

Lifetime Earnings Discrimination against Women in Germany

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1 Introduction

Income discrimination against women is usually measured as the difference between male and female hourly wage rates, under the assumption that other factors influencing these rates are equal. Income differences resulting from gender-specific differences in formal education, working time and labour market experience are typically not regarded as discrimination. In this paper we deal with the question of the extent to which reduced working times and interruptions in labour market participation influence women's earnings. For this we investigate the effect not only on hourly wage rates, but on earnings over the whole lifetime. The study is based methodologically on similar studies like Rake et al. (2000) for the United Kingdom and Seel/Hufnagel (2000) for Germany. The central aim is to estimate the effect of child rearing on lifetime earnings.

Because there are no data which make it possible for us to calculate lifetime earnings empirically, we simulate typical work histories. For this, it is necessary to determine the possible wage rate as well as the kind of labour market participation for each year. In our paper both the wage function and the labour supply function are estimated empirically. Based on these two functions we simulate courses of lifetime earnings for three types of qualification: 1) *Hauptschule* plus vocational training (low education), 2) *Realschule* or *Abitur* plus vocational traditional training (intermediate education) and 3) a post-secondary degree (high education).

For these three types we calculate simulations for men and women, first without children and then with two children. We are interested in *typical* lifetime courses, therefore we run simulations under the assumptions that people start as singles, marry, then have children and remain married. The determination of the age of marriage and the timing of births are based on empirical averages and differ among the education types.

2 Measuring wage discrimination: Traditional approaches

Wage discrimination is usually defined as the difference between wages that is based only on gender differences – or ethnicity, nationality or other personal characteristics (see Cain 1986, Sloane 1985, Atkinson 1983: 147ff., Polachek/Siebert 1993: 137ff., Kunze 2000). Differences that are the results of different human capital or, more general, productivity, are usually not regarded as discrimination.

The main question of this paper is how differences between men and women in labour market experience, and hence human capital, influence lifetime earnings. In the narrow,

traditional approach this is not regarded as discrimination. We will explain below why labour market experience as a component of human capital can be seen as discrimination, because it reflects gender-specific differences. But before we discuss this we will show how the variable of labour market experience is treated in the traditional neoclassical approach to discrimination. The first step is to estimate a wage function that takes into account all factors which can justify differences between wages. The difference then remaining between the wages of men and women is regarded as discrimination.

To estimate a wage function one needs an explicit functional form. Because total working time is usually not seen as a source of discrimination, the variable to be explained is not monthly earnings, but the hourly wage rate; since Mincer (1976) it has become standard to use the logarithm of the wage rate as the dependent variable. The human capital variables of education and labour market experience are typically used as explanatory variables.

Many studies include no information about actual job experience. Therefore age is used as a proxy, or more precisely, the difference between age and the end of school or vocational training. However, this measure for labour market experience is only appropriate for continuous – i.e. typical male – work careers. The explicit aim of this study is to investigate discontinuous work careers. To do this we use the German Socio-Economic Panel, which provides information about the actual work biographies of all participants since the age of 15. Nevertheless, we also use age as an explanatory variable. The reason for this is that the studies which use age as a measure for experience reveal a hump-shaped relationship between age and the hourly wage rate. That means that wages initially increase with age, but that this increase eventually slows down and can even reverse at higher ages. However, this reduction is a function of age alone and not of experience, because there is no reason why wages should decrease with “too much” experience. The cause of the specific form of relationship between age and wages is that productivity decreases at higher ages, which might lead to lower wages.

For these reasons Hufnagel (2001) suggests using age as well as labour market experience to estimate a wage function. However, this raises the problem that for men, whose careers are typically interrupted only briefly, there is a high correlation between age and experience. For this estimation it is thus necessary to assume that the effect of these two variables on wages takes two different functional forms. Hufnagel advocates using a linear term and a quadratic term for age to estimate the hump-shaped relation, but argues that a logarithmic term is more

appropriate for the variable of experience, because then the effect is always positive, but decreasing. We follow his arguments in our estimations as well.

Besides labour market experience and age, the main indicator for human capital is formal education. Again, there are some possibilities for operationalisation. One customary method is to use “years of education” and to assume that human capital increases with this variable. For estimation this has the advantage that only one variable and one parameter must be estimated. Another way to operationalise formal education is to use dummy variables for each kind of qualification. In this study we use three dummy variables corresponding to the three education types.

Besides these variables – labour market experience, age and formal education – empirical estimations often use further variables that might have effects on wages, for example region, unemployment rate, nationality, kind of employment, kind of occupation, and so on. We do not use these additional variables here, because if we did we would need to place additional assumptions on each variable. Furthermore, for some variables it is not absolutely clear that the choice of occupation has nothing to do with discrimination (see Strengmann-Kuhn/Seel 2004: 14ff.). Thus including these variables might lead to an underestimation of discrimination.

As regards the estimation of the wage function, one is faced with an additional well-known problem. Obviously, wages can be observed only for the employed. If we assume that people without employment, on average, would have lower wage rates, this would lead to a selection bias of the estimated parameters. Several methods are available that take this into account. The most common is a two-stage estimation proposed by Heckman (1979). In the first stage, labour market participation is estimated. Using the results of this estimation it is possible to calculate a parameter λ , which is then used as an additional variable to estimate the wage function. This is the method used in this study.

Finally, for the measurement of discrimination there are two standard methods: the so-called dummy variable approach and the Oaxaca-Blinder approach. In the dummy variable method, the wage functions of men and women are estimated together by introducing an additional dummy variable, with a value of 1 for women and 0 for men. The wage function then looks like the following:

$$\ln w = X\beta + u = \beta_0 + \beta_f \cdot D_f + \sum_{j=1}^k \beta_j \cdot x_j + u, \quad \mathbf{1}$$

with the dummy D_f equal to 1 for women and 0 for men. The estimated parameter β_f gives the wage difference based only on gender. The k variables x_j are all of the other variables, including the λ explained above, which results from the Heckman procedure.

