Lower Wages for Less Hours ?

A simultaneous wage-hours model for Germany

preliminary version — please do not quote —

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Abstract:

In this paper the impact of working hours on the gross hourly wage rate of West German women is analyzed. We use a simultaneous wage-hours model which also takes into account the participation decision. Furthermore, we check if the effect of working hours on wages depends on individual characteristics, such as human capital, firm size or industry sector.

We can conclude that in our preferred specification, the exogeneity assumption of working hours in the wage regression does not really cause a problem for the estimation of the wage differentials between part-timers and full-timers. However, if it is assumed that the effect of working hours on the hourly wage rate is the same for all individuals, the labor supply decision should be fully taken into account. Our estimates show that the hourly wage rate is strongly affected by the working hours. Further we detect different wage-hours profiles for some specific groups. Depending on the specification and the selected group, the wage rate increases with rising working hours up to a threshold which varies between 21 and 34 hours a week. Taking into account the measurement error in working hours moderates the high wage reductions for long working weeks.

1. Introduction

Whether part-time workers earn lower wages than full-timers is an often discussed issue by workers, employers and policy makers. In Germany, this topic does not only concern people in marginal jobs, that is, employees who work below the threshold for social security coverage, but also those working less than the standard working hours which are fixed by collective agreements. The question about the existence and the size of the wage differentials among jobs with different working hours is exciting itself, but it becomes even more urgent since it has far-reaching implications for the labor supply decision of individuals. Negative wage premiums for part-time jobs, for example, would decrease the labor supply for those jobs. In this setting, people would tend to work either full-time or leave the labor market.

In Germany, the part-time rate for women was about 33.9 percent in 1995, though there still exist substantial differences between East and West Germany. In East Germany, only 20.8 percent of the employed women worked part-time, in West Germany the part-time rate was 37.3 percent. Compared to women, the part-time rate of men is much lower and varies between 2.9 percent in East Germany and 3.2 percent in West Germany. Given that part-time work is not very widespread in Germany, it may be argued that possibly negative wage differentials induce people to work either full-time or not to work. The object of this paper is to check whether the Germans earn lower wages for less hours. We confine ourselves to West-German women, because the other groups of part-time workers are too small to draw convincing results.

In the literature, we can find several explanations for a dependence of wages on hours. One point is that the labor costs of the firm do not increase proportionally with hours worked, because part-time jobs cause relatively higher fixed costs to the firm (e.g. recruiting and training costs, arranging a work-place and coordination costs). Therefore, Oi (1962) draws the conclusion that lower wage rates are paid at low hours of work than at high hours of work. On the other hand, the amount of working hours may also influence productivity. Barzel (1973) argued that marginal productivity declines at sufficiently high working hours, resulting in a lower marginal wage rate for overtime hours. His model further suggests that the productivity of the last hour of a "normal" working day exceeds the average daily productivity, which leads to lower wage rates for part-time workers. Contrary to this result, Tummers and Woittiez (1991) argue that also reduced working hours may raise hourly productivity because they avoid the negative fatigue effect of a long working day or they may reduce unproductive time, or "slack". In this case, gross part-time wages - given they are based on labor productivity - should be higher. In Germany, the lump sum taxation of jobs without social security coverage, the so called marginal jobs, provides another reason for a wage reduction for these jobs. Empirical results lead one to suppose that employers shift the entire tax burden (15 percent of the gross wage rate in 1995) on to employees. As a result of this, the hourly wage rates of these jobs are about 15 percent below those for comparable full-time jobs. Another explanation for wages dependent on hours is based on the idea of compensating wage differentials or a potential lack of part-time jobs. In short, there are reasons for supposing that there exist substantial wage differences between full-time and part-time jobs in Germany, and especially between jobs with and without social security coverage. According to the importance of the different effects, the resulting wage differentials could be either positive or negative.

However, most empirical labor market studies, especially for Germany, ignore that wages might be affected by the weekly working hours. Recent exceptions include Schwarze (1998) and Wolf (1998) for Germany, Tummers and Woittiez (1991) for the Netherlands, Blank (1990) and Averett/Hotchkiss (1997) for the US, Main (1988) and Ermisch/Wright (1993) for Great Britain and Ilmakunnas/Pudney (1990) for Finland. Most analyses suggest that jobs with less hours are paid by a lower hourly wage rate. Even so, there exist contradicting evidence. The results differ strongly between countries, sex and the various econometric methods. In addition, it turned out that in order to fully measure the effect of working hours on wages, the labor supply decision must be taken into account. For Germany, a study which considers that the working hours are not exogenous, but result from the utility maximization process of the individuals does not exist yet. The aim of this paper is to close this gap in the German empirical literature.

The paper is organized as follows. In the next section, we show how the impact of hours on wages can be captured empirically and in section 3, the data underlying the empirical part of the paper are described. Section 4 presents the econometric model. The estimation results are discussed in section 5. The last section summarizes the findings and concludes.

2. How to capture the impact of hours on wages empirically

A simple way to capture the effect of hours on wages would be to include the weekly working hours as exogenous variable in the standard wage equation. Schwarze (1998), for example, used dummy variables to capture the effect of marginal jobs and part-time work on the hourly wage rate. The coefficients turned out to be significantly negative, that is, people with reduced working hours earn lower wages, even if he controls for differences in human capital and other wage determining variables. However, these results could be extremely biased. Analyzing the impact of working hours on wages, we have to deal with two problems.

First, economic theory suggests that individuals share their time among leisure and working hours h in such a way that their utility function $U(h, Y)$ is maximized. Y describes the corresponding labor earnings plus the non-labor income. Even if employees cannot always freely choose their working hours, the assumption of exogenous hours is too restrictive. The labor supply decision depends, among others, on the opportunity costs of labor, that is, the hourly wage rate. Thus, working hours themselves depend on the potential market wage rate. In this setting, the two variables of interest are mutually dependent. Ignoring this relation may produce misleading results.

Second, provided that wage differentials among jobs with different working hours do exist, they also determine the decision to enter the labor market. These two considerations suggest that the labor supply decision must be fully taken into account. Thus, the traditional single-equation wage function is not an appropriate approach.

As a result, some economists attempt to tackle the problems of the standard approach. The new models differ in that the hours equation is specified either as a discrete choice model or as a continuous model and whether selection on the labor market is explicitly taken into account.

An easy methodology to account for the endogeneity of hours is to generate an instrumental variable representing the expected working hours of each employee. This instrument can be created using a set of variables that are correlated with the working hours but not with the hourly wage rate. In the context of working hours and wage rates it is extremely difficult to find appropriate instruments because hours and wages are mutually dependent. However, if the instrument is only weakly correlated with the hours, the IV-approach can produce biased estimates of the coefficients in the wage equation (Staiger/Stock, 1997). Biddle and Zarkin (1989) applied the IV-approach to estimate a wage-hours model for American men. Their empirical results strongly reject the neoclassical assumption that wages are independent of hours worked. Instead, their estimates imply that the wage-hours relation is dome shaped with a peak at about 2500 annual hours. In addition they find that OLS estimates are biased. However, applying the TSLS method, the compositional differences between part-time and full-time workers are ignored. Another drawback of this procedure is that the results are only based on observed wages. Because both observed wage rates and working hours are conditional upon a person's decision to work, the problem of selectivity bias should be taken into account. Hence a participation equation must be specified and the standard errors in the wage equation have to be corrected in a complicated way. Averett and Hotchkiss (1997) criticize further that the IV-approach fails to account for a discontinuous budget curve if necessary. Therefore, they suggest to estimate a sequentially ordered response selectivity model. By this means they switch to the discrete choice method for the hours estimation and obtain selectivity-corrected full-time and part-time wages for all observations.

