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ICT and substitution between out-of-home and at-home work: the importance of timing

Thomas de Graaff, Piet Rietveld
Faculty of Economics and Business Administration, Vrije Universiteit Amsterdam, De Boelelaan 1105, 1081 HV Amsterdam, The Netherlands; e-mail: tgraaff@feweb.vu.nl, prietveld@feweb.vu.nl
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Abstract. This paper investigates the determinants of at-home and out-of-home labor supply in the Netherlands in the 1990s, focusing on the presence of information and computer technology (ICT) in households—in particular modem possession. To investigate these determinants, a sequential hurdle model is estimated in which people first decide to work and then decide to divide total labor supply in at-home and out-of-home labor supply. To correct for possible endogeneity, the modem variable is estimated by means of instrumental variables. When we consider only office hours, possession of ICT facilities at home stimulates both at-home and out-of-home labor supply. Thus, the two may be called complements from the ICT perspective. However, outside office hours, modem possession leads to less work out of home. During this part of the day the time worked less on the job is partly substituted by work at home. Thus, during this part of the week we find that substitution dominates. However, because labor supply during office hours dominates labor supply during the rest of the week we find complementarity as the main feature of overall labor supply. These results underline the importance of timing issues.

1 Introduction

In the 1990s use and possession of personal computers and Internet connections became common within households in many countries. It has been argued that this large-scale introduction of information and communication technology (ICT) would have a profound impact on daily activities. For example, claims have been made that ICT in the form of telecommuting would substantially reduce commuting travel (for critical reviews see Hjorthol, 2002; Salomon, 2000). This would imply a shift from out-of-home labor supply to at-home labor supply. ICT connections between home and work include access to the server at the office and to a person's own files and e-mail, and may also enable people to be present (although not physically) at meetings (video-conferencing). On the other hand, the use of ICT could also promote at-home labor supply outside office hours (weekends and evenings) where at-home labor supply is then used to complement out-of-home labor supply. In order to address this issue, this paper focuses on the impact of the use of ICT on at-home labor supply. Special attention is paid to the timing of at-home labor supply and its correlation with out-of-home labor supply.

Unfortunately, statistics about telecommuting are scarce. For illustration, the Ministry of Transport, Public Works and Water Management in the Netherlands[1] has only a rough estimate for the number of teleworkers in the Netherlands in 2001 of about 400 000 workers (which amounts to 3.7% of the labor force). For telecommuting the Ministry uses the following definition: a teleworker is an individual who works partly at home (or somewhere other than at work) and who uses ICT for that purpose.[2] The ministry estimated that on average Dutch teleworkers work one or one and a half days at home per week.

From the policy side the stimulation of telecommuting—and its corresponding shift to at-home labor supply—is advocated as an important policy instrument for reducing

[1] See http://www.minvenw.nl/cend/faz/telewerken/introductie/feitenencijfers.htm
[2] This definition also includes workers who have to work at home because of their occupation.

congestion during peak hours. Traffic intensity in the Netherlands has increased by 44% since 1986, while the total length of the roads increased by only 14% (Ministerie van Verkeer en Waterstaat, 2001). Therefore, as in other European countries, congestion has become a serious policy issue. It has been argued that an increase in telecommuting with its deviant travel pattern in relation to normal commuting patterns could reduce congestion during peak hours, although the empirical basis for this statement is rather weak.

Recently, much research has been done in the field on the adoption of telecommunication (for example, Mokhtarian and Salomon, 1996a; 1996b; Yen, 2000) and whether there is substitution or complementarity between telecommuting and travel behavior (Mokhtarian, 1998; Salomon, 2000). In addition, attention has also been given to the characteristics of individuals who work at home (Bélanger, 1998; DeSanctis, 1984; Olson, 1983; Vilhelmson and Thulin, 2001; Yap and Tng, 1990). However, less research has been done into the impact of the use of ICT on the hours of working at home. Hjorthol's (2002) work is an exception in looking at the relation between daily travel and the use of the personal computer in Norway. Therefore, the aim of this paper is to present an analysis of the hours of working both at home and out of home among the Dutch labor force in relation to ICT. To achieve this, we use a bivariate tobit model with sample selection, in which we are able to relate the decision to work, the number of working hours at home, and the number of working hours out of home. As an approximation for the presence of ICT within households, we use modem possession.

Characteristic of the Dutch labor force are the large number of people who work part-time (especially women) and the flexible behavior of the labor force. However, a substantial part of the female labor population work less hours than men, are more inclined than men to give up their job when conditions in a household change, and have a lagging position on the Dutch labor market in the 1990s (Fortuijn, 1993). Therefore, we look at the male and female labor populations separately. In addition, to examine timing effects, we split our sample into office hours and nonoffice hours.

In the next section we first provide a description of the data we use in this research. In addition, we examine the distribution of ICT appliances across socioeconomic groups in the Netherlands and the distribution of working hours and travel time for an average working day. Thereafter, we proceed with the construction of an econometric model that is able to relate at-home to out-of-home labor supply, taking into account the participation decision. The succeeding section provides the variables used in the model, their measurement, and the corresponding results. The last section concludes and provides a research agenda.

2 ICT in the Netherlands

The data we use were collected in 1995. At that time, the employed workers in the Netherlands worked on average 33.1 hours per week (including overtime). However, large differences can be observed among the population. Women worked on average 26.6 hours per week, whereas men worked 37.3 hours. Individuals who worked part-time spent 20.9 hours per week on their job, full-time workers 40.1, and flexible workers 17.9 hours (CBS, 1997). Although the personal computer was not as common as nowadays, 39% of the Dutch households were already reported to be in possession of a personal computer (for more recent statistics, see SCP, 2002).

The data stem from the 1995 wave of the "Tijdsbestedingsonderzoek" (Time Use Survey), a survey of 3227 individuals, representative of the Dutch population above the age of 12 years. First, a sample of households was selectively chosen and asked to participate by telephone or letter. In a second phase, individuals were chosen randomly from each household. Our sample is a subset of the total database ($n = 3197$) after missing values have been removed. The individuals were supposed to record in a diary

Table 1. Possession of ICT-related appliances for different socioeconomic groups, Netherlands, 1995, $N = 3197$ (source: SCP, 1996).

Variable	Possession of a computer (%)	Possession of a modem (%)	Possession of an Internet connection (%)
Gender			
Male	54.6	14.4	4.3
Female	51.5	12.0	3.4
Partnership			
Partner	53.4	13.7	3.6
No partner	37.1	9.1	3.5
Education			
Basic	21.8	4.6	3.5
Lower vocational	35.8	5.5	1.6
Medium vocational	43.1	10.5	2.0
Craft education	52.9	10.0	2.0
High vocational	56.4	19.1	5.5
College	68.4	18.3	5.4
University	78.6	26.0	9.2
Family income (€)			
<909	33.4	6.6	2.9
909–1364	42.6	7.9	2.2
1364–1818	54.9	12.6	3.8
>1818	68.2	20.6	5.8

their two main activities each quarter of an hour during a whole week, including paid work at home and out of home. About 6% of the total sample report that they are freelancers and a very small percentage (< 1%) report being self-employed. Over half (53%) are in possession of a home computer (so it seems that households with computers are slightly overrepresented compared with the national average), and 13% are in possession of a model; 4% of the individuals report that they have an Internet connection at home.