In the dummy variable method, the wage function is estimated under the assumption that the impact of all variables on wages is the same for men and women. In contrast to this, the other method assumes that the parameters are different for men and women. Therefore two wage functions have to be estimated:

$$\ln w^f = X^f \beta^f + u^f = \beta_0^f + \sum_{j=1}^k \beta_j^f \cdot x_j^f + u^f \quad 2$$

and

$$\ln w^m = X^m \beta^m + u^m = \beta_0^m + \sum_{j=1}^k \beta_j^m \cdot x_j^m + u^m \quad 3$$

Now the difference between men and women can no longer be observed on the basis of a single estimated parameter. Instead the difference between the average hourly wage rates can be divided into two parts. The first is the result of the different human capital, and the second remaining difference can then be interpreted as discrimination. To separate these two parts the following procedure is used, which was developed by Oaxaca (1973) and Blinder (1973) independently of each other. For linear regressions there is $\overline{\ln w^f} = \overline{X^f} \hat{\beta}^f$ and $\overline{\ln w^m} = \overline{X^m} \hat{\beta}^m$; here, $\hat{\beta}^f$ or $\hat{\beta}^m$, respectively, are the arrays of the estimated parameters for men and women, $\overline{X^f}$ and $\overline{X^m}$ are the arrays of the averages of the explanatory variables for men and women and $\overline{\ln w^f}$ and $\overline{\ln w^m}$ are the average logarithmic hourly wage rates received by men and women. Thus it follows for the difference of the average logarithmic wage rates between men and women that:

$$\begin{aligned} \overline{\ln w^m} - \overline{\ln w^f} &= \overline{X^m} \hat{\beta}^m - \overline{X^f} \hat{\beta}^f = \overline{X^m} \hat{\beta}^m - \overline{X^f} \hat{\beta}^m + \overline{X^f} \hat{\beta}^m - \overline{X^f} \hat{\beta}^f \\ &= \left(\overline{X^m} - \overline{X^f} \right) \hat{\beta}^m + \overline{X^f} \left(\hat{\beta}^m - \hat{\beta}^f \right) \end{aligned} \quad 4$$

The first term is the difference resulting from the different human capital of men and women under the assumption that the relationship between these variables is the same for both genders. The second term is then the measure for discrimination, namely the difference that results from different estimated parameters under the assumption of equal human capital.

3 Measuring lifetime earnings discrimination: A new approach

A large portion of the difference between male and female wages is the result of women's lower labour market experience. In traditional approaches this would not be called discrimination. This is relevant because there is a convergence of formal education between men and women such that differences in human capital are based mainly on different job experience – and will be even more so in the future –, which leads to lower wages for women (see Beblo/Wolf 2000 and 2002, Kunze 2002). Furthermore, women earn less or nothing at all during periods of interrupted employment and part-time work. Thus women have a double disadvantage with regard to their lifetime income if they reduce employment to rear their children. The aim of this paper is to quantify this difference in lifetime earnings between men and women.

First, however, we discuss the extent to which this can be regarded as discrimination, since it could be argued that this is simply a voluntary decision by women such that there would be no grounds to consider social policy consequences, nor any reason to use the term “discrimination”. On the other hand, however, there are arguments for the view that discrimination is at work when women decide for child rearing and against employment. In principle, children can be reared by the father as well as by the mother, with the exception of nursing – and even then child rearing duties could be shared. Besides the father and mother, one has to take into account that children could also be reared by others, in particular grandparents, neighbours or public child care.

However, in West Germany most mothers decide against employment, or at least against full-time employment, while fathers – in both West Germany and East Germany – usually work full time. That leads to the suspicion that women's choice to reduce working hours or stop working is by no means voluntary. For example, the decision might be restricted because alternative child care opportunities are not available. Particularly for children under three years of age, there are very few child-care facilities in West Germany, and the ones that do exist are often too expensive (see Spiess et al. 2000). In East Germany the supply of child care facilities is much better and the labour market participation of women much higher. However, this is not the only reason for the different participation rates. In West Germany – in contrast to East Germany, but also other countries like France, the U.S. or the Scandinavian countries – traditional roles are much more common. The result is relatively high social pressure from other family members, including the father, for the mother to reduce employment while the father continues working.

Finally, there are economic conditions that strengthen these tendencies toward traditional job roles. One reason is the wage gap between men and women, which has the consequence that it is economically rational for the mother, and not the father, to reduce employment to rear children. Additionally, tax and social transfer regulations set incentives for the mother to take care of the children while the father continues working. One example is the joint taxation of couples (*Ehegattensplitting*), which has the consequence that equal sharing of work and rearing children between both parents leads to substantial losses in income (see Hufnagel 2002). Thus, if the mother wishes to keep working, or if both parents would like to share child rearing equally, external circumstances such as the lack of child care facilities, economic reasons and/or social pressure often have the consequence that it is the mother and not the father who reduces work to rear the children.

Therefore interruptions in women's employment for child rearing are very closely connected with socially assigned gender-role patterns. In this sense, one can indeed say that the resulting earnings losses are consequences of gender as such, and therefore, of discrimination.

3.1 Method and assumptions

Our study is oriented on the study of Rake et al. (2000) for the U.K., and goes beyond similar investigations for Germany like Seel/Hufnagel (2000) and Hufnagel (2002). In contrast to Rake et al. (2000), we focus only on employment age, neglecting effects on pensions, and we focus on *typical* employment and life careers. Compared to Seel/Hufnagel (2000) and Hufnagel (2002) the main differences concern three important points: First, the employment pattern is not assumed, but simulated based on empirical estimations of a participation function. Second, we do not assume that marital status is constant for the whole period. We assume that individuals at the beginning of the life cycle are singles, then marry and stay married for the rest of their life (or at least until they reach retirement age). Third, the age at marriage and upon the completion of education, and the timing of births are predetermined on the basis of empirical results and vary with level of education completed.

Our main focus is on *typical* life cycles and employment careers. Thus, we assume that at the beginning people are in school or training, they start to work, then marry into a stable marriage, and then have two children. Therefore, for the simulation we need the following: 1) the age at completion of education and the beginning of employment, 2) the age at which people marry and 3) the ages at which they have children. To determine these dates we

calculate the median and the mean for all women between 35 and 55 who have borne two children.

Table 1: End of education, age of marriage, and age of mother at birth of first and second children by education type

	Low education			Intermediate education			High education		
	assump.	median	mean	assump.	median	mean	assump.	median	mean
End of education	17	17	16.6	18	18	18.2	23	24	22.7
Marriage	22	22	22.5	23	22	23.6	26	26	26.5
Birth of 1 st child	23	23	23.4	25	25	25.4	29	29	28.4
Birth of 2 nd child	27	27	27.4	29	29	29.8	32	32	32.3

Source: GSOEP 1991-2000, German women in West Germany aged 35 to 55 who have borne two children, own calculations

Table 1 shows how these results vary with education types. The database is a pooled data set from the German Socio-Economic Panel, waves 1991 to 2000. On the basis of these results we choose our assumptions for the following simulations. Women with *Hauptschule* and vocational training finish their education at the age of 17, marry at 22 and have children at 23 and 27. Mid-qualified women (*Realschule* or *Abitur* plus vocational training) enter the labour market and marry one year later. The first child is born when they are 25 and the second child four years later. Women with post-secondary degrees (high education) complete their studies at 22.7 years on average (arithmetic mean),; the median is 24. For the simulations we assume an age of 23. They marry at 26 and, on average, have their first children between two (mean) or three (median) years later. We assume that the birth of the first child takes place at the age of 29. The second child is born when the mother is 32. Thus, the interval between the first and the second birth is shorter than for women with less education.