An alternative approach is a joint wage-hours model. Moffit (1984) combines a discrete labor supply model with a wage-hours locus offered by the employer. These two functions are estimated simultaneously. The results confirm Barzel's hypothesis of an S-shaped budget constraint. Hourly wages of older women in the US rise with hours at a slowing rate and peak at about 34 hours per week. The drawback of this model is that the working hours and the participation decision are determined by the same set of variables. In view of the fixed costs of work and involuntary unemployment one would expect that the worker's choice of hours is separately determined from the (partly involuntary) decision to work or not to work. Tummers and Woittiez (1991) tackle this problem by estimating a simultaneous wage and labor supply model with hours restrictions. They show that in the Netherlands the before-tax hourly wage rate is highest for women working 28 hours a week and slopes downwards for additional hours.

A two stage discrete choice approach was estimated by Simpson (1986) and Main (1988). They adopt a model for wage comparison with selection bias which is extensively used for union and non-union wage differentials (Lee, 1978). Separate wage equations are estimated for full-time and part-time workers - including an inverse Mills ratio capturing the potential selection bias. The results indicate that the wage differential between part-time and full-time workers in Canada decreases from 13 to 10 percent after adjusting for the selectivity. Main (1988) concludes that full-time jobs of British women are paid 15 percent more than part-time jobs - half of the total differential is due to the differential way in which part-time jobs paid less for the same characteristics than full-time jobs. A comparable study for British women establishs smaller differentials between full-time and part-time workers (Ermisch/Wright, 1991). Even so, the analysis indicates that the differences in women's expected wage offers are a crucial determinant of wether they work part-time or full-time. Blank (1990) extends this discrete choice approach to a simultaneous model which contains three endogenous variables, that is, participation, part-time work and the wage rate. Apart from the switching function for the different labor supply regimes, the decision to enter the labor market is specified in a separate equation. This enables her to measure the effect of part-time work on wages in such a way that the selection into part-time work is fully taken into account. In contrast to other studies, their results indicate that once the choices to enter the labor market and to work part-time are accounted for, part-time female workers in the US appear to earn higher wages across all occupations than equivalent full-time workers. The fact that accommodating the selection into part-time jobs reverses the outcome implies that those women who work part-time would also receive lower wages if they held a full-time job. Furthermore, this endogenous switching regression model of Blank (1990) provides different coefficients of the wage equation for part-timers and full-timers.

As we are not only interested in the effect of part-time work on wages, but rather in the overall relation between working hours and wages, we generalize the model of Blank (1990) with respect to the hours equation. We assume that people choose among all possible number of working hours, not only among part-time and full-time work.[1] This allows for computation of any differentials related to hours worked. We estimate the effect of hours on the wage rate using a simultaneous model of wages, working hours and the selection to enter the labor market. In order to estimate the effect of working hours on wages, we include hours in the wage equation. Further, we use interaction terms between working hours and other exogenous variables to allow for different effects of working hours for different education levels, experience groups, firm sizes or industries. This

[1] Thus, we assume that the limited choice of working hours does not affect the hourly wage rate. This does not mean that hours restrictions do not matter with respect to labor supply.

approach enables us to estimate different wage determination processes for all labor supply regimes, to account for the decision to enter the labor market and to allow for endogenous hours.

3. The data and some descriptive figures about working hours and wages in Germany

The empirical part of the paper is based on the German Socio-economic Panel (GSOEP) for the year 1995. The GSOEP is a yearly household panel which is conducted since 1984 in West Germany, since 1990 also in East Germany. The first wave contains almost 6000 households who lived in West Germany in 1984. The Germans, about 4500 of the interviewed households, were sampled randomly. The other sub-sample is a stratified sample of immigrants and guest-workers from Italy, Spain, Turkey, Yugoslavia and Greece who lived in Germany in the period during which information was collected. Households of other nationalities are represented in the first sample. In this study, we left out the sample of immigrants and guest-workers, because of the non-random selection. The Non-European households are also excluded, because their labor supply behavior and the wage determination may be substantially different from those of Germans. As we are interested in the wage structure of the German labor market, we dropped all self-employed women and those working in the farming sector. Our selected sample contains only women aged between 20 and 60 years who are not in apprenticeship. There remain about 2420 observations of West German women, which provide all necessary informations.

Figure 1 provides a histogram of actual weekly working hours and the mean hourly wage rates in the sample. We generated nine categories of working hours from 1 to 60 hours a week[2] and another group for all people out of work. Women who do not participate at the labor market present about almost 48 percent of

[2] Several women claimed that they work more that 60 hours a week. In view of the legal limit of 60 working hours a week, we censored the weekly hours at the legal threshold.

the sample. The distribution of the weekly working hours has a peak at 36-40 hours, which mainly represents standard full-time jobs. Women with reduced hours are spread over the range of 5 to 35 hours, but most of them work between 16 and 20 hours a week. In view of the fact that agreed working hours never exceed 40 hours a week by law, about 4.4 percent of all women in the sample work overtime.

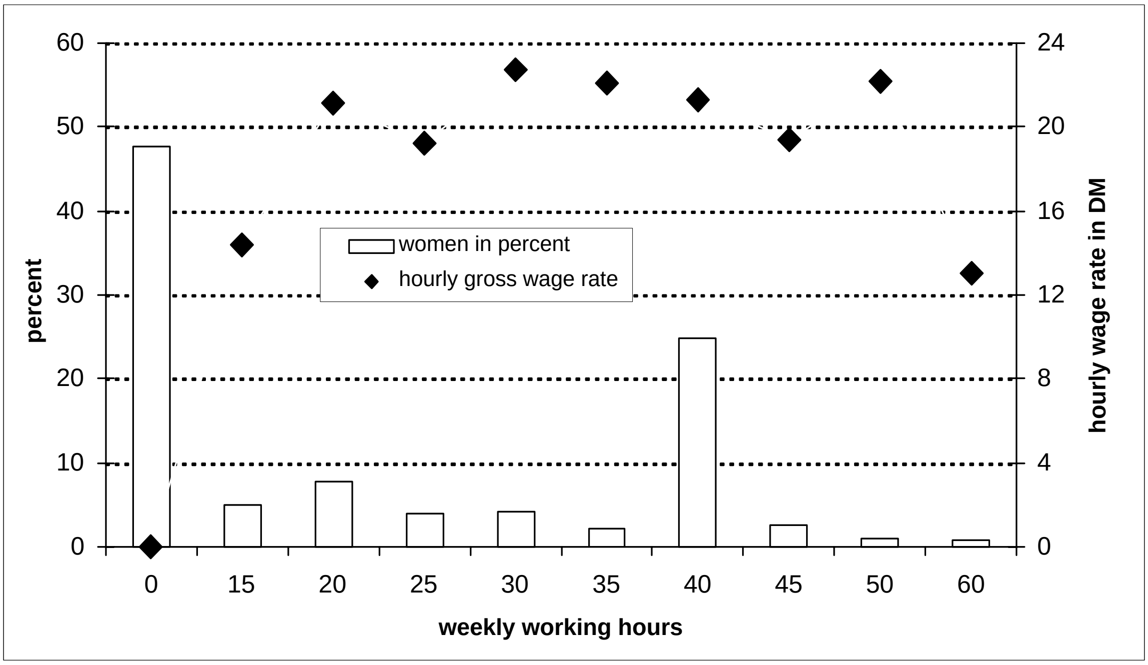

Figure 1: Distribution of weekly working hours and hourly wage rates

The hourly wage rate varies between 13 DM for women working 50 or more hours and almost 23 DM for the employees with 26 to 30 hours a week. Figure 1 further shows that jobs with less hours are paid by lower wages than full-time jobs or extended part-time jobs (30-35 hours). These results suppose that there exist substantial wage differentials among full-timers and employees with very little hours. But also women who work more than 10 overtime hours a week suffer high wage reductions. Let us assume that in principle the overtime hours are compensated with an additional wage premium or if not, occur mainly in managerial jobs, which are already paid at very high wage rates. Thus, one would expect that the hourly wage rate of overtime hours exceeds the earnings from the standard working hours. Our findings lead one to suggest that either the overtime premiums are avoided or that the wage for jobs with "unpaid" overtime work are not as high as expected. This picture may give rise to the supposition that part-time jobs are more often chosen by less qualified and experienced women, so that the wage differentials are caused by selectivity. Therefore, Figure 2 presents the share of the each qualification level in four different labor supply regimes. In contrast with the nine categories in Figure 1, we now create larger groups because of the small number of observations in some cells.