Table 1 provides a more detailed look into the distribution of personal computers, modems, and Internet connections and shows the differences in personal computer ownership between various groups of household heads. First, females have a slightly lower propensity to own a computer, modem, or Internet connection. Second, people with a higher education have a higher chance of owning a modem and to be active on the Internet. Furthermore, having a higher income also induces people to have a higher propensity to own a personal computer, modem, or Internet account. Therefore, ICT appliances can be characterized as luxury goods, although the small number of observations compels us to be cautious.

As table 2 (see over) shows, those people who work more at home have a higher chance of owning a modem and being active on the Internet. However, those individuals who work mainly at home (more than 24 hours per week) use fewer ICT appliances. Probably, this last category includes mainly workers who only work at home and therefore do not need to communicate with their workplace. Table 2 indicates a significant positive correlation between working at home and possession of ICT appliances. However, a multivariate analysis is needed to investigate the correctness of this hypothesis.

To understand the relation between working at home and out of home over an average working day, figure 1 (over) presents the percentages of the Dutch population working at home, out of home, and the time spent travelling (for all purposes) per quarter of an hour. It shows clearly that the time spent travelling is still dominated by

Table 2. Relation between possession of ICT-related appliances and working time at home, Netherlands, 1995 (source: SCP, 1996).

Hours worked at home per week	Possession of a computer (%)	Possession of a modem (%)	Possession of an Internet connection (%)
0	50.8	11.4	3.1
1–8	64.0	32.0	5.0
9–16	71.2	28.8	8.2
17–24	82.9	44.1	40.0
>24	66.7	31.6	37.1

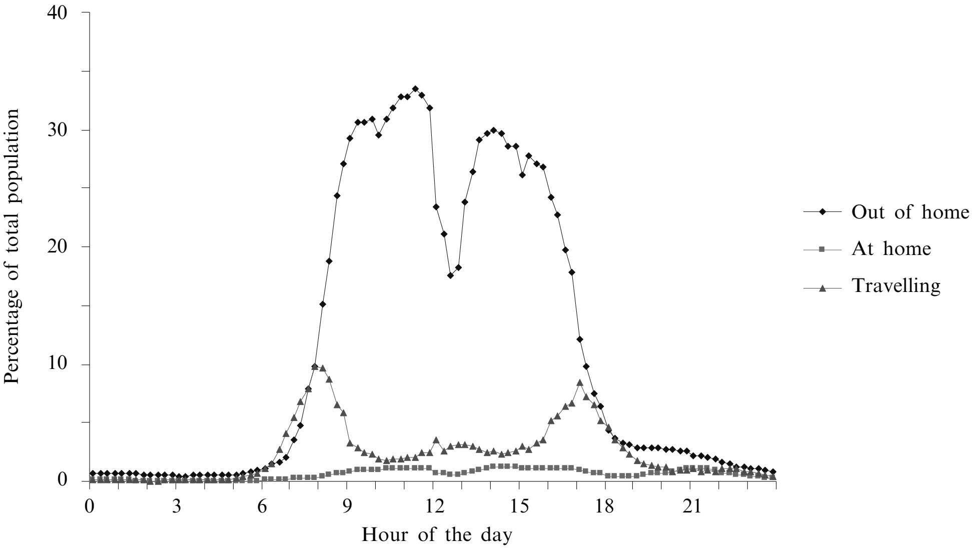

Figure 1. Distribution of (paid) working at home and out of home and travelling (for all purposes) across the day (Monday – Friday average) (source: SCP, 1996).

commuting, as can be concluded from the two peaks at 8 am and 5 pm. Moreover, working at home is highly dominated by working out of home. Only up to 2% of the total sample report working at home. Note, that this is still in line with the 3.7% of the labor force reported by the Ministry of Transport, Public Works and Water Management. In the evening hours the percentage working at home converges to that working outside home, because of those people who continue to work at home after leaving the office. Noteworthy also are the coffee breaks at 10 am and 3 pm, and the sharp lunch break between 12 am and 1 pm for out-of-home workers. To a lesser extent, this behavior can also be observed for at-home working, where there are breaks in the distribution at 12 am and 6 pm, representing lunch time and dinner time, respectively.

In order to gain a better insight into the relations between the location of the workplace and the possession of telecommunication goods, the following section will deal with a joint analysis of at-home and out-of-home labor supply.

3 A correlated system of at-home and out-of-home labor supply

Most likely, the number of hours working at home is related to the number of hours working out of home. There are two opposing hypotheses. First, a working day has a rather fixed number of hours in which one is able to work. Obviously, the amount of time working in an office cannot be used to work at home. On the other hand, people who work much out of home may also be likely to have a higher number of working

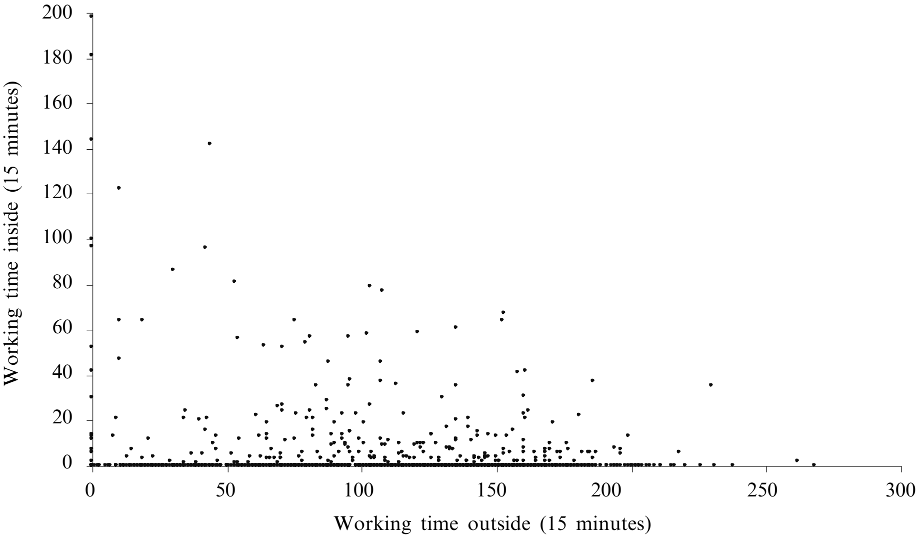

Figure 2. The relation between quarters of an hour working at home (Y) and out of home (X) per week. In regression terms: $Y = 5.88\,(0.74) - 0.027\,(0.006)\,X$, with standard errors in parentheses (source: SCP, 1996).

hours at home, because of unobserved characteristics with regard to, for example, work attitude. Probably, individual preferences towards labor income and leisure time will play a role here. In figure 2 working at home and working out of home are plotted against each other.

Figure 2 clearly shows a statistically significant negative correlation between working at home and out of home. However, the relation is not very strong. A person who works an hour more out of home, works only 97 seconds less at home. A possible explanation could be that those who work in the Netherlands do not work much at home, as has been shown in figure 1. The Dutch work on average slightly less than 1.5 hours at home per week. This all points to a weak negative correlation between at-home and out-of-home labor supply. Note also the many observations in figure 2 positioned on the horizontal and vertical axes. This means that a substantial amount of people work only at home or out of home, instead of a combination of both.