The simulation procedure then is as follows. At first the wage equation and the participation equation are estimated independently on the basis of the GSOEP data. Wage is dependent on age, qualification and labour market experience. Labour market participation depends on the individual's own wage rate, the partner's wage rate, and the age and number of children. The choice of the variables that are used for the participation estimation is based on the theory of labour supply, which is described in section 3.3.1. The estimation technique is explained in 3.3.2. For the simulation of labour market participation by women we need the wage rate of the women herself as well as the wage rate of her partner. Therefore we have to estimate three equations: A wage function for women, a wage function for men and a participation function for women. We assume that men are continuously employed after they complete their education.

On the basis of these three equations the simulation is calculated for each year of age. Wage and participation are not independent of each other, since the probability of being employed increases with (potential) wage, and the participation decision changes the labour market experience. This influences the (potential) wage rate in the following year, which, in turn, influences the decision about whether to participate in that year.

We begin the simulation at the age of 17, when all women are still in school or training. We assume that there are no earnings and no labour market experience until education is completed. For the first years after education we assume that both men and women are employed full time, which is usually the case for singles (men and women). From the time of marriage on we simulate the participation of women based on the estimated function, while we assume that men are still always employed full time. Further, we assume that both partners are the same age and have the same level of education. Thus we neglect the “age gap” (see Elul et al. 2002), that is, the effect that the man is usually somewhat older than the woman in a partnership. If we were to include this effect, the resulting estimated differences between men and women would be even greater. To calculate the effects of having children on lifetime earnings we also simulate earnings profiles for individuals without children under the same assumptions. In both cases, with and without children, we distinguish among the three education types.

3.2 Wage estimation

As discussed, we estimate two wage functions: one for men and one for women. The procedure is the one described in section 2. The database is a pooled data set of the years 1991 to 2000. The advantage of a pooled data set is that the case numbers are higher and therefore the estimation more stable. A problem is that the level of wages is exactly comparable between the years due to inflation and general wage growth. Therefore a trend variable is required to estimate the average yearly rise of wages. This wage is constructed such that it has a value of 0 for 2000, a value of -1 for 1999, and so on. For the simulation this variable is set to zero so that the results reflect the situation in the year 2000. Because the estimation is performed using income and wages measured in DM, the simulations are also performed in DM rather than euros (the exchange rate is 1.96 DM to 1 €, so you can simply divide the results by 2 to receive the approximate amounts in euros).

Besides the trend variable, we choose independent variables for age, work experience and education. As discussed above, for age we use a linear term and a quadratic term, and for

work experience the logarithm. Experience is measured as a weighted sum of the years with full-time and part-time employment, with part-time work assigned a weight of 0.3. The variables for education are three dummies corresponding to our three qualification groups.

Table 2: Estimated wage functions for West German women and men (pooled data set)

	Wage estimation (ln w)	Pooled OLS
	Women	Men
Constant	2.21***	2.45***
Age	0.014***	0.024***
Age ²	-0.00022***	-0.00019***
Log (full-time years + 0.3*part-time years)	0.193***	0.046***
Low education	0.060***	0.069***
Intermediate education	0.218***	0.160***
High education	0.558***	0.475***
Trend variable year	0.020***	0.018***
Λ	-0.08***	-0.34***
R ²	0.2198	0.2804

Source: GSOEP 1991-2000, Germans residing in West Germany, own calculations

The estimated value of the trend variable is 0.018 for men and 0.020 for women, i.e. the wages of women increased by 2% per year for the same education, same age and same work experience, and those of men by 1.8% per year (see table 2). The linear part of the age effect is 0.024 for men, and thus much higher than the value of 0.014 for women. This can be interpreted as an yearly wage increase of 2.4% for men and 1.4% for women, in addition to the estimated trend. However, it must be taken into account that the estimated quadratic term slows this effect. The estimated parameters are -0.00022 for women and -0.00019 for men, which means that the increase in wages decreases more for women than for men with each year of age. Beside these pure age effects, the effect of additional experience must be recognised as well. This amounts to 0.046 per year for men, but the estimated parameter of 0.193 is four times higher for women.

The parameters for qualification also have the expected sign and magnitude. For low education (*Hauptschule* plus vocational training) the estimated parameter is 0.06 for women and 0.007 for men, which means that the hourly wage rates are, respectively, 6% and 7% higher than for women and men without vocational training. With an intermediate qualification these values are 22% for women and 16% for men; with a post-secondary degree, 56% for women and 47.5% for men.

3.3 Estimation of labour market participation

Besides the wage equation we also estimate the labour market participation function. In the following we will first, in section 3.3.1, give a short overview about labour supply theories

(see Killingsworth 1983, Bryant 1990, Bergstrom 1997, Vermeulen 2002). In 3.3.2 we explain the estimation method, and in 3.3.3 we present the results.

3.3.1 Labour supply theories

The neoclassical micro-economic theories typically use one-person models. In the basic case this is only a one-period model. To explain our model choice for the estimation, we first describe the standard neoclassical model and then discuss possible extensions.

As usual in microeconomics, the first step is to define the preferences in terms of a utility function, and in the second step, restrictions, particularly budget constraints. In the basic standard model, utility depends on consumption and leisure time. Thus, the utility function U_i of an individual i can be generally written as:

$$U_i = U_i(c_i, l_i), \quad 5$$

with c_i consumption and l_i leisure of i . In the simple basic model, consumption goods can only be bought. Therefore it is necessary to have income. People get income by selling their labour, measured in hours h in the labour market, where they receive a constant hourly wage rate w . Besides this it can be assumed that people have additional non-labour income V , which may be capital income, or private or state transfers.

The resulting budget constraint is then:

$$c_i = h_i \cdot w_i + V_i \quad 6$$

or, under the assumption that the entire disposable time can be divided into work time and leisure time, with disposable time normed to 1:

$$c_i = (1 - l_i) \cdot w_i + V_i \quad 7$$

In this simple model labour supply depends only on the wage rate w and non-labour income V . The direction in which the wage rate affects labour supply is not clear, and depends on individual preferences, i.e. the assumed utility function. This is because a changing wage rate has two opposite effects: the substitution effect and the income effect. When the wage rate increases, on the one hand, consumption becomes cheaper in relation to leisure. The consequence is an increasing labour supply. This is the substitution or price effect: leisure time is substituted by work time. On the other hand, there is the income effect, which leads in the opposite direction. This effect means that, as income increases, so does demand for each good, including the good “leisure”. When working hours remain constant, a higher wage rate

leads to a higher income, which leads to higher demand for leisure and a reduction in labour supply. Put simply, the reason for this income effect is that with higher wages it is possible to earn the same income while working less.