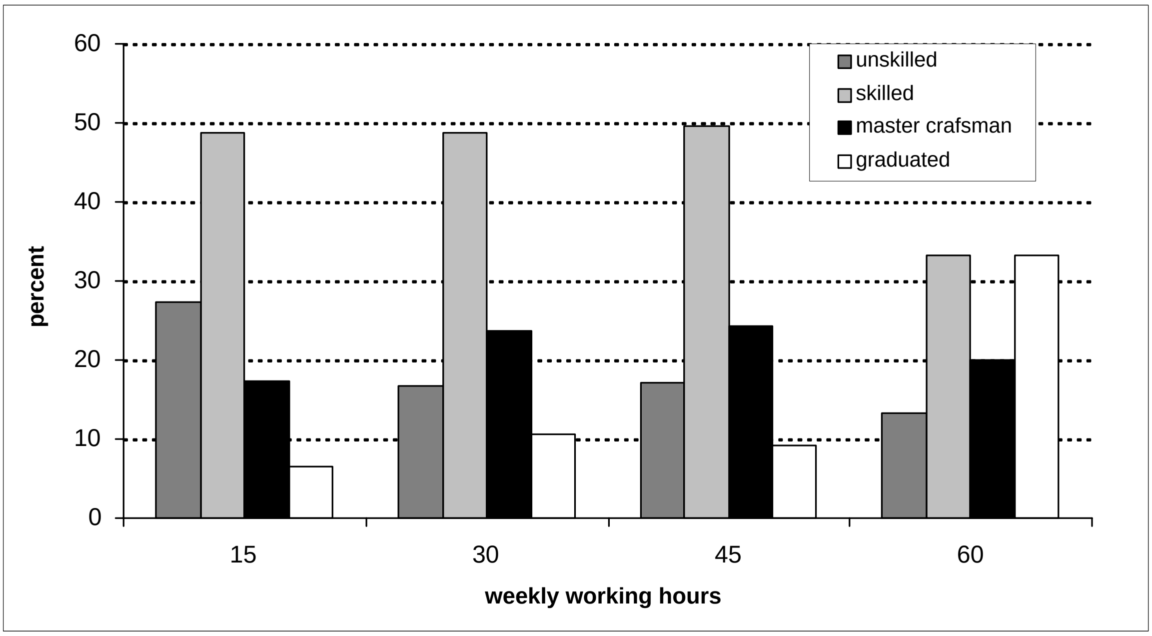

Figure 2: Share of education level by weekly working hours

Apart from the women working overtime hours, the skilled women are the most important group. They represent almost 50 percent of all employees in the first three labor supply categories. In contrast, the shares of the other qualification levels vary more with the number of weekly working hours. 27 percent of the employees with marginal jobs are unskilled, but only 13 percent of those working overtime hours. Thus, the share of unskilled declines with increasing working hours. The opposite is true for the graduated women. The share of graduated women rises from 6.6 percent ($<$ 15 hours) to 10 percent for the standard full-time jobs. As a result, the simple selectivity hypothesis can not fully explain the wage structure. The differences with respect to the qualification level appear to be one possible explanation for the observed wage differentials between small part-time jobs and full-time jobs. However, the wage reductions of over-time jobs must be caused by other factors, such as the endogeneity of the working hours, experience, firm size and industry sector. Hence we will now turn to the econometric model which enables us to detect the wage-hours profiles for different groups of individuals.

4. The econometric model

4.1 Participation

The decision to enter the labor market is modeled by a binary choice approach. The equation of the continuous latent variable is given by:

$$P^{*} = f(Z, \gamma) + v. \tag{4.1}$$

Given involuntary unemployment, the actual labor market participation cannot be interpreted strictly as an individual decision. Thus, the matrix of exogenous variables Z contains both factors which determine the labor supply, such as qualification and the number of small children, and the labor demand, such as the regional unemployment rate. P^* is unobservable but relates to the observable dichotomous variable P (participation status) as:

$$P = \begin{Bmatrix} 0 \text{ if } & P^{*} \leqslant 0 \\ 1 \text{ if } & P^{*} > 0 \end{Bmatrix}$$

4.2 Working Hours

The second equation describes the hours decision. We use a linear specification with actual weekly working hours as dependent variable.[3]

$$h = f(Y, \beta) + u \tag{4.2}$$

where Y is a vector of explanatory variables and β the parameters to be estimated. We specify the reduced form equation of hours worked in a very flexible way, so that it is consistent with almost any structural labor supply model, or is at least a good approximation. The vector Y also includes variables describing the household context, such as the number of small children, the marital status and the other household income. These covariates capture both the opportunity costs of working and the effect of taxation on labor supply. Thus, the coefficients of this equation should not be interpreted in a structural way.

4.3 Wage rates

We estimate a single wage equation for all employees, irrespective of wether they work full-time, part-time or any other number of hours:

$$\ln w = \alpha_1 \cdot X + \alpha_2 \cdot h + \alpha_3 \cdot h^2 + \alpha_4 \cdot X \cdot h + \alpha_5 \cdot X \cdot h^2 + e \tag{4.3}$$

The dependent variable is the log gross hourly wage rate of the employed women. In order to estimate the effect of working hours on wages, we also include hours in the wage equation. Most of the previous studies suggest that hours affect the wage quadratically (Moffit, 1984; Tummers/Woittiez, 1991). Consequently, we also use the quadratic specification of the working hours, which arises from the fixed costs of work on the one hand and the declining marginal productivity at high hours on the other hand (Barzel, 1973). Further, we use interaction terms between the hours and the exogenous variables $\left[(X \cdot h) \text{ and } (X \cdot h^2)\right]$ to allow for different effects of working hours for different education levels, experience groups or firm sizes. If the coefficients α_2, α_3, α_4 and α_5 turn out to be zero, our

[3] Alternatively, the hours decision could be interpreted as a limited choice between a finite number of categories, such as part-time and full-time (see e.g. Blank, 1990). A drawback of this procedure is that assumptions on the frontiers between the different labor supply regimes are required.

wage function is consistent with the standard Mincer earnings function, that is, working hours do not affect the hourly wage rate.

4.4 Properties of the error terms

The error terms of the three equations (e, u, v) are assumed to be trivariate normally distributed with mean zero and covariance Σ. The variance of v ($\mathrm{Var}(v) = \Sigma_{3,3}$) is normalized to one. The three covariances between the error terms are identified by the simultaneous maximum likelihood estimation.

4.5 Measurement error in the hours

One reason for the high wage reductions of overtime hours (see figure 1) could be that the reported working hours do not refer to the earnings in the previous month. Let's assume that a woman usually works 5 paid overtime hours a week. If the employer pays for the overtime hours every month, thus the declared earnings include the payments for the five additional hours, the hourly wage rate is measured exactly. However, this is only one possible agreement about the timing of the overtime reward. There may be also firms which remunerate the overtime hours after they exceed a certain threshold as a result of which the usual working hours do not correspond to the reported earnings. The same problem arises if the additional hours occur very irregularly, that is, during one month 10 weekly overtime hours are worked and zero hours in the other. Since we do not have any information about whether the reported earnings actually include overtime premiums, the match between the observed hours and wages is not absolutely reliable.