In order to gain some more insight into the determinants of working inside or outside one's home we develop a model where at-home and out-of-home labor supply are analyzed simultaneously. First, denote by y_i^* the desired amount of time spent on work. Then a simple model would look like (compare Greene, 1993):

$$y_i^* = \boldsymbol{\beta}^{\mathrm{T}} \boldsymbol{x}_i + \delta\omega_i + \varepsilon_i \,, \tag{1}$$

where $(\boldsymbol{\beta}, \delta)$ is a vector of parameters, $\boldsymbol{x}_i$ is a vector of the personal characteristics of individual i, ω_i the offered market wage for individual i, and ε_i is drawn from an independent and identically distributed (iid) error term. The regression coefficients in equation (1) depend on whether individuals actually participate in the labor market (see also Heckman, 1979).[3]

[3] Naturally, this is true when individuals are able to adjust their labor supply freely, which seems to apply better to the female labor population (Heckman, 1974; Killingsworth and Heckman, 1986; Renes, 1991). Involuntary unemployment (for example, among males) could prohibit such a participation *decision*. However, unemployment individuals will most likely differ systematically from employed individuals in education level, age, experience levels, and so forth.

In fact, this decision identifies whether the individual's market wage is larger than or equal to his or her reservation wage. That is, if the reservation wage is larger than the market wage, then the productivity of other activities (for example, household work) is always higher.(4) Such a participation decision can then be denoted as:

$$\omega_i - R_i = \gamma^{\mathrm{T}} \boldsymbol{w}_i + u_i \,, \qquad (2)$$

$$z_i = \begin{cases} 1, & \text{if } \omega - R_i \geqslant 0, \\ 0, & \text{otherwise.} \end{cases}$$

Here γ is a vector of parameters, $\boldsymbol{w}_i$ is a vector of personal characteristics of individual i that determine whether i participates in the labor market or not, and u_i is drawn from an iid error term. Here z_i is the observed variable, R_i is the reservation wage of individual i, and ω_i is defined as above. If $\omega_i - R_i \geqslant 0$, then the individual decides to participate in the labor market and $z_i = 1$. Otherwise the observed variable is zero. Assuming that $\delta \neq 0$, a correlation between ε and u causes a selection bias when not accounted for (Pencavel, 1986). To correct for a possible correlation between ε_i and u_i, we assume ε_i and u_i to have the following bivariate distribution:

$$(\varepsilon_i, u_i) \sim \text{bivariate normal}\,[0, 0, \sigma_\varepsilon^2, 1, \rho_{\varepsilon u}]\,.$$

So the variance of the participation decision is assumed to be equal to 1.

Assume that individual i is able to spend his or her desired amount of time working (y_i^*) on both out-of-home (y_{1i}^*) and at-home work (y_{2i}^*), so $y_i^* = y_{1i}^* + y_{2i}^*$. In this case, it depends on the costs of labor supply, y_{1i}^* and y_{2i}^*, whether individuals work at home or out of home. These costs include not only commuting costs, but also office costs, communication costs, and information costs. The timing here is crucial. First, individual i compares the reservation wage R_i with the offered market wage ω_i in order to decide to work or not. Thereafter, individual i decides upon the time spent on out-of-home work y_{1i}^* and on at-home work y_{2i}^*, conditional of course upon the costs of both types of labor supply and the time spent on at-home labor supply and out-of-home labor supply, respectively. This means that, for a given job and person, the reservation wages and the wage rates are the same for at-home and out-of-home labor supply. Such a wage structure applies especially to individuals who accepted a job first and decided at a later stage to telecommute one or two days a week within the same job.

As figure 2 has already shown, not all individuals in the sample work both at home and out of home. On the contrary, one of the two types of labor supply is usually zero. Moreover, both types of labor supply have a positive probability of being zero together. The latter is caused by the small observation period of the individuals (a week). Thus, individuals may not have worked at all because of sickness, holidays, sabbatical leave, etc. Therefore, both y_{1i}^* and y_{2i}^* are censored. Allowing for a correlation between y_{1i}^* and y_{2i}^* leaves us then with a bivariate tobit model (Maddala, 1983):

$$y_{1i}^* = \boldsymbol{\beta}^{\mathrm{T}} \boldsymbol{x}_i + \delta_1 \omega_i + \xi_1 \vartheta_i + \varepsilon_{1i}\,, \qquad y_{2i}^* = \boldsymbol{\beta}^{\mathrm{T}} \boldsymbol{x}_i + \delta_2 \omega_i + \xi_2 \vartheta_i + \varepsilon_{2i}\,, \qquad (3)$$

$$y_{1i} = \begin{cases} y_{1i}^*, & \text{if } y_{1i}^* \geqslant 0, \\ 0, & \text{otherwise,} \end{cases}$$

$$y_{2i} = \begin{cases} y_{2i}^*, & \text{if } y_{2i}^* \geqslant 0, \\ 0, & \text{otherwise,} \end{cases}$$

(4) This applies especially to the female labor force, which appears to be more elastic between household and paid work than the male labor force (Killingsworth and Heckman, 1986). Moreover, there is a larger occurrence of nonstructural unemployment among the male labor force, such as search unemployment and wait unemployment. We will return to these issues below.

with y_{ki}^* $(k = 1, 2)$ a latent variable (the desired number of working hours), y_{ki} the observed variable, subscript 1 for working out of home and subscript 2 for working at home, ϑ_i reflects the presence of ICT at home, and ξ_k is a scalar. Basically, the only addition to equation (1) is that we assume ε_1 and ε_2 to be correlated, with $\rho_{\varepsilon_1\varepsilon_2}$. Now, each individual i has a positive probability on one of the following four possibilities: in the observed week he or she worked only at home or only out of home, he or she did not work, or he or she worked both at home and out of home. Therefore, we distinguish the following four sets:

$$\left.\begin{aligned} S_1 &: y_1 > 0, \quad y_2 > 0, \\ S_2 &: y_1 > 0, \quad y_2 \equiv 0, \\ S_3 &: y_1 \equiv 0, \quad y_2 > 0, \\ S_4 &: y_1 \equiv 0, \quad y_2 \equiv 0. \end{aligned}\right\} \tag{4}$$

In addition to the bivariate tobit model in equations (3) we also incorporate the selection mechanism in the form of a participation decision as denoted in equation (2). The joint likelihood of equations (2) and (3) is now determined by the product of the likelihoods of equations (4), given the decision to participate in the labor population. Now, denote the trivariate density of $(\varepsilon_1, \varepsilon_2, u)$ by $\mathrm{f}(.,.,.)$, the density of the error term in the selection model by $\mathrm{f_z}(.)$ and the error term of the bivariate tobit model by $\mathrm{f_b}(.,.)$. Hence, collecting terms will leave us with the following likelihood (see also Amemiya, 1985, page 385; Maddala, 1983, page 206):

$$\begin{aligned} L &= \prod_{z=0} \mathrm{f_z}(u) \prod_{z=1} \mathrm{f}(\varepsilon_1, \varepsilon_2, u) \\ &= \prod_{z=0} \mathrm{f_z}(u) \prod_{z=1} \mathrm{f_z}(u) \prod_{z=1} \mathrm{f_b}(\varepsilon_1, \varepsilon_2 \,|\, u) \\ &= \prod_{z=0} \mathrm{f_z}(u) \prod_{z=1} \mathrm{f_z}(u) \prod_{S_1 | z=1} \mathrm{f_b}(\varepsilon_1, \varepsilon_2 \,|\, u) \prod_{S_2 | z=1} \int_{-\infty}^{-\boldsymbol{\beta}_2^{\mathrm{T}} \boldsymbol{x}_2} \mathrm{f_b}(\varepsilon_1, \varepsilon_2 \,|\, u) \mathrm{d}\varepsilon_2 \\ &\quad \times \prod_{S_3 | z=1} \int_{-\infty}^{-\boldsymbol{\beta}_1^{\mathrm{T}} \boldsymbol{x}_1} \mathrm{f_b}(\varepsilon_1, \varepsilon_2 \,|\, u) \mathrm{d}\varepsilon_1 \prod_{S_4 | z=1} \int_{-\infty}^{-\boldsymbol{\beta}_1^{\mathrm{T}} \boldsymbol{x}_1} \int_{-\infty}^{-\boldsymbol{\beta}_2^{\mathrm{T}} \boldsymbol{x}_2} \mathrm{f_b}(\varepsilon_1, \varepsilon_2 \,|\, u) \mathrm{d}\varepsilon_1 \, \mathrm{d}\varepsilon_2 \,, \end{aligned} \tag{5}$$