Which one of these effects dominates depends on the assumed preferences. Usually, the income effect is higher for high incomes. Then labour supply decreases with increasing wages. How wages affect labour supply for low incomes depends on further assumptions, especially on whether a subsistence level exists within the utility function. If this is the case, then the income effect is higher for low income as well. If wages decrease, it is necessary to increase labour supply to reach the subsistence level. Without a subsistence level in the utility function, or if non-labour income V is higher than the subsistence level, then the substitution effect is higher, that is, labour supply increases when wages increase. For some utility functions the substitution effect and the income effect are always equal. This is the case, for example, for the customary Cobb-Douglas utility function without a subsistence level. Then labour supply is independent of the wage rate.

This simple standard model can be extended in manifold ways. First, it makes sense to analyse dynamic models with more than one period, because both future expectations and decisions in the past might have effects on current labour supply. Second, the model can be extended such that, besides work and leisure, there is a third kind of time use: home production. The assumption then is that goods can also be produced by the individual, and/or that consumption goods must be processed within in the household before they lead to utility. Third, it is necessary to model the labour supply decision as a decision made by a multi-person household, usually as a two-person model (husband and wife). In the following we discuss some options for such models.

A first possibility, which is quite similar to the one-person model, is to assume that individuals decide separately, but that the income of the partner is taken into account as an independent variable. The only difference from the one-person model is that the partner's income is then part of the exogenous non-labour income V . This is the typical model used for empirical labour supply estimations. A variant of this model is the “male-chauvinism model” (cf. Killingsworth 1983: 30, Merz 1990: 244, Eissa/Hoynes 1998). In this model, the wife decides whether to participate in the workforce only after her husband. In this case, his income is an exogenous variable in her decision, and she then decides as in the one-person model. We do not think that this model is appropriate. The more general case, that both partners decide separately and independently from each other (the “solipsistic model”), also

seems unrealistic. It can be shown that the result based on a joint decision is pareto-superior compared to the results of the solipsistic model (see Vermeulen 2002).

If we assume that a couple decides together on labour supply, then there are, again, several ways to model such a decision (see Vermeulen 2002). One possibility is to assume that there is a household utility function that they wish to maximize (see Bryant 1990: 137ff. and 264ff). Generally, this household utility function can be written as:

$$U = U(c_f, l_f, c_m, l_m), \quad 8$$

where c_f and l_f are the consumption and leisure of the woman and c_m and l_m consumption and leisure of the man. Under the assumption of a household utility function, the main factor on labour supply is the relation of (potential) hourly wage rates of the two partners. The problem with this model, however, is that such a household utility function exists only under quite restrictive assumptions, namely when the individual utility functions are identical, or when there is only one person in the household making decisions, who is altruistic and takes the consumption and leisure of the partner into account (see Becker 1974).

If individual utility functions are assumed, but a joint decision process, then game theory models, known as “bargaining models” are appropriate (see Ott 1992). These models can be divided into two classes, with the two “players”, i.e. husband and wife, “playing” or bargaining either against each other or together. Non-co-operative games can conclude, again, with results that are not pareto-efficient, i.e. there may be solutions in which both would be better off (see Ashworth/Ulph 1981). In co-operative games, however, the result is always pareto-efficient, i.e. it is not possible for one to be better off without the other losing (see Chiappori 1988). We do not accept the assumption of a co-operative game unquestioningly (see Elul et al. 2002, Bergstrom 1997), but we follow this customary conclusion to the extent that we assume a co-operative model on labour supply in the following.

The solution of such kind of model is not unique, however, so that in the case of a co-operative decision, too, the balance of power between men and women plays an additional and important role. A way to reach a unique solution in even such a case has been formulated by Samuelson (1956). He assumes that the household members have individual and different preferences, but that the choice among the many pareto-efficient solutions is based on a household welfare function, which is dependent on the utilities of each household member. This means that individual preferences are different, but there is a consensus on how

individual utilities are distributed within the household. Such a household welfare function can be written as:

$$W = W(U_f, U_m), \quad 9$$

with U_f und U_m the utility functions of the female and the male partner, respectively, both dependent on consumption and leisure. Thus equation 9 can be rewritten as:

$$W = W(c_f, l_f, c_m, l_m), \quad 10$$

Equation 10 and equation 8 are formally identical. Whether the decision within a household is based on a unitary household utility function or on different individual utility functions is therefore an interesting, but only theoretical question. In each case the result is dependent on the same variables, specifically, the (potential) wage rates of both partners. To distinguish between these two kinds of models empirically, specific additional assumptions are necessary (see Kooreman/Kapteyn 1990). We abstain from this, because any such additional assumptions are subject to debate.

Instead we simply assume that the labour market participation depends linearly on the individual's own wage rate and on the wage rate of the partner. We assume that the higher the individual's own wage rate and the lower the partner's wage rate, the higher the participation. Whether this is the result of a joint utility function or the result of a bargaining process is of no interest for our research question.

Wage rates are not the only factors influencing labour supply (see Andreß/Strengmann-Kuhn 1997). In particular, it is important whether there are children in the household. Children typically lead to a reduced labour supply of women, not only for economic reasons, but due to social norms, which, again, are influenced by the level of education, as traditional role patterns are more common in lower-educated groups.

In summary, we therefore use the following variables to estimate the participation function: the individual's own (potential) wage rate, the partner's (potential) wage rate, the level of education, and number of children, distinguishing among three age groups: below 3 years of age (before preschool), 3 to 6 years old (preschool) and 7 to 16 years old (schoolchildren).

3.3.2 Estimation

There are generally two possibilities to estimate labour supply. The first is to estimate the working hours supplied. We did not do that here because descriptive analyses of the distribution of working hours show that this is not continuous, but that there are certain specific values around which the distribution is concentrated. Therefore an estimation of hours is not appropriate. It is more sensible to distinguish the extent of labour market participation into groups. We differentiate between five groups: no labour market participation, minor employment (less than 15^h/week), part-time work (15 to 30^h/week), full-time employment (at least 30^h/week) and over full-time employment (more than 40^h/week). To estimate this, a multinomial technique is required. The standard methods for this are probit or logit models.

