They allow for the random coefficient of β_{0n}[30]. These two models are the only two specifications that have a significant value of β_0 and for β_2 (i.e. the interaction of leisure with female dummy). Model 5 is the unique specification that detects a significant deviates of the parameters β_{0n}.

As shown in Table 7, L_H, $L_{H|E}$, $T_{H|H}$ and $T_{H|E}$ are accurately predicted, which means that model 5 can be used in practice by the government in predicting outcomes when tax rates or fines are changed.

It is worth noting that in all specifications being salaried does not affect significantly the choice of honest or cheating behaviours. This fact seems surprising, since employed and self-employed individuals differ in the opportunities to evade and are subject to different conditions of tax-enforcement. However, the models implemented here do not capture any peculiarities in the reporting decisions of the two groups.

8 Conclusion and suggestions for future research

The paper improves the analysis of discrete choice labour supply model when tax evasion is an option through the inclusion of stochastic components and random parameters. Different distributional assumptions on random parameters are tested and their effects on goodness of fit and quality of predictions are verified.

[30] Different random distributions of β_{0n} were implemented in many other specifications, but the deviates were not found to be significant.

Deviates in marginal utility of consumption are always found to be significant, thus suggesting the importance of heterogeneity in consumer tastes on labour supply decisions.

Empirical results highlight the importance of social and moral factors and, in particular, of the reported proclivity to evade. Some specifications find a significant effect of the reported social acceptability of evasion, and some models detect also the existence of unobserved attributes that, in addition to social and moral factors, distinguish honest behaviour from evasion strategies.

As far employment status (employed or self-employed) is concerned, further improvements of tax-evasion analysis could be carried out through the development of functional forms of utility that account for the differences in the tax-reporting procedures and schedules of self-employed and employed workers.

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APPENDIX

Table 1. Summary statistics of the sample.

Number of observations	659	
Number of non-evaders Number of evaders	592 67	
Percentage of female in the sample	48.7%	
Percentage of respondents who believe tax evasion is socially accepted	52.6%	
	Mean	Standard deviation
Age	41.29	10.06
Hourly wage rate NOK	168.33	74.43
Gross annual wage income(from regular sector) NOK	326824.7	152429.4
Weekly hours worked in the regular economy	35.39	10.7
Annual tax NOK	102787.9	67056.99
Perceived fine if detected, percentage of income	0.305	0.189
Subjective probability of detection	0.1295	0.047

Table 2. Summary statistics of non-evaders.

	Mean	Standard deviation
Age	41.56	10.14
Percentage of female in the sample	51%	
Percentage of respondents who believe tax evasion is socially accepted	50.16%	
Hourly wage rate NOK	169.77	76.09
Gross annual wage income(from regular sector) NOK	328212.8	153118.3
Weekly hours worked in the regular economy	35.16	10.15
Annual tax NOK	103369	67528.93
Perceived fine if detected, percentage	0.3058	0.1882
Subjective probability of detection	0.13	0.047

Table 3. Summary statistics of evaders

	Mean	Standard deviation
Age	38.89	8.97
Percentage of female in the sample	28.35%	
Percentage of respondents who believe tax evasion is socially accepted	74.62%	
Hourly wage rate NOK	155.6045	56.62
Gross annual wage income(from regular sector) NOK	314597.7	146738.3
Weekly hours worked in the regular economy	37.43	14.63
Annual tax NOK	97653.41	62977.93
Perceived fine if detected, percentage	0.2985	0.2038
Subjective probability of detection	0.1029	0.035