In order to check whether these measurement problems reinforce the strong decline in hourly wage rates for long working hours, we slightly modify the econometric model described above. In contrast to the hours equation 4.2 we now take the weekly working hours in logs.[4] Consequently, let's assume that the true

[4] Since the distribution of weekly working hours is two-humped, the normality assumption is violated in either case.

hours[5] h^* relate to the observed hours h as:

$$\log(h) = \log(h^*) + \xi \; ; \tag{4.4}$$

where ξ is the measurement error. Since in our model the hourly wage rate is a function of the working hours, the definition of the wage rate converts into:

$$\log(w) = \log(y) - \log(h) = \log(y) - \log(h^*) - \xi = \log(w^*) - \xi \; . \tag{4.5}$$

Applying these changes to the wage and hours equation discussed above results in the following model:[6]

$$\log(w) = \alpha_1 X + \alpha_2 f[\log(h)] + e - \alpha_2\xi - \xi = \alpha_1 X + \alpha_2 f[\log(h)] + \varepsilon \tag{4.6}$$

$$\log(h) = f(Y, \beta) + u + \xi = f(Y, \beta) + \upsilon \; . \tag{4.7}$$

We can see that the measurement error ξ adds linearly with opposite signs to the two equations and enters the new error terms ε and υ. As a result, the measurement error ξ causes a negative correlation between the wage and the hours equation.[7] Assuming that the measurement error matters, one would expect that the correlation between the two equations is negative, or at least smaller compared to the correlation ρ_{eu}.

[5] That is, the working hours which actually refer to the observed earnings of the previous month.

[6] As the participation equation is not affected by these modifications, we refrain from the repeated presentation of the complete model. For simplicity, we summarize all coefficients capturing the impact of working hours on wages (α_2 to α_5 in equation 4.3) to one coefficient α_2.

[7] This also holds for the previous model (see equations 4.2 und 4.3). However, the error term e of the wage equation is not a linear function of the measurement error ξ, thus the correlation of the measurement errors in the wage and hours equation should be smaller.

5. Estimation results

Before discussing the estimation results, we will briefly address the identification problem. We estimate reduced-form equations of the participation and the hours equation. The wage function is the only structural equation. Therefore, the question is whether the wage equation can be distinguished from a linear combination of all other functions in the simultaneous model. In principle the model is identified by the functional form. In addition to that, we insert several exclusion restrictions. First, we exclude all family characteristics, such as the number of children, from the wage equation. Thus, it is assumed that children affect the wage rate only through the employment break, which is captured by the experience variable. The information about the children living in the household enters the hours and the participation equation in two different ways. For the selection function, we use one variable indicating the age of the youngest child and another for the number of children in the household. This specification serves as a measure of the time need for the children, whereas the number of children by age groups, which enters the hours equation, captures the fiscal effect of the children in the household. Second, the marital status, participation status of the partner[8] and the other household income is excluded from the wage equation. Furthermore, a variable describing the fixed costs of working enters the participation equation. The presence of entrance costs is measured by a dummy variable, indicating whether at least one member of the household is in need of care [9] or whether the observed individual is a lone mother with a child younger than 4 years. In order to capture the labor demand restrictions, we include the regional unemployment rate in the participation equation.

In a first step, we estimate the simultaneous model based on the equations

[8] Bernasco (1994) points out that the employment status of the husband affects the participation of Dutch wives. However, the female occupational prestige, which is among others a function of income, does not depend on the participation of the men.

[9] Persons who care for their old parents or other relatives face high entrance costs to the labor market, because they would have to pay for a geriatric nurse or an old people's home, which can be extremely expensive according to the state of health.

4.1 to 4.3. We present four models with different restrictions concerning the correlation between the error terms of the three equations and the structure of the wage equation. Model 1 is the most restrictive framework. It is assumed that working hours do not affect the wage rate and that participation, hours worked and wages are mutually independent. Model 2 drops the later restriction. Model 3 includes hours and hours squared in the wage equation, imposing that the impact of working hours on the wage rate is just a shift effect, which is the same for all individuals. It also allows for correlation among the error terms e, u and v. Finally, we check whether the wage structure, such as the returns to education, is determined by the hours worked. For this reason, we include several interactions between the working hours and other variables in the wage equation (Model 4). Interactions which turn out to be insignificant are dropped out for simplicity of presentation. In a second step, we replicate Model 3 and 4 based on the measurement error model from section 4.5.

Presenting the estimation results, we give most attention to the wage equation, because the auxiliary equations of hours and employment status are reduced-form estimates. The estimation results of equation 4.1 and 4.2 are given in Table A2 in the Appendix.

The wage function is modeled on the basis of an extended human capital approach. The education level is measured by three dummy variables. The actual labor market experience is described by two continuous variables, the number of years in full-time employment and the years in part-time work. However, the returns to part-time experience turned out to be insignificant in all wage regressions and therefore we excluded them from the set of explanatory variables. In addition to these human capital variables, we include dummy variables to control for the firm size and the industry sector of the employed women. The estimation results of the wage equation of the four models described above are presented in Table 1.

Table 1: Estimation results of the wage functions (continued)

	Model 1		Model 2		Model 3		Model 4	
	coeff.	t-value	coeff.	t-value	coeff.	t-value	coeff.	t-value
constant	2.745	70.44	2.812	64.66	2.395	21.78	2.575	18.57
hours					0.038	8.91	0.028	3.51
hours^2					-0.069	-11.12	-0.062	-4.63
unskilled	-0.140	-5.50	-0.119	-4.52	-0.110	-4.31	-0.117	-4.67
master craftsman	0.047	1.95	0.053	2.19	0.055	2.39	0.065	0.48
graduated	0.336	10.23	0.328	9.92	0.364	11.33	0.359	11.42
ft. experience	0.026	7.67	0.021	5.79	0.020	5.24	-0.050	-2.98
ft. experience^2	-0.046	-4.61	-0.036	-3.39	-0.031	-2.93	0.193	3.50
20-200 empl.	0.022	0.84	0.022	0.85	0.041	1.61	0.036	1.44
201-2000 empl.	0.169	6.70	0.163	6.49	0.152	6.32	0.144	6.10
>2000 empl.	0.211	8.31	0.207	8.20	0.196	8.10	0.198	8.33
energy, mining	-0.031	-0.48	-0.037	-0.58	-0.018	-0.30	-0.011	-0.18
metal industry	-0.027	-0.51	-0.025	-0.48	-0.037	-0.75	-0.042	-0.86
other industry	-0.136	-2.80	-0.136	-2.83	-0.147	-3.20	-0.147	-3.24
trade, service	-0.217	-6.05	-0.210	-5.86	-0.187	-5.46	-0.115	-1.03
transport	-0.038	-0.69	-0.034	-0.61	-0.047	-0.90	-0.045	-0.86
banking	0.059	1.26	0.060	1.29	0.059	1.35	0.061	1.41
education, health	0.040	1.15	0.044	1.27	0.048	1.43	0.052	1.58
public service	-0.018	-0.44	-0.016	-0.38	-0.025	-0.63	-0.024	-0.63
other sectors	-0.074	-0.83	-0.061	-0.68	-0.052	-0.61	-0.040	-0.47
interactions:								
master ∗ hours							0.005	0.54
master ∗ hours^2							-0.016	-0.99
exp.∗ hours							0.004	3.18
exp.^{2} ∗ hours							-0.012	-3.54
exp. ∗ hours^2							-0.004	-2.04
exp.^{2} ∗ hours^2							0.013	2.58
trade/service ∗ h.							-0.011	-1.48
trade/service ∗ h^2							0.026	2.02
$\rho^2_{wage,hours}$	-	-	0.065	1.76	0.168	1.90	0.078	0.85
$\rho^2_{wage,part}$	-	-	-0.267	-3.63	-0.276	-2.53	-0.211	-1.87
$\rho^2_{hours,part}$	-	-	-0.570	-10.52	-0.536	-9.91	-0.527	-9.53

continued from Table 1:

	Model 1	Model 2	Model 3	Model 4
Log Likelihood	-2.530	-2.516	-2.491	-2.482
Likelihood ratio Test		$\chi^2_3 = 68.3$	$\chi^2_2 = 119.1$	$\chi^2_8 = 44.1$
Wald-Test statistics:				
hours, hours^2 ($\chi^2_2 = 5.99$)			124.60	30.56
master $*$ hours ($\chi^2_2 = 5.99$)				5.34
experience $*$ h. ($\chi^2_4 = 9.49$)				27.95
trade/service $*$ h. ($\chi^2_2 = 5.99$)				8.61

Remark 1 *The reference group are skilled women who work in the chemical or electrical goods industry or in the engineering sector and are employed by a firm with less that 20 employees. The variables $hours^2$ and $full - time\ experience^2$ are divided by 100. The likelihood ratio test compares the actual with the preceding model.*

The wage function of Model 1 corresponds to the standard OLS wage regression with the log hourly wage rate as dependent variable. Wages increase with the education level and the firm size. Also the experience variables generate the expected dome shaped curve, that is, wages rise with labor market experience up to 28 years in full-time employment. Additional experience reduces the hourly wage rate of West German women. Comparing the first two models illustrates that allowing for correlation between the error terms of the three equations improves the fit of the model significantly. However, the coefficients change only slightly. Albeit the correlation between wages and hours is positive, it is very small and insignificant. In other words, unobserved characteristics which rise the gross wage rate also tend to increase the working hours, but the effect is not very important. However, the negative correlation with the error terms of the participation equation is surprising. Presuming that the unobserved variables which raise the probability to work are personal characteristics, such as ambition, motivation or the thirst for action, one would expect that the residuals of the participation equation and the wage and hours equations, respectively, are correlated positively. In our case the opposite is true. Women who have a high unexplained probability to work earn ceteris paribus lower wages and work less hours. One explanation could be that women in precarious economic situations, for which we cannot precisely control (for?), accept jobs with lower wages and less hours than those who found themselves not in a predicament. Especially women who receive social welfare may avoid to earn too much additional income in order to stay entitled to their benefits. Another consideration is that married women with small children, whose husbands earn high incomes also have a low predicted probability of working. If these women intend to take up working after the child break, is seems rational that they temporally accept a job with less hours and a lower wage rate in order to keep in touch with the labor market. Thus, the negative correlation with the participation equation may be due to the life cycle maximization of the individuals.

In the next step we relax the assumption that the amount of working hours does not affect the hourly wage rate (Model 3). Hence we include hours and hours squared in the wage equation, which are highly significant and improve the fit of the model. According to previous studies our estimates lead to a S-shaped budget curve. The hourly wage rate increases up to the peak of 27 hours a week and starts to decrease afterwards. Thus, our results are consistent with the findings in other countries, even if the maximum hourly wage rate is paid to women with less hours (Moffit, 1984; Ermisch/Wright, 1991). Although we control for various variables, we can still find a significant decline of wages for women working overtime hours, that is in general more than 40 hours a week. Later on we will address the question, to which extend this result may be due to measurement problems of the hourly wage rate. If we take a look at the estimated covariance matrix, we realize that taking the labor supply decision into account becomes more important. The positive correlation between wages and hours increases and is almost significant. To put it differently, there are some unobserved characteristics which influence the wage rate and the hours decision in the same way. This implies that ignoring the endogeneity of the working hours leads to lower estimated wage rates for jobs with reduced working hours (see Figure 6 in the Appendix). Also the negative correlation between the wage function and the participation status is still significant.

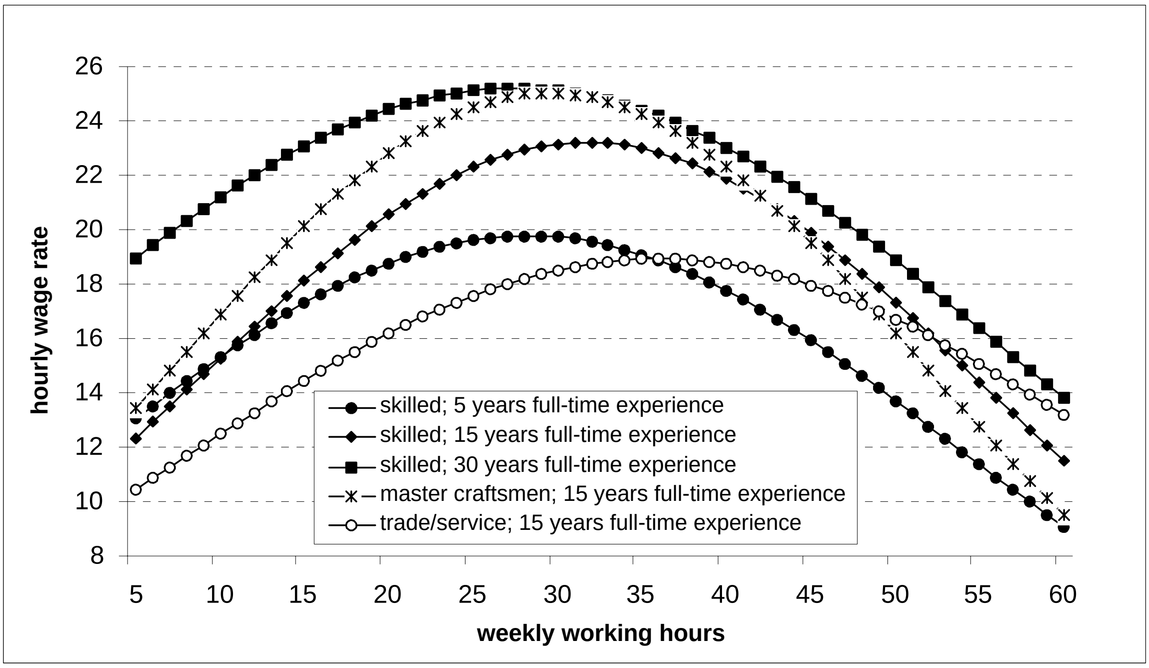

Figure 3: Wage-hours profiles for selected groups

Remark 2 *If not defined otherwise, the characteristics of the reference group are valid.*

Up to this point it has been assumed that the impact of the amount of working hours on the wage rate is the same for all individuals. Even if the way how the working hours influence the hourly wage rate should be independent of qualification level, experience, firm-size or industry, the intensity of the effect could vary among different groups of employees. We ran a variety of regressions in order to identify different hours effects for different workers. Finally we ended up in model 4 (see last column of Table 1). Two primary observations should be made about these results. First, the assumption that the impact of working hours on wages is the same for all individuals must be strongly rejected.[10] Second, the correlation among the equations of the simultaneous model decrease and two of three correlation coefficients become insignificant, implying that the joint estimation has little effect on the wage equation. Please note that this result only

[10] The likelihood-ratio test between model 3 and model 4 generates a test statistic of 44.1. The critical value of (χ^2_8) is 15.5.

holds for this last specification of the wage function.