In the following, this approach will be explained for the simpler binomial case of variables with two values. Suppose we have only information about whether labour is supplied or not. The observable variable thus can have a value of 1 (labour supply) or 0 (no labour supply). It is then assumed that the decision process is based on a latent, unobservable variable y^* , which is dependent on a set of observable variables X . Then the equation is:

$$y^* = X\beta + u, \quad 11$$

where u is an error term with an expected value of 0. y is then 1 if y^* is higher than a certain threshold, and 0 if y^* is below this threshold. Because the unit of y^* is arbitrary, it is possible to define the threshold, for example to set it to a value of zero. The probability that y is equal to one, i.e. there is labour supply, is then equal to the probability that y^* is positive or that $X\beta + u$ is greater than zero. However, for symmetric distributions this is identical to the value of the cumulative distribution function, or formally:

$$P(y = 1) = P(y^* > 0) = F(X\beta + u). \quad 12$$

The probability of labour being supplied and the parameter values β can now be estimated. It depends on the choice of the distribution function whether the estimation model is probit (normal distribution) or logit (logistic distribution).

The model can be extended for the multinomial case, where y can have more (n) values. For the probability that y is equal to one, equation 12 is the same. For the values 2, 3 and so on, we have:

$$P(y \leq i) = F(\alpha_{i-1} + X\beta + u). \quad 13$$

Thus, besides the parameters β , the additional constants α_1 , α_2 and so on are also estimated. Because we have five values for y , there are three additional constants to estimate. The estimated probability that y is equal to five is then: $1 - P(y \leq 4) = 1 - F(\alpha_3 + X\beta)$.

3.3.3 Results

As explained above, we assume that singles as well as married men are always employed full time. For married women we simulate the kind of labour market participation. The basis of our simulation is an estimation of the discussed labour participation function of all women who are living with a partner.

Table 3: Labour market participation function of German women with a partner in West Germany

	Labour market participation (pooled ordered probit)
Constant 1	-0.67***
Constant 2	1.01***
Constant 3	1.68***
Constant 4	2.12***
Own wage	0.019***
Partner's wage	-0.010***
Age	0.016*
Age ²	-0.00068***
Low education	0.064**
Intermediate education	0.25***
High education	0.37***
Children under 3	-1.55***
Children aged 3 to 6	-0.76***
Children aged 7 to 16	-0.35***
Trend variable year	0.013***
Number of cases	15,090

Labour market participation: not employed, minor employment, part-time employment, full-time employment, over full-time employment

Source: GSOEP 1991-2000, German women with a partner residing in West Germany, own calculations

Table 3 shows the estimated parameters of the labour market participation function for this group. The parameters indicate the extent to which the latent, unobservable variable y^* is affected, which determines the employment probability. Thus, a positive (negative) value means that the independent variable is positively (negatively) correlated with the probability of employment. All parameters are significantly different from zero.

The higher the individual's own *wage rate* and the lower the partner's wage rate, the higher the labour market participation, with a parameter of 0.19 for the individual's own wage rate higher than the parameter of 0.10 for the partner's wage rate. However, these parameters cannot be interpreted in the same way as parameters estimated by linear regression. The parameter value of 0.19 does not mean that probability of a woman being employed increases

by 0.19% with every additional DM. What can be said is that the effect of a 1-DM increase in a woman's wage rate has about the same effect as an increase of 2 DM in the partner's wage rate.

As for the wage equation, we also assume a hump-shaped curve for the *age* effect on labour market participation. Therefore we estimate parameters for a linear term and a quadratic term and the result is, as expected, a negative parameter for the quadratic term and a positive one for the linear term. The latter is, however, only weakly significant. Concerning *education* we also find the expected effects: the extent of labour market participation increases with education. For the variable "low education" we observe a relatively low value of 0.06; for intermediate education, 0.25; and for high education, 0.37. All parameters measure the difference to women without vocational training. The strongest effect on labour market participation is exerted by the existence and age of *children*. Each child under 3 years of age reduces the unobserved latent variable by 1.55. With increasing age, this value is lower: 0.76 for preschool children and 0.35 for schoolchildren. As for the wage equation, again we estimate a trend variable, because we assume that labour market participation increases over time. This assumption is confirmed: the parameter is significantly positive with a value of 0.013.

4 Simulations

Based on the estimated wage functions and the labour market participation function of married women, we simulate labour market participation and earnings over the life cycle from age 17 to 60. The aim is to describe the typical work careers of women and men with two children for the three education types. To investigate the effect of child rearing, these simulations will be compared with simulations for men and women without children.

4.1 Labour market participation

We start with the question of how the probability of labour market participation changes over the life cycle. As discussed, we assume that before marriage all persons are employed full time, i.e. the probability of being employed full time is 1.

Figure 1: Simulation of labour market participation of women with low education (without children and with two children)