Table 4. Estimates from model 1 and model 2

	MODEL 1	MODEL 2
Z_3 (salaried)	0.0020 (0.3594)	-0.0812 (0.36490)
Z_1 (socially acceptable)	0.4883 (0.3285)	0.4691 (0.31928)
Z_2 (incline to evade)	1.5849*** (0.3254)	1.5755*** (0.31415)
δ_0	-5.4949*** (0.4050)	-5.5361*** (0.43249)
λ	0.0424 (0.1086)	-0.4810 (0.38102973)
α_0	3.0545*** (0.9628)	25.0494 (27.898)
π_{0n}	-	13.496 (18.3396)
γ	-13.596*** (2.9566)	-10.2828*** (1.7423769)
β_0	0.1244 (0.1277)	0.5869 (0.44260)
β_1	0.0961 (0.1088)	0.3511 (0.28066222)
β_2	0.0970 (0.0998)	0.3967 (0.2452)
Mean log likelihood	-1.55214	-1.5354800

NOTE:Robust standard errors are in parenthesis
*** 1% level of significance
** 5% level of significance
* 10% level of significance

Table 5. Predictions from model 1 and model 2

Variable means	Observed	Prediction MODEL1	Prediction MODEL 2
P(E)	0.10166920	0.1017	0.1012
P(H)	0.89833080	0.8983	0.8988
L_H	1776.2421	1754.4598	1756.17
L_H|H	1768.2409	1770.03	1770.35
L_E	7.8581184	23.70	27.06
L_E|E	77.291045	233.153	267.41
T|H (average tax paid by non evaders)	98009.811	98976.41	99144.27
T|E (average tax paid by evaders)	91902.805	88364.14	88758.52
T_H|E (average true amount of tax evaders should pay)	97130.220	104460.27	107335.63
T (overall average tax)	97388.917	97897.47	98088.36
EVASION= T_H|E-T|E	5227.4149	16096.119	18577.099

Table 6. Estimates from model 3,4,5, and 6.

	MODEL 3	MODEL 4	MODEL 5	MODEL 6
Z_3 (salaried)	0.0035 (0.3595)	-0.0682 (0.3639)	-0.0900 (0.3662)	-0.0360 (0.3741)
Z_1 (socially acceptable)	0.4868 (0.3285)	0.4774 (0.3325)	0.4719 (0.3364)	0.5065 (0.3393)
Z_2 (incline to evade)	1.5864*** (0.3255)	1.5779*** (0.3280)	1.5758 *** (0.3315)	1.5836 *** (0.3317)
δ_0	-5.4914*** (0.4049)	-5.5625*** (0.4132)	-5.5724 *** (0.4137)	-5.6890 *** (0.4329)
α_0	3.4104*** (0.3479)	5.6160 *** (0.6729)	5.1697 *** (0.4671)	6.0077 *** (0.6247
π_{0n} (i.e. s_{11})	-	2.6007 *** (0.4015)	5.1697 *** (0.4671)	3.8678 *** (0.5610)
γ	-13.6791*** (2.9960)	-10.6039 *** (2.2565)	-16.6098 *** (1.4326)	-9.8897 *** (1.3484)
β_0	0.1190 (0.1234)	0.5276 (0.4262)	0.0814 * (0.0469	0.8709 * (0.4772)
η_{0n}		-	0.0548 ** (0.0274)	0.0023 (0.0261)
β_1	0.0917 (0.1061)	0.3375 (0.3141)	0.0636 (0.0405)	0.1707 (0.1719)
β_2	0.0953 (0.0990)	0.3008 (0.2467)	0.0491 * (0.0294)	0.3193 * (0.1663)
s_{21}	-	-	-	0.6934 * (0.3759)
Mean log likelihood	-1.55225	-1.54258	-1.52807	-1.52188

NOTE: Robust standard errors are in parenthesis
*** 1% level of significance
** 5% level of significance
* 10% level of significance

The true correlation between α_{0n} and β_{0n} is, as explained in equations [3.18] and [3.20], equal to the product $s_{11}s_{21}$ and by applying derivative rule is found to be insignificant.

Table 7. Predictions from model 3,4,5, and 6.