Figure 3 presents the wage-hours curves for some selected groups of individuals. We detect different wage-hours profiles for master craftsmen and for women working in the service or trade sector. Wages of women with master craftsman diploma or comparable qualifications rise faster than those of the other qualification groups. At the peak at 30 hours a week, the before-tax hourly wage rate of masters with 15 years full-time experience is about 1.80 DM higher than for skilled women with the same experience. However, for additional hours the wage decreases very quickly and it comes closer to the wage-hours path of skilled women for higher numbers of working hours. In contrast to this steep curve of the craftsmen, wages in the service sector grow very moderately with additional working hours.

Also the previous labor market experience determines the shape of the wage-hours curve. For example, skilled women with 5 or 15 years of full-time experience earn approximately the same hourly wage rate if they have a marginal job, that is, they work less than 15 hours a week. Once they increase their labor supply, the wages of women with more experience rise much faster. The highest hourly wage rate for skilled women with 15 years of experience is paid to those working 32 hours a week. Less experienced women reach their maximum at 28 hours. At this point, the gross wage differential between these two experience groups, keeping all other characteristics constant, is 3.14 DM per hour, that is 378 DM per month. Women with 30 years of full-time experience start from a higher wage rate than less experienced women. Yet, the gradient of their wage-hours locus is moderate compared to women with 15 years of experience. Even so, additional experience raises the hourly wage rate at any point on the labor supply curve.

Despite the different shapes of the wage-hours curves, they all have in common that the hourly wage rate for over-time hours falls substantially. To check whether the shape of the wage-hours curve is biased due to the measurement error in hours, we reestimate model 3 and 4 based on the modified equations 4.6 and 4.7. The estimation results are presented in Table 2.

Table 2: Estimation results of the model with log(hours)

	Model 3a		Model 4a	
	coeff	t-value	coeff	t-value
constant	-0.341	-0.66	-0.988	-1.14
log(hours)	2.042	7.24	2.584	4.80
$\log(hours)^2$	-3.234	-7.78	-4.285	-5.09
unskilled	-0.109	-4.17	-0.124	-4.83
master craftsman	0.051	2.14	0.043	1.88
graduated	0.342	10.55	0.338	10.69
full-time experience	0.022	5.61	-0.234	-1.80
full-time experience^2	-0.036	-3.30	0.921	2.04
20-200 empl.	0.026	1.02	0.017	0.65
201-2000 empl.	0.159	6.49	0.151	6.26
>2000 empl.	0.202	8.22	0.202	8.35
energy, mining	-0.024	-0.39	-0.018	-0.30
metal industry	-0.027	-0.52	-0.029	-0.59
other industry	-0.145	-3.10	-0.144	-3.12
trade, service	-0.194	-5.56	3.166	3.93
transport	-0.050	-0.92	-0.054	-1.02
banking	0.063	1.40	0.066	1.50
education, health	0.048	1.41	0.051	1.52
public service	-0.026	-0.65	-0.029	-0.74
other sectors	-0.054	-0.62	-0.039	-0.45
interactions				
$exp. * \log(hours)$			0.118	1.41
$exp.^2 * \log(hours)$			-0.468	-1.66
$exp. * \log(hours)^2$			-0.123	-0.93
$exp.^2 * \log(hours)^2$			0.539	1.24
$trade/service * \log(h)$			-2.270	-4.33
$trade/service * \log(h)^2$			3.712	4.42
$\rho^2_{wage,hours}$	0.119	1.07	-0.013	-0.12
$\rho^2_{wage,part.}$	-0.262	-2.01	-0.129	-1.01
$\rho^2_{hours,part.}$	-0.688	-10.96	-0.668	-9.87
mean log likelihood	-0.802		-0.792	

Remark 3 *See Table 1.*

Apart from the coefficients of the constant and the hours-variables, the modified model does not differ from the previous results. The interactions $master * \log(hours)$ and $master * \log(hours)^2$ are excluded from Model 4a, because they were insignificant. As expected, the correlation between the hours and the wage equation σ^2_{eu} decreases. Furthermore, the correlation coefficient is no more significant in either model. This suggests that the actual working hours do not always fit to the reported earnings of the previous month, that is, the measurement error in the hours variable is substantial. To illustrate the effect on the wage-hours locus, Figure 4 presents the resulting profiles. We can see that at the beginning the hourly wages rise faster with increasing working hours. Striking is that the decline of the wage rate for full-time jobs and overtime work is moderate. This leads one to suppose that for high number of working hours, the reported pre-month earnings do not include the rewards for these overtime hours. There are two possible explanations for this measurement error. First, overtime hours come up very irregularly and are paid afterwards. Second, even if the employee permanently works additional hours, they may be rewarded irregularly, for example, after a certain limit is achieved. As a result, the observed hourly wage rates for these jobs are in general lower than the true wages. For example, in the measurement error model skilled women who completed 15 years of full-time employment start with about 7 DM per hour for a 5-hours job. Compared to the previous results, the estimated entry wage is very low. But the wage rate already doubled for jobs with 10 hours a week. The highest hourly wage rates (about 23 DM) are paid for part-time jobs with about 28 working hours. Thus, the maximum of the wage-hours profile if shift to the left. Figure 4 shows that accounting for measurement errors generates an increasing wage rate over the whole range of working hours for women working in the service or trade sector. Similar to the previous results, additional years in full-time employment shift the wage-hours profile upwards.

Another way to look at the relation between experience and the hourly wage rate is to compare the wage-experience profiles of different labor supply regimes.

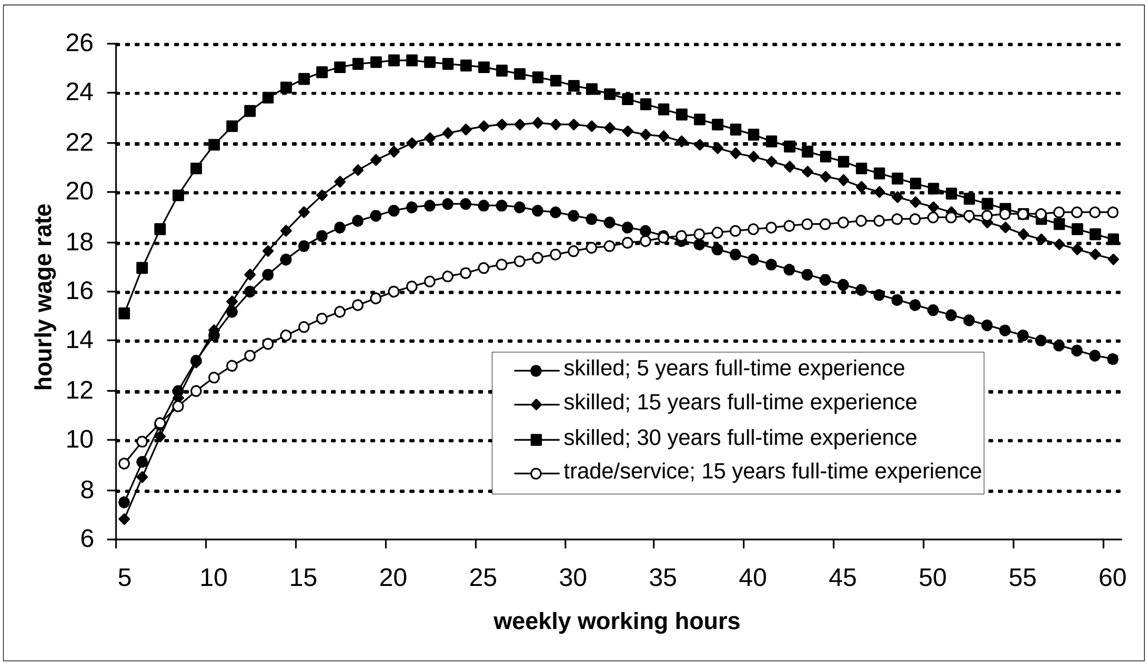

Figure 4: wage-hours curves of the model with log(hours)

People who just entered the labor market are not supposed to possess any experience. During the years in employment they accumulate general and firm specific human capital which is rewarded by the firm. Figure **??** shows that the returns to learning by doing, approximated by the years in full-time employment,[11] depend on the current amount of working hours. Women who work for example 30 hours a week get higher compensations for their experience than part-time workers. The difference between full-time and part-time women is highest for employees, who already have been working full-time for 17 years. In this case, the different returns to labor market experience cause a wage differential among a 20-hour part-time job and a standard full-time job of about 2.30 DM per hour. Once 30 years in full-time employment are completed, working hours do not matter any more for the compensation of experience.