with parameter vector $\boldsymbol{\theta} = (\boldsymbol{\beta}_1, \boldsymbol{\beta}_2, \delta_1, \delta_2, \gamma, \xi_1, \xi_2, \sigma_1^2, \sigma_2^2, \rho_{\varepsilon_1\varepsilon_2}, \rho_{\varepsilon_1 u}, \rho_{\varepsilon_2 u})$. As can be seen in equation (5), because of the assumption of normality of the error terms, each of the subsets S_i can now be rewritten as the product of two conditional normal density or distribution functions (using Bayes's rule).(5) Appendix A provides a more detailed (concentrated) log likelihood.

(5) That is, if ε_1 and ε_2 are normally distributed, $\mathrm{N}(\mu_1, \sigma_1^2)$ and $\mathrm{N}(\mu_2, \sigma_2^2)$, respectively, then

$$\begin{aligned} \varepsilon_1 | \varepsilon_2 &\sim \mathrm{N}\left[\mu_1 + \rho_{\varepsilon_1\varepsilon_2} \frac{\sigma_{\varepsilon_1}}{\sigma_{\varepsilon_2}} (\varepsilon_2 - \mu_2), \sigma_{\varepsilon_1}^2 (1 - \rho_{\varepsilon_1\varepsilon_2}^2)\right] \\ &= \frac{1}{\sigma_{\varepsilon_1} (1 - \rho_{\varepsilon_1\varepsilon_2}^2)^{1/2}} \phi\left\{\left[\varepsilon_1 - \mu_1 - \rho_{\varepsilon_1\varepsilon_2} \frac{\sigma_{\varepsilon_1}}{\sigma_{\varepsilon_2}} (\varepsilon_2 - \mu_2)\right] \Big/ \sigma_{\varepsilon_1} (1 - \rho_{\varepsilon_1\varepsilon_2}^2)^{1/2} \right\}. \end{aligned}$$

Conditioning in a trivariate normal distribution is a straightforward extension (for example, see Greene, 1993, for more details).

The structure of equation (5) resembles the double hurdle or zero-inflated models originally proposed by Cragg (1971) and further developed by Blundell et al (1987) and Blundell and Meghir (1987). However, the double hurdle model is fundamentally different, in assuming an additional probability of the observation being zero. In other words, there are two populations. The first population always displays a zero observation, whereas the second population shows a zero or a positive value, hence the name zero-inflated models. In our case, we do not have to estimate another probability of being zero, because we observe whether individuals work or not.

Our model is more closely related to another set of models, which—rather confusingly—are also called hurdle models and where the outcomes are generated from a sequential decisionmaking process. Yoshida and Guariglia (2002) estimate such a hurdle model with a bivariate tobit structure. The main difference between the model Yoshida and Guariglia use and equation (5) is that we explicitly allow for a correlation between the decision to participate and the number of hours individuals decide to work. In contrast to what is usual in the literature, the tobit structure in equation (5) originates from the division of labor between at home and out of home and the small spell of observation time, instead of the decision not to participate in the labor market. Normally, the comparison between market wages and reservation wages causes a tobit structure, whereafter one may correct for small observations spells, misreporting, etc.

Labor supply can still be underestimated by equation (5). Those who are willing to work could fail to find a suitable job. A possible method to correct for this is the incorporation of an additional probability measure or model in the participation decision (see, for example, Maki and Nishiyama, 1996). Thus, individuals who are willing to work for the market wage face a probability of not finding a job. Such a structure leaves us then with a mixture of a hurdle and a double hurdle model. For reasons of simplicity, we omit this extension. In the next section we first discuss the variables used in the analysis and then present the estimation results.

4 Variables and results

4.1 Variables

In order to address the issue of telecommuting, we focus on the possession of ICT appliances, in this case possession of a modem. Obviously, a person who works at home does not necessarily need to use a modem. However, the definition of telecommuting as cited in the introduction is rather broad and may even involve only a telephone. The hypothesis here is that having more advanced ICT appliances (such as modems) stimulates working at home. A more fundamental problem is the possible endogeneity of modem possession and working at home or out of home. The point is that the decision to work at home could stimulate the purchase of a modem as well as the possibility that owning a modem could induce people to work at home. Therefore, we use an instrumental variable approach to explain the possession of a modem. As well as the usual socioeconomic instruments, we use working or playing with a personal computer for a hobby as an instrument. Obviously, individuals who start teleworking could purchase ICT appliances and may be induced by their presence to spend leisure time with them. However, the reverse relation is much more likely. People who like spending leisure time with ICT appliances already have both the equipment and the knowledge to use ICT to increase their at-home labor supply. Appendix B provides the details of the binary probit regression from which we use the results to construct an (estimated) probability for each individual to possess a modem.

An important explanatory variable in the theory of labor supply is the hourly market wage an individual faces (for example, see Pencavel, 1986). Whether individuals work more or less when their market wage increases is a priori difficult to determine. However, empirical evidence suggests that in the long run individuals work less when the wage rate increases. For example, from 1959 to 1995 net yearly income in the Netherlands per person or couple who received an income increased by 70% (in 1996 prices) whereas the hours worked per full-time worker decreased in the same period by 22%.(6) A possible explanation is that leisure time can be regarded as a luxury good and will therefore increase with the wage rate.(7) Our dataset reports only net household incomes instead of individual wage rates. To estimate individual wage rates, we selected single households and divided the total net income by the contractual number of working hours. Then we carried out a log-linear wage regression on single working individuals from which we used the coefficients to construct the new wage-per-person variable for individuals in all types of households. Appendix C provides the results of the wage regression. In addition to log wages, we also incorporate a non-linear effect in the form of squared log wages in equation (5). That ensures that with higher wages labor supply is able to drop (also called a backward bending effect) as discussed above.

The remainder of the socioeconomic variables used in the specification are all straightforward and conform to intuition. We include a dummy for being married and a categorical variable for the number of children in order to control for household characteristics. The dummy for being a female and the cross effect of being a female with a child under 12 are used to correct for the weaker position of females in the labor market compared with males. We incorporate a categorical variable for the distance to the nearest train station and a dummy for car possession in order to incorporate the generalized costs of commuting. Finally, we correct for education, age, and the type of job the individual has.(8) The latter is incorporated as proxy for sector effects.

For the participation decision, we use the following variables: age dummies, being female, being female and having a child under the age of 12, the urbanization level of the place of residence, having children under the age of 12, a measure for the social class of the household, and the estimated wage rate. The dummies for having a child under 12 and being female are incorporated to correct for the fact that females tend to spend more time on child care than males. The following subsection gives the results.