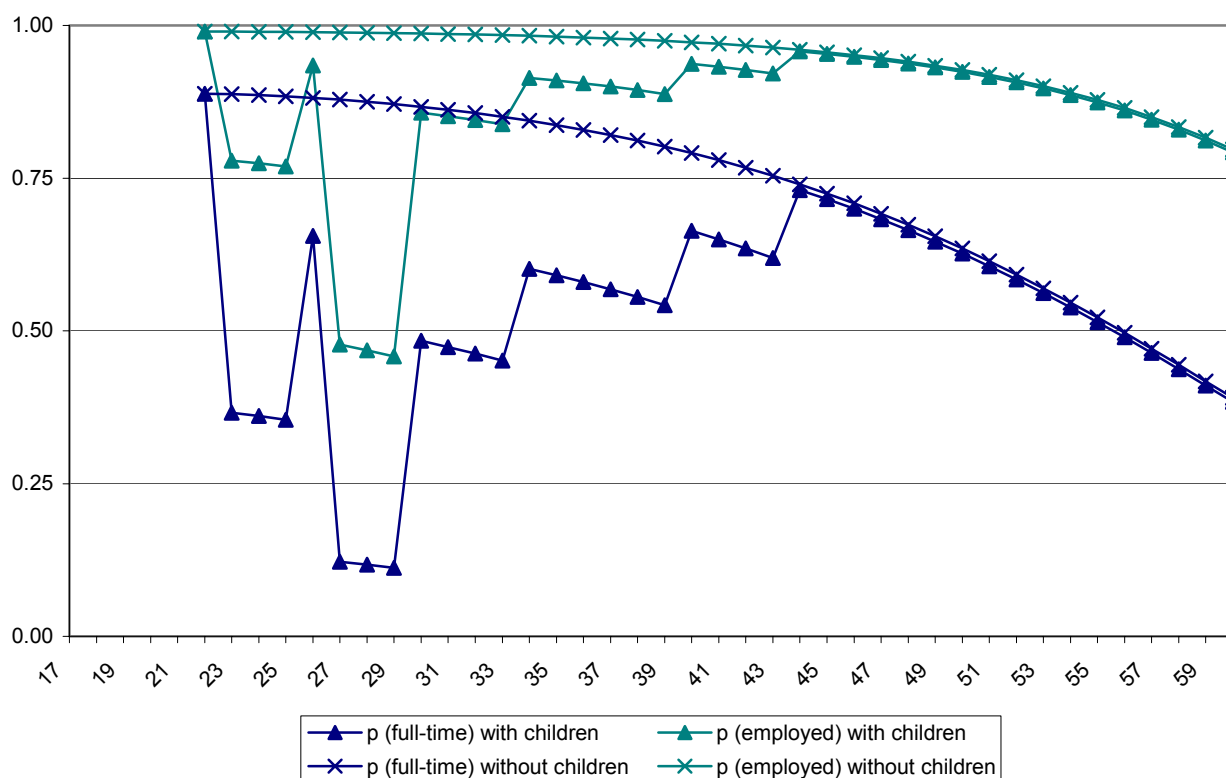


Figure 1 shows the simulated employment probabilities and probabilities of full-time employment for women with low education, i.e. *Hauptschule* plus vocational training, with and without children, under the assumption that children are born when the mother is 23 and 27 years old. On average, people with low education marry at 22. At this time, the probabilities of employment (99%) and also of full-time employment (nearly 90%) are very

high. For women without children this probability decreases to 80% when they are 60 years old because of the estimated age effect. That means for the simulation that they are employed all the time. However, the probability of full-time employment decreases so strongly that the average woman reduces employment to part time starting at age 56.¹

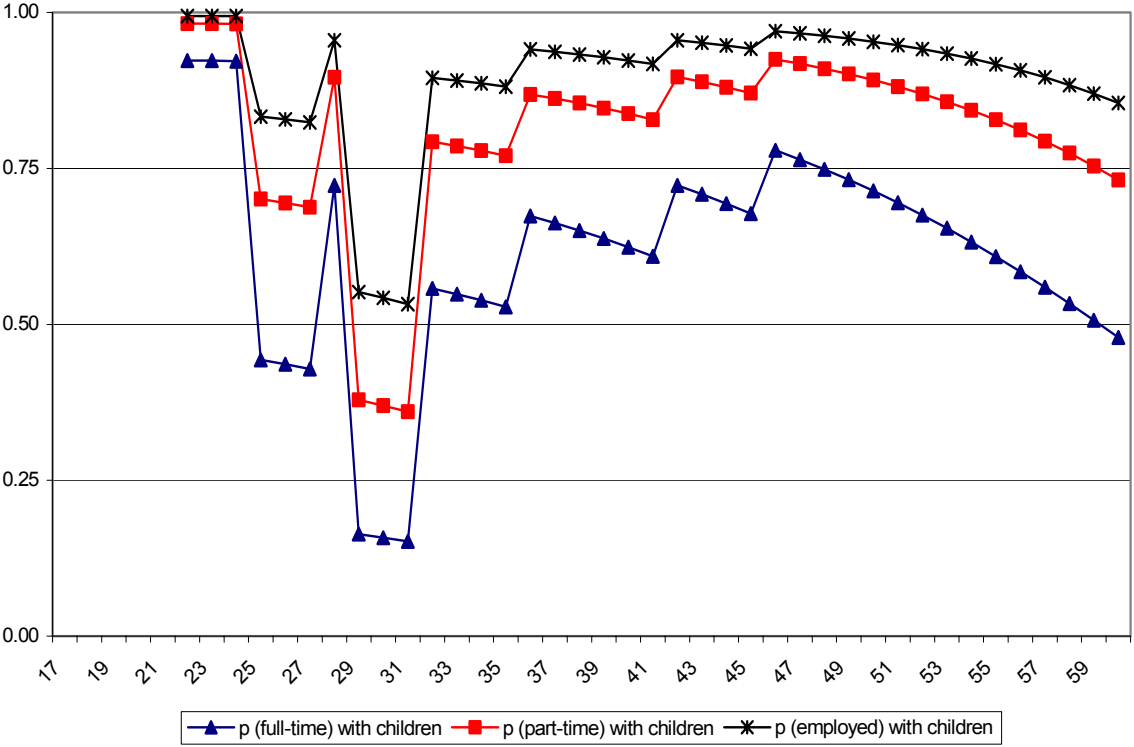
For women with children, the probability of employment drops to 78% with the birth of the first child, and the probability of full-time employment to 37%. This means for our simulation that employment typically is reduced to part time. The first child goes to preschool at the age of 3, with the consequence that full-time employment increases to 66%; thus full-time employment is simulated, but only temporarily – for one year, until the second child is born. Then the possibility of being employed is restricted such that the probability of labour participation decreases below 50% and employment is interrupted for three years.

When the mother is 31 years old, the first child starts school and the second child starts preschool. This leads to a re-entry into the labour market. However, the probability of full-time employment is still below 50%. Thus, for the typical case, employment is initially only part time. This does not change until the second child starts school. Then full-time employment increases to 60%. We assume that children aged 17 or older are independent enough that there is no longer any employment restriction. Therefore, when the mother is 40 or 44, respectively, the probabilities of employment increase once more and reach nearly the level of women without children.

The course of employment probabilities for mid-educated women (*Realschule* or *Abitur* plus vocational training) looks similar (see figure 2). However, marriage takes place one year later (at the age of 23) and each of the two children is born two years later, but with the same difference of four years between the two births. For this education type, too, all women are employed full time until the birth of the first child, then employment is reduced to part time; before the birth of the second child there is, again, one year of full-time employment simulated. Then the employment probabilities drop, but not as much as for low-educated women, namely to just over 50%. Therefore the mother is still working, but only for less than 15 hours per week.

¹ In the data there is no increase in part-time employment for older women. However, an increase in the non-employment rate can be observed, although a high share of women is still employed full time. The simulated effect is thus an increase in part-time employment.