[11] Whether firm specific human capital creates additional wage growth is still an open question. Mincer/Jovanovic (1981) and Topel (1991), as two prominent examples, concluded that there are large returns to seniority. In contrast to theses results, recents studies for the US (Altonji/Williams, 1997) and for Germany (Dustmann/Meghir, 1998) do not confirm that tenure generates additional wage growth.

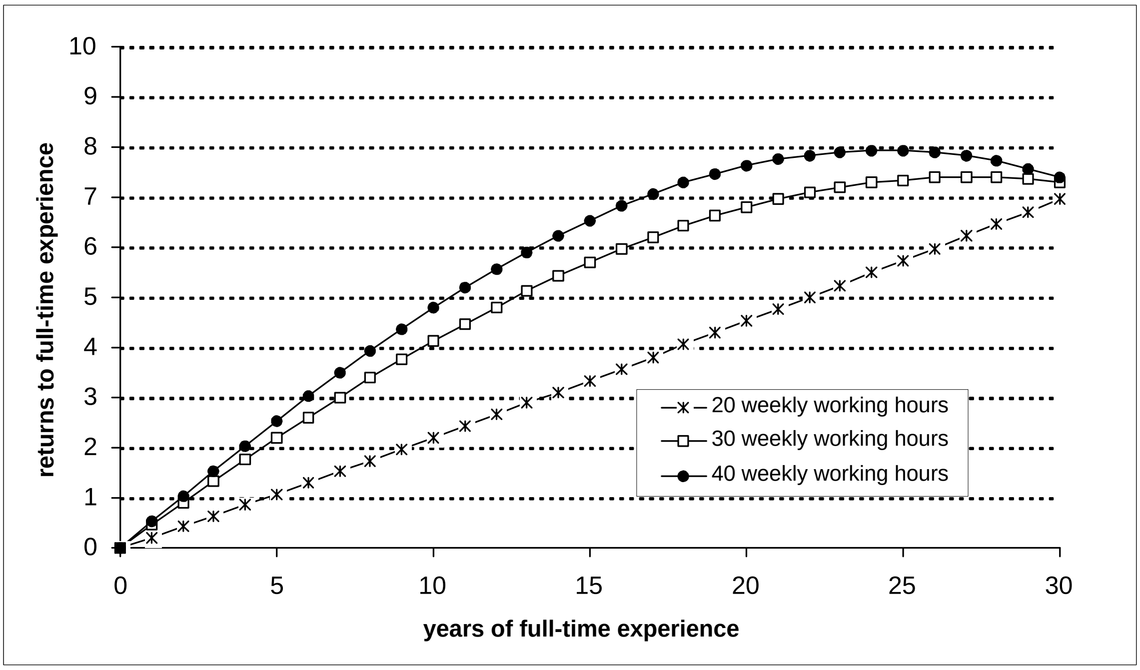

Figure 5: Returns to full-time employment

6. Conclusion

Do part-time workers earn lower hourly wage rates than full-timers? Economic theory provides many reasons why and how the gross hourly wage rate could be determined by the working hours. However, the shape of the wage-hours profile is not clearly determined by the theoretical arguments. The size of the wage differentials among jobs with different working hours is not only interesting for policy makers, employees and employers, but has also far-reaching implications for the labor supply decision of individuals. Negative wage premiums for part-time jobs, for example, would decrease the labor supply for those jobs. In this setting, people would tend to work either full-time or leave the labor market.

Empirical studies for different countries do not provide clear evidence about the wage structure. The different results may be partly due to the different econometric methods. Previous studies for Germany suggest that women with marginal or part-time jobs earn lower wages than full-time employed women even if the qualification level and other explanatory variables are controlled for. The drawback of these studies is, however, that the individual labor supply decision are assumed to be exogenous, which contradicts economic theory. Therefore, we use a simultaneous model which allows for endogeneity of the weekly working hours and further takes into account the participation decision. Furthermore, we relax the usual assumption that the effect of working hours on wages is the same for all individuals.

Three primary observations should be made about our results. First, for West German women, the exogeneity assumption of working hours in the wage regression must be rejected if the wage-hours locus is assumed to be the same for all individuals. As a result of this the wage rate of part-time employees is underestimated in the standard OLS estimates. However, if we allow for compositional wage differences between part-timers and full-timers, the OLS estimates are not biased. That is, in our preferred specification, unobserved characteristics which may influence the wage rate and the amount of working hours at the same time, can be ignored. These results show that in principle the labor supply decision should be fully taken into account, because the unobserved characteristics may be crucial in the specific case.

Second, our estimates show that the hourly wage rate is strongly affected by the working hours. Depending on the specification, the wage rate increases with rising working hours up to a threshold which varies between 21 and 34 hours a week. For example, skilled women with 15 years of full-time experience earn the highest hourly wage rates at about 34 hours a week. Furthermore, we detect different wage-hours profiles for some specific groups. Women working in the trade or service sector experience a flatter wage-hours curve than those in other sectors. Wage rates of women with a master craftsman diploma or comparable qualifications rise faster than those of other qualification groups. But, once they work more than 30 hours a week the hourly wage declines strongly. Also the previous labor market experience determines the shape of the wage-hours locus. People who work for example 40 hours a week get higher compensations for a specific experience in full-time employment than part-time workers. Once the women completed 30 years in full-time work, the current working hours do not matter any more for the returns to their experience.

Finally, we realized that the hours variable in our data is measured imprecisely. As a result of the measurement error in hours, the wage rates for over-time hours are underestimated. Taking into account the additional error term generates a moderate decline of wages for a long working week. Even so, the highest hourly wage rates are payed for jobs with reduced working hours.

These results show, that the wage distribution does not seem to be the driving factor for the marginal importance of part-time work for West Germany women. On the contrary, the comparable high hourly wage rate for jobs with about 30 hours per week should be a reason for the labor supply in this category. Given that very few women actually choose this labor supply regime leads one to suggest that these jobs may be very rare. Possibly, creating a 30-hour job affords more organizational effort than dividing a full-time job in two 20-hour jobs. Another reason could be that a 30-hours job is less compatible with the available child care facilities so that women are forced to accept either a standard part-time job or to leave the labor market. Further research is necessary to decide whether women are constraint with respect to extended part-time jobs or whether other factors prevent them to choose these high paid jobs.