4.2 Results

Table 3 (see over) presents the maximum likelihood estimates from the log likelihood as denoted in equations (5). We consider the nonfarming labor force, where labor supply is taken over the whole week. For comparison, table D1 in appendix D also presents the maximum likelihood estimates for the labor supply during office hours.

(6) Figures obtained from the website of the Dutch statistical office (CBS) (http://statline.cbs.nl/StatWeb/).

(7) We refer to Becker (1965) for an extensive elaboration of why the number of working hours tends to decline with increasing wage rates.

(8) Our sample also contains self-employed individuals and is here corrected for. Ideally, one would separate the sample in two and run two estimations—as a referee suggested—but unfortunately the number of persons self-employed in our sample is rather small. It even turns out that leaving them out or not does not matter for the estimates. We decided to leave them in because the definition used for teleworking in the first section does not mention the exclusion of self-employed individuals.

Table 3. Correlated tobit estimates of hours per week worked (nonfarming) at home and out of home with sample selection (maximum likelihood estimation: probability values in parentheses).

	Out of home		At home		Participation	
	coeff.	prob.	coeff.	prob.	coeff.	prob.
Constant	−135.04	0.00	−80.27	0.00	−2.82	0.00
Possession of a modem (instrumental variable)	4.53	0.09	13.86	0.00		
Dummy female	−6.77	0.00	0.76	0.28	−0.29	0.00
Dummy married	−1.88	0.00	−0.89	0.18	0.04	0.23
Female × children <12 years	−7.40	0.00	2.36	0.09	−0.60	0.00
Distance to nearest train station	−0.65	0.03	−0.01	0.49		
In possession of a car	1.30	0.00	1.54	0.13		
Urbanization level					−0.04	0.00
Social class					−0.09	0.00
Estimated ln(hourly wage)	156.89	0.00	43.43	0.08	2.09	0.00
Estimated ln(hourly wage)^2	−38.68	0.00	−2.56	0.37		
Occupation dummies (reference: uneducated blue-collar)						
High-skilled white-collar	−0.25	0.01	2.43	0.08		
Medium-skilled white-collar	2.78	0.00	−2.06	0.05		
Low-skilled white-collar	2.15	0.01	−0.69	0.30		
Educated blue-collar	3.84	0.00	1.38	0.19		
Self-employed or freelance	−2.91	0.01	13.04	0.00		
Education dummies (reference: basic)						
Lower vocational	10.16	0.00	−1.06	0.30		
Medium vocational	7.94	0.00	−5.14	0.02		
Craft education	9.52	0.00	−5.59	0.01		
High vocational	9.02	0.00	−5.25	0.03		
College	9.57	0.00	−0.65	0.39		
University	10.82	0.00	−1.00	0.37		
Age dummies (reference <20 years)						
20–30 years	−2.12	0.22	−9.84	0.02	0.78	0.00
30–40 years	−3.84	0.10	−12.84	0.00	0.44	0.00
40–50 years	−2.87	0.16	−14.68	0.00	0.28	0.32
50–60 years	−3.11	0.12	−14.35	0.00	−0.93	0.00
>60 years					−2.58	0.00
σ_{ε_i}	13.91	0.00	13.06	0.00		
$\rho_{\varepsilon_i u}$	−0.22	0.11	−0.12	0.34		
$\rho_{\varepsilon_1 \varepsilon_2}$			−0.03	0.40		
Log-likelihood						1901.96
Pseudo-R^2 [a]						0.39
N						3197

[a] The pseudo-R^2 is defined as: $1 - \ln L / \ln L_0$, where L_0 is the likelihood of the restricted model (with all parameters being zero except the constants).

Table 3 shows that the substitution hypothesis of at-home and out-of-home labor supply over the whole week is not supported ($\rho_{\varepsilon_1 \varepsilon_2}$ is close to zero), although there is a substitution effect for labor supply during office hours (see appendix D). The main result is that modem possession increases latent at-home labor supply by almost 14 hours when measured across the whole week. In addition, possession of a modem also increases latent out-of-home labor supply by 4.5 hours. Given the censoring, these marginal effects reduce to 4.08 and 2.57 hours, respectively. Note that the increase in at-home labor supply is remarkable because of the relatively low level of actual at-home labor supply.[9] Moreover, being in possession of a modem is for at-home labor supply the only significant variable (except for the control dummies), indicating the relative importance of ICT appliances compared with socioeconomic variables.

For out-of-home labor supply, the female dummy and the cross-effect between females and having children younger than 12 years in particular are significant and sizeable, reflecting the still common division of tasks in households in the Netherlands. Commuting costs seem to be especially important for out-of-home labor supply and not significant for at-home labor supply, although the possession of a car seems to increase at-home labor supply marginally. The control dummies indicate that the propensity to work at home increases with education and decreases with age, whereas out-of-home work does not display an obvious structure for age and education level.

The coefficients determining the participation decision are mainly intuitive and significant. Being female, having children younger than 12 years, and being in a low social class[10] lower the propensity of being active in the labor market, which conforms to intuition. The age dummies display a negative relation between age and participation. The higher the age, the less active individuals are in the labor market. After the age of 60 this probability declines very rapidly. Moreover, the higher the estimated hourly wage, the higher the propensity to work. Wages are compared here with the reservation wage and confirms the theory that below a certain wage level individuals stop supplying labor because of opportunity costs of, for example, household activities.

The coefficients of the wage rates for labor supply are intuitively appealing. Figure 3 depicts the simulated relation between wage rate and labor supply for married high-skilled white-collar male workers, with university education, between 30 and 40 years, and in possession of a modem (all other dummies and variables in table 3 are set at zero).

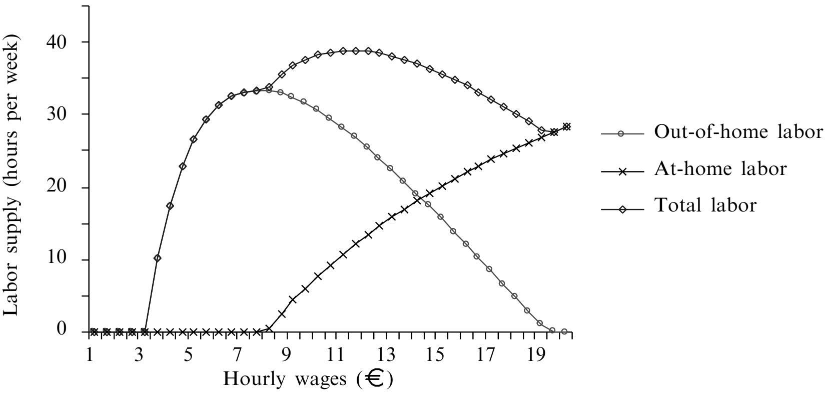

Figure 3. Simulated relations for married high-skilled white-collar male workers, with university education, between 30 and 40 years old, and in possession of a modem between net hourly wages and weekly labor supply, calculated using the estimation results from table 3.

[9] It is also possible to use a personal computer or an Internet account dummy instead of a modem dummy. The two ICT coefficients have the same sign for both the personal computer dummy and the Internet account dummy. Moreover, as one may expect it appears that the personal computer dummy has a lower impact than the modem dummy and the Internet account dummy a higher impact. If we have to extrapolate these results to the current situation, then a broadband connection may have an even higher impact on at-home labor supply. At least it is clear that the more sophisticated the ICT appliance is, the higher the impact. However, whether this should be regarded *relative* to the other ICT appliances in the same period or whether this is an *absolute* process over time remains an issue for further research.