Variable means	Observed	MODEL 3	MODEL 4	MODEL 5	MODEL 6
P(E)	0.10166920	0.1017	0.1014	0.1023	0.1018
P(H)	0.89833080	0.8983	0.8986	0.8976	0.8982
L_H	1776.2421	1754.3465	1755.9296	1754.9246	1753.24
$L_H\|H$	1768.2409	1768.2409	1770.76	1765.2506	1764.27
L_E	7.8581184	23.5723	27.56	29.05	29.63
$L_E\|E$	77.291045	231.823	271.7253	283.9511	290.92
T|H (average tax paid by non evaders)	98009.811	98965.8	99103.231	98549.518	98561.883
T|E (average tax paid by evaders)	91902.805	88380.044	88570.629	92164.112	91182.248
$T_H\|E$ (average true amount of tax evaders should pay)	97130.220	104380.64	1074492.18	112433.13	111736.11
T (overall average tax)	97388.917	97889.55	98032.39	97900.319	97811.601
EVASION= $T_H\|E$-T|E	5227.4149	16000.6	18921.54	20269.015	20553.86

Table 8. Estimates from model 7,8,9,10.

	MODEL 7	MODEL 8	MODEL 9	MODEL 10
Z_3	0.0171	-0.0707	0.1302	0.0340
(salaried)	(0.4073)	(0.4313)	(0.4373)	(1.6781)
Z_1	0.5650	0.5731	0.6290*	1.8452
(socially acceptable)	(0.3637)	(0.3830)	(0.3641)	(1.3678)
Z_2	1.7584***	1.8230***	1.8337***	10.1829***
(incline to evade)	(0.3541)	(0.3710)	(0.3654)	(4.7857)
δ_0	-6.0229***	-6.2515***	-6.4545***	-23.4512***
	(0.4584)	(0.5103)	(0.4949)	(8.2124)
α_0	3.4077***	5.6827***	6.0703***	5.0879***
	(0.3484)	(0.6896)	(0.7690)	(0.5490)
π_{0n}	-	2.6573***	2.9322***	2.7611***
(i.e. s_{11})		(0.4146)	(0.4865)	(0.4719)
γ	-13.7116***	-10.5529***	-10.2616***	-19.3860***
	(3.0216)	(2.2414)	(2.1518)	(1.8476)
β_0	0.1175	0.5405	0.6236	0.0335
	(0.1230)	(0.4351)	(0.4821)	(0.0233)
η_{0n}	-	-	-	0.0274
				(0.0177)
β_1	0.0909	0.3489	0.4138	0.0296
	(0.1057)	(0.3224)	(0.3667)	(0.0227)
β_2	0.0944	0.3086	0.3574	0.0205
	(0.0988)	0.2517	(0.2802)	(0.0152)
s_{31} †	-	-	-0.5928	-
			(0.3639)	
μ_H	1.0000	1.0000	1.0000	1.0000
	(normalized)	(normalized)	(normalized)	(normalized)
μ_E	0.3341	0.7045***	0.5562**	11.2549***
(i.e. s_{33})	(0.2884))	(0.2881)	(0.2266)	(4.1711)
Mean log likelihood	-1.55208	-1.54209	-1.53973	-1.52479

NOTE:Robust standard errors are in parenthesis. *** 1% level of significance,** 5% level of significance,* 10% level of significance.

†In model 9 the Cholesky composition of random terms follows equation [3.18]. Therefore, $Cov(\alpha_{n0}, \mu_E) = Cov(\varepsilon_H, \varepsilon_{\alpha no}) = s_{11}s_{31}$, where s_{11} is the coefficient of π_{no}. The standard deviation of nest error term μ_E is equal to $\sqrt{s_{31}^2 + s_{33}^2}$. Variance-covariance matrix of s_{11},s_{31} and s_{33} is:

$$Var(s_{ij}) = \begin{pmatrix} 0.238 & 0.07 & 0.014 \\ 0.07 & 0.1323 & 0.0042 \\ 0.014 & 0.0042 & 0.0513 \end{pmatrix}$$

By applying derivative rule, see Revelt, and Train (1998), we have that Cov(ε_{no}, μ_E)=-1.73 with a standard deviation of 0.98, thus significant at 10% level. The standard deviation of nest error term μ_E is equal to 0.8132 wit h a standard deviation of 0.29, hence significant at 1% level.