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Appendix

A.1 Likelihood Contributions

In our framework, the multivariate econometric problem involves both continuous (wages and hours) and discrete variables (participation). Therefore, the likelihood function is made up by term that are probability densities with respect to the limited dependent variable and integrated probability functions with respect to the continuous variables. This composition is based on Bayes' theorem. Under normality assumptions, a joint density function can be decomposed in a partial density function and a conditional density function.

$$\varphi(Y^1, Y^2; \mu^1, \mu^2, \Sigma) = \underbrace{\varphi(Y^2; \mu^2, \Sigma^{22})}_{\text{p.d.f.}} \cdot \underbrace{\varphi(Y^1; \mu^*, \Sigma^*)}_{\text{c.d.f}}; \quad (1)$$

where Y^1 and Y^2 are the discrete and continuous variables of interest and μ^1 and μ^2 are their expected values. The correlation matrix Σ is composed of $\Sigma^{11} = cov(Y^1)$, $\Sigma^{22} = cov(Y^2)$ and $\Sigma^{12} = cov(Y^1, Y^2)$. Then, the distribution of Y^1 conditional on Y^2 can be written as $Y^1 \mid Y^2 \sim N(\mu^*, \Sigma^*)$, where $\mu^* = \mu^1 + \Sigma^{12}(\Sigma^{22})^{-1}(Y^2 - \mu^2)$ and $\Sigma^* = \Sigma^{11} - \Sigma^{12}(\Sigma^{22})^{-1}\Sigma^{21}$.
The likelihood function of our model can be divided into the likelihood contribution of the non-participants and the part of the active workers.

$$L = \mathrm{P}(P^* < 0) + f(w, \ln h) \cdot \mathrm{P}(P^* > 0 \mid w, \ln h) \quad (2)$$

The first part describes the probability of not working in the labor market and the second term describes the joint distribution of the observed wage rates and the corresponding working hours of the employed people. The likelihood contribution of these individuals is presented as a partially integrated normal density. In terms of the above specified model (see equation 4.1 to 4.3) the likelihood function can be rewritten as

$$
\begin{aligned}
L &= \mathrm{P}(v < -\gamma \cdot Z) + f(w, \ln h) \cdot \mathrm{P}(v > -\gamma \cdot Z \mid w, \ln h) \\
&= \Phi(-\gamma \cdot Z) + \varphi(w, \ln h; \mu, \Sigma) \cdot \Phi\left(\frac{\mu^*}{\Sigma^*}\right), \qquad (3) \\
&\quad \text{where } \mu^* \text{ and } \Sigma^* \text{ are defined above.}
\end{aligned}
$$

A.2 Sample description

Table A1: Descriptive statistics of the sample

	mean	stand. dev.	minimum	maximum
log(wages)	2.99	0.4	1.5	4.0
working hours	31.53	10.9	6.0	60.0
years in full-time employment	8.60	8.0	0.0	43.0
other household income	3.28	2.2	0.0	19.4
regional unemployment rate	9.26	1.8	7.0	14.0
taste for work	-1.62	9.9	-46.7	20.0
	freq	percent		
participation	1268	52.4		
unskilled	588	24.3		
skilled	1085	44.8		
master craftsman	546	22.6		
graduated	202	8.3		
$<$ 20 employees	461	36.4		
20 - 200 employees	225	17.7		
201 - 2000 employees	270	21.3		
$>$ 2000 employees	312	24.6		
chemical/electrical ind., engeneering	119	9.4		
energy mining	34	2.7		
metal industry	57	4.5		
other industry	72	5.7		
trade, service	291	23.0		
transport	50	3.9		
banking	84	6.6		
education, health	409	32.3		
public service	137	10.8		
other sectors	15	1.2		
kids in the household (Y/N)	1085	44.8		
lone mother, relative in need of care	88	3.6		
married	1641	67.8		
participation of the spouse	1292	53.4		
# observations	2421	100		

A.3 Estimation results

Table A2: Hours equation and participation probability (Model 4)

hours			participation		
	coeff	t-value		coeff	t-value
constant	41.829	42.28	constant	1.683	3.19
# kids < 3 year	-4.538	-1.92	kids	-1.548	-10.96
# kids 4-6 year	-6.600	-3.67	AGEKID	0.121	11.62
# kids 7-16 years	-5.016	-2.95	KIDS16	-0.169	-1.10
unskilled	0.348	0.47	unskilled	-0.217	-2.78
master craftsman	1.517	2.28	master craftsman	-0.005	-0.07
graduated	1.791	1.78	graduated	0.446	3.31
experience	-0.404	-3.50	age	-0.036	-1.24
$\text{experience}^2/100$	0.855	2.89	$\text{age}^2/100$	-0.062	-1.77
married	-3.620	-5.50	experience	0.221	13.48
OINC	-0.170	-0.61	$\text{experience}^2/100$	-0.353	-9.13
$\text{OINC}^2/1000$	-0.174	-0.73	married	-0.127	-1.51
OINC * KIDS16	-0.390	-2.37	OINC	-0.185	-5.41
taste for work	0.094	3.28	$\text{OINC}^2/1000$	0.118	3.73
KIDS16 * experience	0.042	0.68	PART_SP	0.262	3.70
KIDS16 * SCHOOL	0.162	1.27	taste for work	0.009	2.78
			KIDS16 * experience	-0.017	-2.85
			KIDS16 * SCHOOL	0.024	2.10
			regional unempl. rate	-0.028	-1.74
			CARE	-0.115	-1.27

Remark 4 *Note: OINC: other net household income; KIDS16: number of childen up to the age 16; SCHOOL; years of education; AGEKID: age of the the youngest kid in the household; PART_SP: particiaption of the spouse; CARE: lone mothers with children up to 3 years or existence of people in need of care in the household; the variable "taste for work" is created by a factor analysis from the question "How important are the following thinks for your life". Among the topics which are evaluated by the indicicduals are (1) to fulfil oneself, (2) success on the job, (3) to have children, (4) to be happily married or (5) to be able to afford something. These items are used to create a factor named taste for work.*

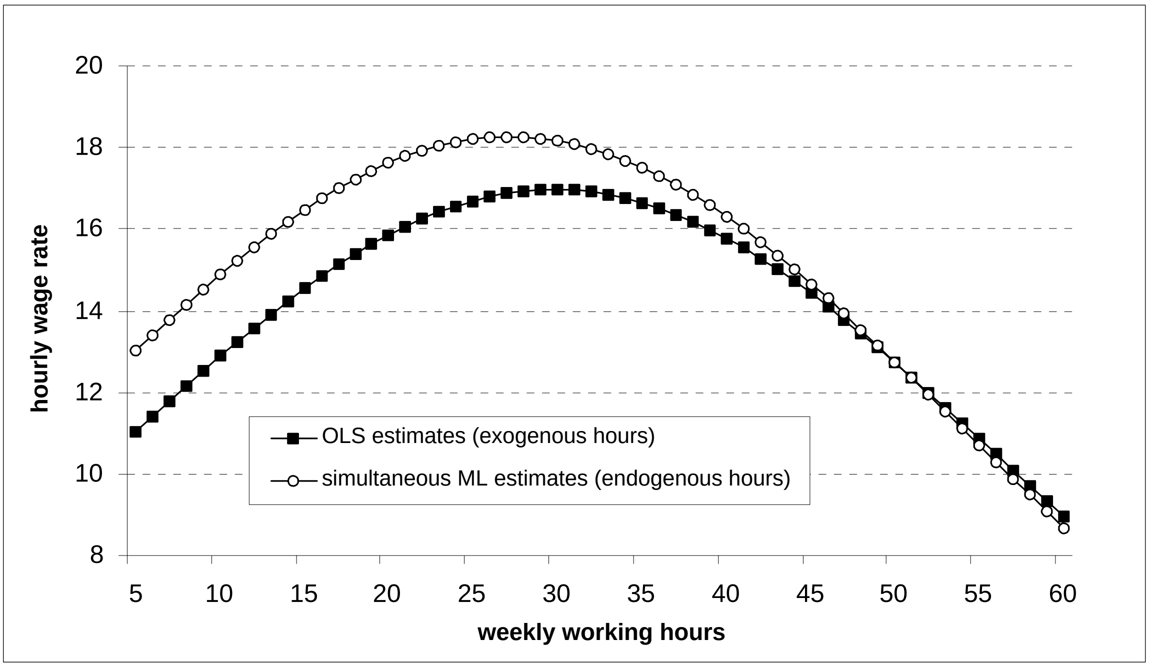

Figure 6: Wage-hours profile with exogenous and endogenous hous (Model 3)