[10] The social class variable (derived from a combination of house ownership, educational attainment, and income) is an interval variable from 1 to 5, where 1 is the highest social class and 5 the lowest.

Clearly, the impact of wages on out-of-home labor supply is much larger than on at-home labor supply. However, there is a back-bending effect in this relation. After approximately a net wage rate of €8 per hour, workers of the type mentioned above tend to supply less out-of-home labor for an increased wage rate. In our sample, the net mean observed wage rate is about €8.03 per hour, which means that the majority of workers are around the out-of-home supply maximum. At-home labor supply does not suffer from such a back-bending effect (at least for realistic hourly wage rates). That is, from approximately €8 per hour workers tend to supply at-home labor, which eventually surpasses out-of-home labor supply (at an estimated wage rate of about €14). A theoretical justification for this result may be that out-of-home labor supply suffers from commuting costs. At a certain wage level, indirect costs of commuting time will simply be too high to sustain out-of-home labor supply. This is especially true with private transport (that is, the car). Although out-of-home labor supply decreases after a certain threshold, total labor supply will eventually increase because of the increase in at-home labor supply. As figure 1 has already shown, at-home labor supply is still a marginal phenomenon compared with out-of-home labor supply. In addition, it appears to be decreasing with age. For example, at-home labor supply for the age group between 50 and 60 years starts at a higher hourly wage rate, which can be estimated at around €8.5. If we do not allow for modem possession, then both supply curves in figure 3 will shift to the right. However, the effect is particularly strong for at-home labor supply, where people start working at home at €12.5 per hour. In addition, the omission of modem possession also causes total labor supply to decrease to less than 30 hours per week.

In the labor-supply literature (see, for example, Killingsworth and Heckman, 1986), the difference between female and male labor supply has often been stressed. In economic terms, females are supposed to have a comparative advantage in household productivity. To investigate to what extent these differences are still present, we split our sample into a male part and a female part.(11) Interestingly, males and females do not have a fundamentally different labor-market supply. Their coefficients for participation and the labor-supply coefficients display similar patterns for most variables.

However, considerable differences exist between male and female supply with regard to the impact of modem possession and the correlation between at-home and out-of-home labor supply for gender differences towards teleworking (see Mokhtarian et al, 1998). In addition to these differences, the timing of labor supply appears to have another crucial influence on the modem coefficients and the correlation between the two types of labor supply. Therefore, we examine the marginal effects of these coefficients (given the censoring) further along two lines: namely, the difference between the male and female labor force and the differences between labor supply during office hours and nonoffice hours.

Table 4 displays the marginal effects of modem possession on actual labor supply and the correlation between at-home and out-of-home labor supply for several subsamples.(12) All other coefficients have been omitted for reasons of clarity. However, they are comparable with those reported in table 3. The results for the modem-possession variable in table 4 can be summarized as follows: first, people with ICT facilities at home tend to work more, both at home and out of home. So in general terms there is

(11) We have not included the results of these estimations in this paper. Results are available from the corresponding author upon request.

(12) Marginal effects are calculated for *actual* labor supply (y), instead of *latent* labor supply (y^*). Therefore, the marginal effect is not ξ_j, but $\xi\Phi(\boldsymbol{\beta}^{\mathrm{T}}\boldsymbol{x}_i/\sigma_j)$, with $\boldsymbol{\beta}$ the vector of all coefficients. Significance levels of the marginal effects are calculated using the delta method (Greene, 1993).

Table 4. Marginal effects of modem possession on labor supply and correlations for men and women during office and nonoffice hours (significant at 5% level in bold).

Samples	Modem coefficient		Correlation between at-home and out-of-home labor supply
	out-of-home labor supply	at-home labor supply	
Total labor force			
Total	4.08	**2.57**	−0.03
Office hours	**7.91**	**0.92**	**−0.23**
Nonoffice hours	**−3.64**	**1.54**	0.13
Male labor force			
Total	4.07	2.77	−0.25
Office hours	**6.09**	0.40	**−0.53**
Nonoffice hours	−1.84	1.56	0.06
Female labor force			
Total	5.41	**1.87**	0.26
Office hours	**9.63**	**0.89**	0.19
Nonoffice hours	**−4.90**	**0.96**	0.26

no sign that ICT leads to less time spent at work; on the contrary. The case for complementarity[13] between work at the two places in view of ICT facilities at home is supported by our research. Second, when we consider only *office hours*, we observe that possession of ICT facilities at home again stimulates both at-home and out-of-home labor supply. The second effect is much larger than the first effect. Thus, owners of ICT facilities tend to have fuller work days during office hours at the workplace than other people, and when they are at home during office hours, they are more often involved in work at home. Third, *outside office hours*, modem possession leads to *less* work out of home. Thus the ICT facilities stimulate people not to be at the workplace. The time worked less is partly substituted by work at home outside office hours. This implies that the overall pattern of complementarity of work at home and out of home because of ICT possession during office hours does not hold during the rest of the week. It is here that substitution dominates. Note, however, that labor supply during office hours dominates labor supply during the rest of the week so that for the overall pattern we find complementarity to be the main feature. For transport, this has two important and rather different implications: namely, modem possession leads to (a) fewer work-related trips at the weekends and (b) changes in timing of commuting trips during weekdays resulting in earlier return trips; this may aggravate afternoon peak congestion.[14] Finally, during office hours modem possession has a larger impact on women compared with men as far as at-home work is concerned. The marginal effect of ICT possession is twice as high for at-home labor supply of females during office hours than for the at-home labor supply of males. Therefore, males seem to be less elastic between

[13] In a strict sense complementarity can be defined in terms of cross-price elasticities of supply or demand being negative. As our model formulation is not in terms of ‘prices’ of at-home versus out-of-home work we cannot apply this standard definition here. Instead we use the term complementarity when a factor X has a positive effect on both at-home and out-of-home labor supply. Thus when factor X stands for ‘possession of ICT equipment at home’ and we find positive effects of X on labour supply at home and out of home we use the term complementarity. When, on the other hand, one effect is positive and the other is negative we use the term substitution.

[14] Along similar lines this may imply a later trip to the workplace because people work at home during the morning peak and leave for work later. This would soften congestion problems during the morning peak.

out-of-home and at-home labor supply during office hours. With respect to nonoffice hours and especially work overall, however, modem possession has a larger impact on men than on women for at-home work.

The correlation coefficient displays a similar pattern across the gender groups. During office hours and overall, at-home and out-of-home work are negatively correlated, especially for the male labor force. However, outside office hours this hypothesis does not hold any more and there is even some (weak) evidence for a positive relation between out-of-home and at-home labor. The following section will sum up the main conclusions and offer some directions for further research.

5 Conclusions and further research

Although the impact of ICT on the Dutch labor market appears to be rather large, teleworking in the Netherlands is still a marginal phenomenon. However, with the ongoing decrease in the costs of ICT appliances and services, the further increase in the flexibilization of the Dutch labor force and the increasing adoption of ICT, figures for teleworking are expected to increase. In order to understand the determinants of teleworking and the possible effects they may have, in this paper we have analyzed the effect of ICT facilities within the household on both at-home and out-of-home labor supply. First of all, it appears that at-home labor supply is rather low in the Netherlands. Second, possession of a modem leads to an increase of both at-home and out-of-home labor supply. Actual at-home labor supply during office hours is increased by about an hour when workers are in possession of a modem. In addition, the possession of a modem increases total at-home labor supply by more than 2.5 hours per week. Modem possession also increases out-of-home labor supply and the effect is larger in absolute terms. However, effects on at-home work may be considered larger in relative terms given the very low average level of at-home labor supply. Moreover, during office hours the availability of ICT seems to have a higher influence on the female than on the male labor force, indicating that females appreciate a higher degree of flexibility more than males.