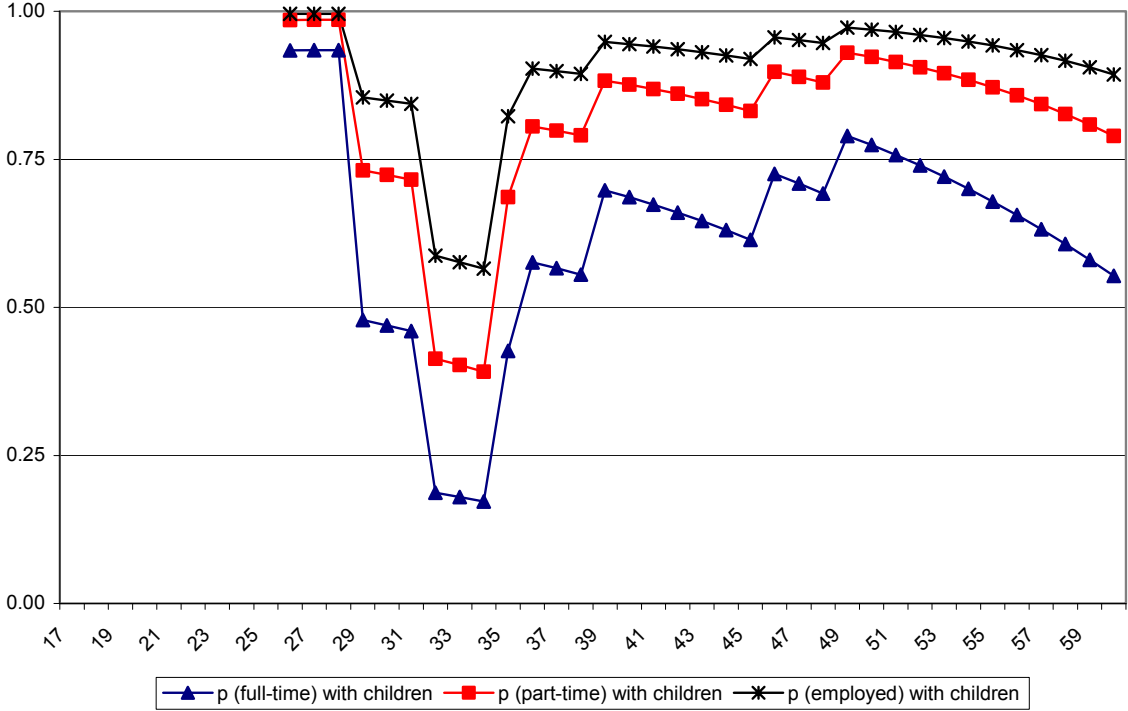
Figure 2: Simulation of labour market participation of women with intermediate education (with two children)



After three years, when the first child starts school and the second starts preschool, employment is extended to full-time work, which is retained (nearly) for the rest of the woman’s career. As shown above, women with low education aged 56 and older reduce their employment to part-time work; for mid-educated women this simulated reduction does not take place until the age of 60, that is only for one remaining year.

Women with high education, i.e. with a post-secondary degree, typically marry at 26 and thus have their children later than the other groups, namely at the ages of 29 and 32. Thus, the difference between the two births is only three years. As a consequence, there is no increase in employment in the last year before the second birth as for the other two education types. Similar to the other types, there is a reduction to part-time work during the first three years of the first child’s life. With the subsequent birth of the second child, the employment probabilities decrease even further, although the burden of child rearing is reduced because the first child starts preschool. Over all, however, labour market participation is reduced to minor employment.

Figure 3: Simulation of labour market participation of women with high education (with two children)



At the age of 35 the probabilities increase again, because the second child starts preschool; as a consequence, employment is extended to part-time work. From the following year on, the first child goes to school and then our simulated woman resumes full-time work. As for the other education groups, for women with post-secondary degrees, too, the probability of employment decreases because of the age effect, but the probability of full-time employment remains continuously over 50%, and is thus not reduced to part time in the simulated typical case.

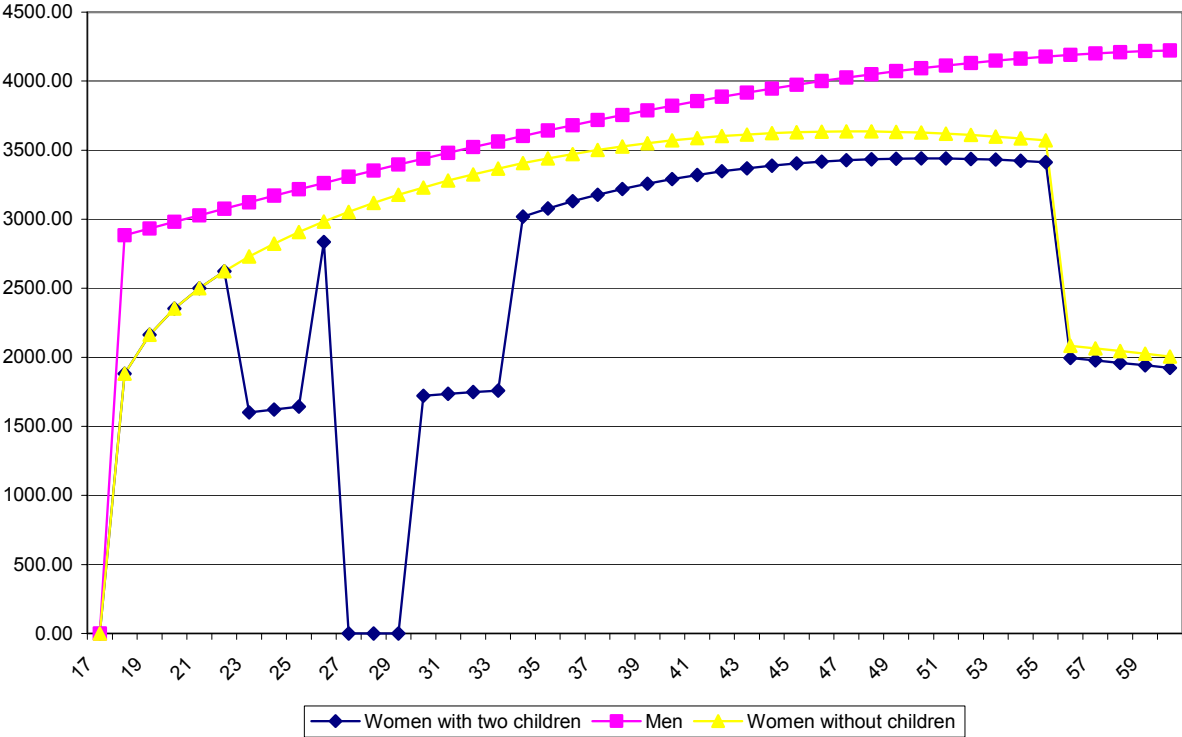
4.2 Monthly earnings over the life cycle

As the next step, the described employment probabilities are used to calculate monthly earnings. For that we assume that full-time employment means 37.5 hours per week, part-time 22 hours, and minor employment 11 hours, which are the averages for these three types of employment. To calculate monthly earnings we multiply these weekly hours by 4.3, the average number of weeks per month, and then by the estimated hourly wage rate. This leads to the following results.