Table 9. Predictions from model 7,8,9,10.

Variable means	Observed	MODEL 7	MODEL 8	MODEL 9	MODEL 10
P(E)	0.10166920	0.1016	0.10148074	0.10256140	0.10137376
P(H)	0.89833080	0.8984	0.89851926	0.89743860	0.89862625
L_H	1776.2421	1754.38	1755.6646	1757.8127	1755.1890
L_H|H	1768.2409	1769.95	1770.8988	1782.0008	1767.3033
L_E	7.8581184	23.57	27.553942	26.082517	28.222954
L_E|E	77.291045	231.80	271.51893	254.31124	278.40492
T|H (average tax paid by non evaders)	98009.811	98968.22	99111.562	99760.887	98786.642
T|E (average tax paid by evaders)	91902.805	88382.84	88352.890	84312.406	90243.736
T_H|E (average true amount of tax evaders should pay)	97130.220	104382.38	107260.23	102009.00	109937.38
T (overall average tax)	97388.917	97892.017	98017.736	98190.252	97918.092
EVASION= T_H|E-T|E	5227.4149	15999.532	18907.336	17696.590	19693.642

Table 10. Estimates from model 11,12.

	MODEL 11	MODEL 12
Z_3	-0.0212	0.1437
(salaried)	(0.3604)	(0.4631)
Z_1	0.4849	0.6451
(socially acceptable)	(0.3298)	(0.3941)
Z_2	1.5829***	1.9212***
(incline to evade)	(0.3263)	(0.4897)
δ_0	-5.7173***	-6.566***
	(0.4072)	(0.8537)
α_0	1.3636***	1.3765***
	(0.1086)	(0.1066)
π_{0n}	-0.3741***	-0.3880***
(i.e. s_{11})	(0.0608)	(0.0687)
γ	-12.5826***	-12.5933***
	(2.7373)	(2.7385)
β_0	0.2060	0.2043
	(0.1964)	(0.1939)
β_1	0.1532	0.1606
	(0.1637)	(0.1668)
β_2	0.1487	0.1542
	(0.1431)	(0.1459)
$s_{31}^{\dagger}$	-	0.6769
		(0.5400)
μ_H	-	1.000
		(normalized)
μ_E	-	-0.7954
(i.e. s_{33})		(0.8721)
Mean α_n	4.1922	4.2706
St.error α_n	0.5282	0.5548
Mean log likelihood	-1.54937	-1.54793

NOTE: *** 1%, ** 5%,* 10%

π_{no} is normally distributed. α_n is log- normally distributed since it is equal to $\exp\left(\alpha_0 + s_{11}\pi_{n0}\right)$. Its mean is equal to $m = \exp(\alpha_0 + (s_{11}\text{^}2)/2)$ and its standard deviation is equal to $st.d = m * \sqrt{\exp((s_{11}\text{^}2) - 1)}$. Variance of the nest error term μ_E and $Cov(\alpha_n, \mu_E)$ computed by applying derivative rule are not significant.

Table 11. Predictions from model 11,12.

Variable means	Observed	MODEL 11	MODEL 12
P(E)	0.10166920	0.1016	0.0946
P(H)	0.89833080	0.8984	0.9054
L_H	1776.2421	1755.89	1752.5772
L_H|H	1768.2409	1771.2134	1756.44
L_E	7.8581184	25.02	26.25
L_E|E	77.291045	246.28	277.512
T|H (average tax paid by non evaders)	98009.811	99075.824	98777.905
T|E (average tax paid by evaders)	91902.805	88509.243	88432.203
T_H|E (average true amount of tax evaders should pay)	97130.220	1055576.54	106666.74
T (overall average tax)	97388.917	98001.528	97726.066
EVASION= T_H|E-T|E	5227.4149	17067.298	18234.538