Typically, higher educated and younger individuals work more at home. In addition, the higher the wage rate, the smaller the out-of-home labor supply and the larger the at-home labor supply. According to the microeconomic framework, costs of out-of-home labor supply (commuting costs, less flexibility, etc) eventually outweigh wages, whereas at-home labor supply becomes more attractive at higher wages. This results in a nonconcave labor-supply function (see figure 3).

Policy measures have been directed to promote teleworking in order to tackle congestion problems. However, subsidizing ICT appliances for households does not seem to be the appropriate measure. Individuals do work more at home because of ICT, but mostly during nonoffice hours (weekends and evenings). ICT facilitates more flexible working hours—which seems especially attractive to the female labor force—so that traffic peaks could be topped off and spread more evenly across the day. But we found also a possible reverse effect: people may avoid overtime work at the job location and return home to continue work at home during the (early) evening. This may cause an increase in the afternoon peak congestion. Therefore, further research into the trade-off between ICT use and commuting with special attention to the timing issue is warranted.

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Appendix A
The log likelihood

Before presenting the log likelihood we have first to construct the following submatrices from the variance–covariance matrix from the trivariate distribution function $f(\varepsilon_1, \varepsilon_2, u)$:

$$\boldsymbol{\Sigma}_{\varepsilon_1} = \begin{bmatrix} \sigma_{\varepsilon_1\varepsilon_2} \\ \sigma_{\varepsilon_1 u} \end{bmatrix}, \quad \boldsymbol{\Sigma}_{\varepsilon_2} = \begin{bmatrix} \sigma_{\varepsilon_1\varepsilon_2} \\ \sigma_{\varepsilon_2 u} \end{bmatrix}, \quad \boldsymbol{\Sigma}_{\varepsilon_1\varepsilon_1} = \begin{bmatrix} \sigma^2_{\varepsilon_2} & \sigma_{\varepsilon_2 u} \\ \sigma_{\varepsilon_2 u} & 1 \end{bmatrix}, \quad \boldsymbol{\Sigma}_{\varepsilon_2\varepsilon_2} = \begin{bmatrix} \sigma^2_{\varepsilon_1} & \sigma_{\varepsilon_1 u} \\ \sigma_{\varepsilon_1 u} & 1 \end{bmatrix},$$

where $\sigma_{\varepsilon_1\varepsilon_2}$ is the covariance between ε_1 and ε_2. After basic manipulation with the normal distribution function, the concentrated log likelihood then amounts to:

$$\begin{aligned}
\ln L = & \sum_i (1 - z_i) \ln \Phi(-\boldsymbol{\gamma}^{\mathrm{T}} \boldsymbol{w}_i) + \sum_i z_i \ln\left[1 - \Phi(-\boldsymbol{\gamma}^{\mathrm{T}} \boldsymbol{w}_i)\right] \\
& + \sum_{i \mid S_1, z_i = 1} \left\langle \ln\left[\frac{1}{\sigma_{\varepsilon_1}(1 - \rho^2_{\varepsilon_1 u})^{1/2}}\right] + \ln\phi\left[\frac{y_{1i} - \boldsymbol{\beta}^{\mathrm{T}}_{1i}\boldsymbol{x}_{1i} - \rho_{\varepsilon_1 u}\sigma_{\varepsilon_1}(1 - \boldsymbol{\gamma}^{\mathrm{T}}\boldsymbol{w}_i)}{\sigma_{\varepsilon_1}(1 - \rho^2_{\varepsilon_1 u})^{1/2}}\right]\right. \\
& \left. + \ln\left[\frac{1}{\left(\sigma^2_{\varepsilon_2} - \boldsymbol{\Sigma}^{\mathrm{T}}_{\varepsilon_2}\boldsymbol{\Sigma}^{-1}_{\varepsilon_2\varepsilon_2}\boldsymbol{\Sigma}_{\varepsilon_2}\right)^{1/2}}\right] + \ln\left\{\frac{y_{2i} - \boldsymbol{\beta}^{\mathrm{T}}_{2i}\boldsymbol{x}_{2i} - \boldsymbol{\Sigma}^{\mathrm{T}}_{\varepsilon_2}\boldsymbol{\Sigma}^{-1}_{\varepsilon_2\varepsilon_2}\begin{bmatrix} y_{1i} - \boldsymbol{\beta}^{\mathrm{T}}_{1i}\boldsymbol{x}_{1i} \\ 1 - \boldsymbol{\gamma}^{\mathrm{T}}\boldsymbol{w}_1 \end{bmatrix}}{\left(\sigma^2_{\varepsilon_2} - \boldsymbol{\Sigma}^{\mathrm{T}}_{\varepsilon_2}\boldsymbol{\Sigma}^{-1}_{\varepsilon_2\varepsilon_2}\boldsymbol{\Sigma}_{\varepsilon_2}\right)^{1/2}}\right\}\right\rangle \\
& + \sum_{i \mid S_2, z_i = 1} \left\langle \ln\left[\frac{1}{\sigma_{\varepsilon_1}(1 - \rho^2_{\varepsilon_1 u})^{1/2}}\right] + \ln\phi\left[\frac{y_{1i} - \boldsymbol{\beta}^{\mathrm{T}}_{1i}\boldsymbol{x}_{1i} - \rho_{\varepsilon_1 u}\sigma_{\varepsilon_1}(1 - \boldsymbol{\gamma}^{\mathrm{T}}\boldsymbol{w}_i)}{\sigma_{\varepsilon_1}(1 - \rho^2_{\varepsilon_1 u})^{1/2}}\right]\right. \\
& \left. + \ln\Phi\left\{\frac{-\boldsymbol{\beta}^{\mathrm{T}}_{2i}\boldsymbol{x}_{2i} - \boldsymbol{\Sigma}^{\mathrm{T}}_{\varepsilon_2}\boldsymbol{\Sigma}^{-1}_{\varepsilon_2\varepsilon_2}\begin{bmatrix} y_{1i} - \boldsymbol{\beta}^{\mathrm{T}}_{1i}\boldsymbol{x}_{1i} \\ 1 - \boldsymbol{\gamma}^{\mathrm{T}}\boldsymbol{w}_i \end{bmatrix}}{\left(\sigma^2_{\varepsilon_2} - \boldsymbol{\Sigma}^{\mathrm{T}}_{\varepsilon_2}\boldsymbol{\Sigma}^{-1}_{\varepsilon_2\varepsilon_2}\boldsymbol{\Sigma}_{\varepsilon_2}\right)^{1/2}}\right\}\right\rangle \\
& + \sum_{i \mid S_3, z_i = 1} \left\langle \ln\left[\frac{1}{\sigma_{\varepsilon_2}(1 - \rho^2_{\varepsilon_2 u})^{1/2}}\right] + \ln\phi\left[\frac{y_{2i} - \boldsymbol{\beta}^{\mathrm{T}}_{2i}\boldsymbol{x}_{2i} - \rho_{\varepsilon_2 u}\sigma_{\varepsilon_{21}}(1 - \boldsymbol{\gamma}^{\mathrm{T}}\boldsymbol{w}_i)}{\sigma_{\varepsilon_2}(1 - \rho^2_{\varepsilon_2 u})^{1/2}}\right]\right. \\
& \left. + \ln\Phi\left\{\frac{-\boldsymbol{\beta}^{\mathrm{T}}_{1i}\boldsymbol{x}_{1i} - \boldsymbol{\Sigma}^{\mathrm{T}}_{\varepsilon_1}\boldsymbol{\Sigma}^{-1}_{\varepsilon_1\varepsilon_1}\begin{bmatrix} y_{2i} - \boldsymbol{\beta}^{\mathrm{T}}_{2i}\boldsymbol{x}_{2i} \\ 1 - \boldsymbol{\gamma}^{\mathrm{T}}\boldsymbol{w}_1 \end{bmatrix}}{\left(\sigma^2_{\varepsilon_1} - \boldsymbol{\Sigma}^{\mathrm{T}}_{\varepsilon_1}\boldsymbol{\Sigma}^{-1}_{\varepsilon_1\varepsilon_1}\boldsymbol{\Sigma}_{\varepsilon_1}\right)^{1/2}}\right\}\right\rangle \\
& + \sum_{i \mid S_4, z_i = 1} \left\{ \ln\Phi_2\left[\frac{y_{1i} - \boldsymbol{\beta}^{\mathrm{T}}_{1i}\boldsymbol{x}_{1i} - \rho_{\varepsilon_1 u}\sigma_{\varepsilon_1}(1 - \boldsymbol{\gamma}^{\mathrm{T}}\boldsymbol{w}_i)}{\sigma_{\varepsilon_1}(1 - \rho^2_{\varepsilon_1 u})^{1/2}}, \frac{y_{2i} - \boldsymbol{\beta}^{\mathrm{T}}_{2i}\boldsymbol{x}_{2i} - \rho_{\varepsilon_2 u}\sigma_{\varepsilon_2}(1 - \boldsymbol{\gamma}^{\mathrm{T}}\boldsymbol{w}_i)}{\sigma_{\varepsilon_2}(1 - \rho^2_{\varepsilon_2 u})^{1/2}},\right.\right. \\
& \left.\left. \frac{\rho_{\varepsilon_1\varepsilon_2}\sigma_{\varepsilon_1}\sigma_{\varepsilon_2} - \rho_{\varepsilon_1 u}\sigma_{\varepsilon_1}\rho_{\varepsilon_2 u}\sigma_{\varepsilon_{21}}}{\sigma_{\varepsilon_1}(1 - \rho^2_{\varepsilon_1 u})^{1/2}\sigma_{\varepsilon_2}(1 - \rho^2_{\varepsilon_2 u})^{1/2}}\right]\right\}, \qquad \text{(A1)}
\end{aligned}$$

where ϕ denotes the standard normal density function, Φ the standard normal distribution function and Φ_2 the standard bivariate normal distribution function. The first two terms in equation (A1) represent the chance of being employed and the last four terms are the likelihood for each set $S_j (j = 1, ..., 4)$ given that individual i is employed. Note that we condition over u, instead of over $(\varepsilon_1, \varepsilon_2)$. The latter would be intrinsically incorrect because $f(\varepsilon_1, \varepsilon_2)$ is not normally distributed because of the censoring, whereas the errors terms in each subset S_j do have a normal distribution.

Appendix B
The modem equation

In order to find instruments for the possession of a modem variable, we first carry out a bivariate probit regression on the possession of a modem. Table B1 reports the results. Denote by $\mathbf{X}_m$ the matrix of exogenous variables and by $\hat{\boldsymbol{\beta}}_m$ the vector of estimated coefficients. Then the estimated probability of owning a modem boils down to $\Phi(\mathbf{X}_m \hat{\boldsymbol{\beta}}_m)$.

Table B1. Maximum likelihood results of a probit regression on the possession of a modem (significant at 5% level in bold).

	Coefficient	Standard error
Constant	**−0.94**	0.18
Age (/100)	**−0.52**	0.22
Dummy female	0.05	0.06
Urbanization level	0.01	0.01
Social class	**−0.22**	0.03
Dummy children <12 years	−0.06	0.06
Dummy employed	**0.25**	0.07
Dummy computer for a hobby	**0.64**	0.06
Log likelihood		1108.84
Pseudo-R^2		0.10
N		3197

Appendix C
The wage equation

In order to obtain individual wages, we carry out a log – linear wage regression on all single person households, which have reported their wage. Table C1 reports the regression estimates.

Table C1. Ordinary least squares results of a log – linear wage regression (significant at 5% level in bold).

	Coefficient	Standard error
Constant	**0.82**	0.23
Age	**0.05**	0.01
Age^2	**0.00**	0.00
Dummy female	**−0.08**	0.03
Education dummies		
Lower vocational	−0.01	0.08
Medium vocational	0.14	0.08
Craft education	**0.14**	0.07
High vocational	**0.26**	0.08
College	**0.24**	0.07
University	**0.32**	0.07
$\bar{R}^2$		0.37
N		205

Appendix D
Estimation for office hours

Table D1. Correlated tobit estimates of hours per week worked (nonfarming) at home and out of home with sample selection (maximum likelihood estimation; probability values in parentheses).

	Out of home		At home		Participation	
	coeff.	prob.	coeff.	prob.	coeff.	prob.
Constant	−129.93	0.00	−50.76	0.07	−2.87	0.00
Possession of a modem (instrumental variable)	9.47	0.00	9.84	0.01		
Dummy female	−5.14	0.00	0.17	0.44	−0.28	0.00
Dummy married	−1.55	0.01	0.04	0.48	0.05	0.19
Female × children <12 years	−7.86	0.00	0.63	0.35	−0.60	0.00
Distance to nearest train station	−0.58	0.03	0.24	0.30		
In possession of a car	1.12	0.09	1.30	0.16		
Urbanization level					−0.04	0.00
Social class					−0.09	0.00
Estimated ln (hourly wage)	138.68	0.00	13.87	0.36	2.11	0.00
Estimated ln $(\text{hourly wage})^2$	−33.79	0.00	2.16	0.42		
Occupation dummies (reference: uneducated blue-collar)						
High-skilled white-collar	1.82	0.09	2.21	0.09		
Medium-skilled white-collar	4.04	0.00	−1.20	0.16		
Low-skilled white-collar	3.81	0.00	−0.47	0.37		
Educated blue-collar	4.35	0.00	2.30	0.07		
Self-employed or freelance	−2.99	0.00	11.07	0.00		
Education dummies (reference: basic)						
Lower vocational	9.65	0.00	−2.21	0.13		
Medium vocational	8.13	0.00	−4.02	0.03		
Craft education	8.79	0.00	−3.17	0.05		
High vocational	10.35	0.00	−2.99	0.12		
College	10.82	0.00	0.56	0.39		
University	12.65	0.00	0.66	0.40		
Age dummies (reference: <20 years)						
20–30 years	0.94	0.31	−2.76	0.28	0.76	0.00
30–40 years	−0.29	0.43	−4.54	0.17	0.42	0.00
40–50 years	0.14	0.47	−6.38	0.06	−0.11	0.27
50–60 years	−0.12	0.47	−6.94	0.02	−0.95	0.00
>60 years					−2.62	0.00
σ_{ε_i}	12.66	0.00	11.11	0.00		
$\rho_{\varepsilon_i u}$	−0.14	0.18	0.12	0.35		
$\rho_{\varepsilon_1 \varepsilon_2}$			−0.23	0.00		
Log-likelihood						1744.55
Pseudo-R^2						0.40
N						3197