We start our description with low-educated persons and compare the monthly earnings of men, women without children, and women who have two children over the course of their

working lives. For all, labour market entry takes place at the age of 18. Men receive a starting wage of about 2,800 DM, while women receive 1,000 DM less, namely 1,800 DM. For men these earnings increase over their whole career, but the increase decreases slightly over time. For women, however, the age effect has the consequence that gross earnings increase until only about the mid 40s and then decrease slightly by about 65 DM until the age of 55. On the other hand, we already showed above that labour market experience has a stronger effect for women than for men. The consequence is that the increase in wages at the beginning of the life cycle is much higher for women, so that the large earnings gap at the beginning rapidly declines. At the age of 35 men earn only 200 DM more per month than women without children. From that point on the difference increases again, which might be one reason why women reduce their employment to part time at the age of 56.

Figure 4: Simulation of gross monthly earnings of low-educated men, women without children and women with children (in DM)



Source: GSOEP 1991-2000, Germans residing in West Germany, own calculations

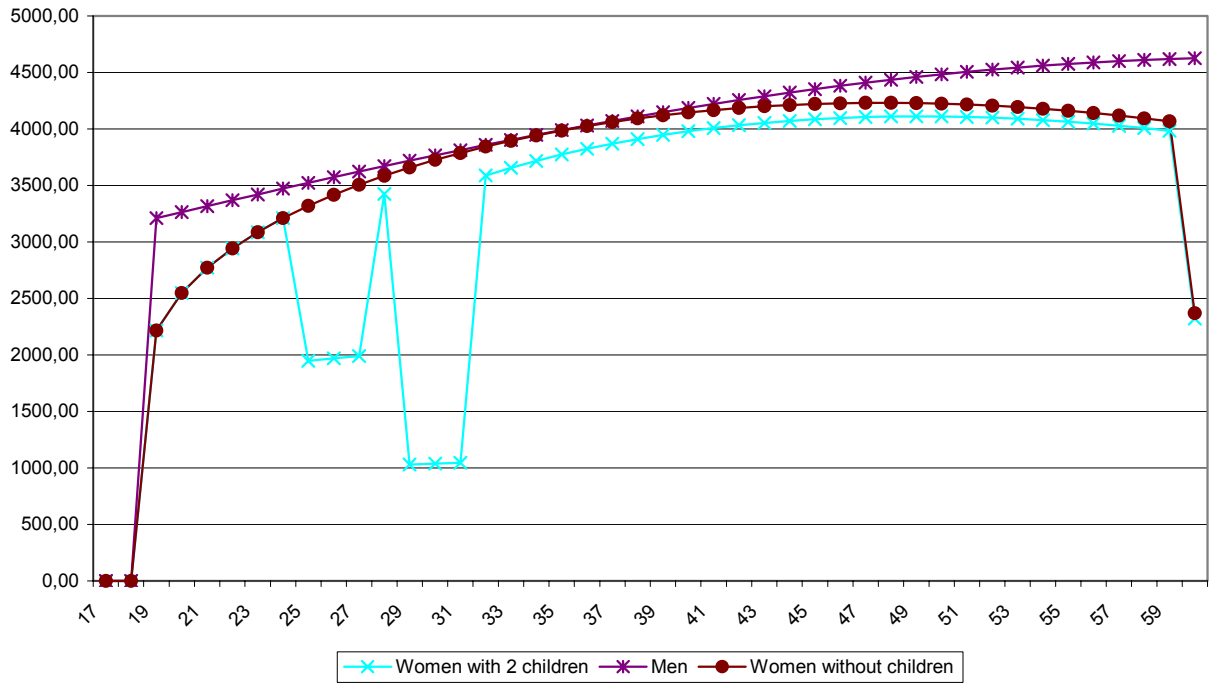
Before the birth of the first child, the development of earnings for women with children is the same as for women without children. But, as described above, after the first maternity leave, labour market participation is reduced to part time for three years, followed by another year of full-time employment before the birth of the second child. Just these three years have

an effect of about 150 DM on the monthly earnings in the one full-time year, reducing wages to 5% below the earnings of women without children.

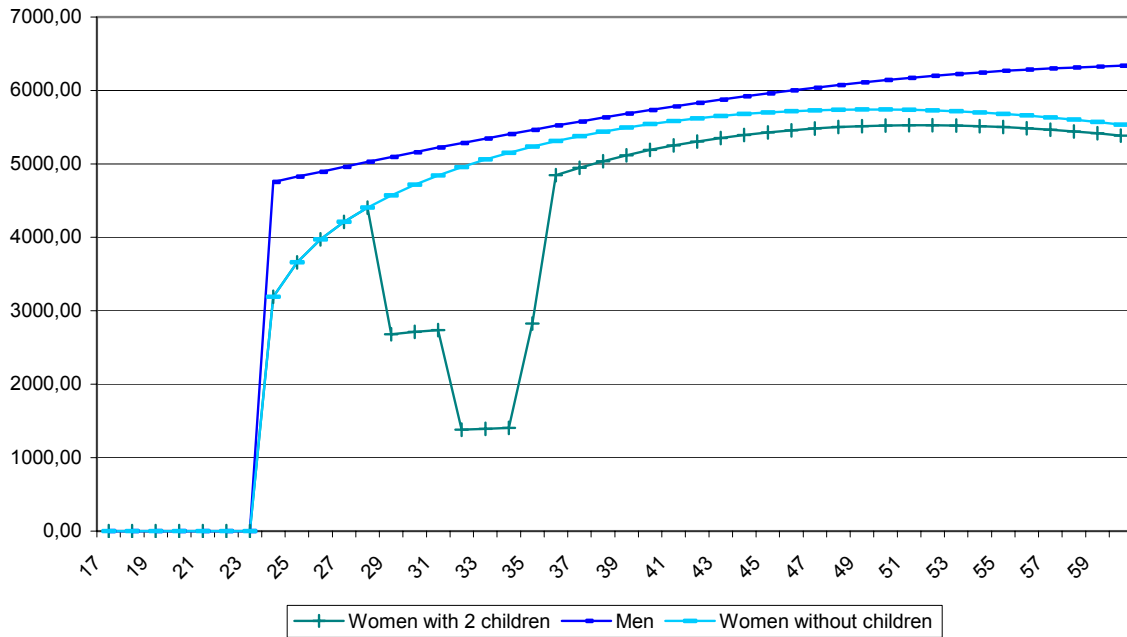
After the birth of the second child there is a labour market interruption of three years followed by four years of part-time employment. When a woman resumes full-time employment, her earnings are 400 DM, or 10%, lower than for comparable women without children. Because of the reducing positive effect of labour market experience, the wages of women with children increase more strongly in the following years, so that the wage difference between women with and without children decreases over time. At the age of 55 the difference is back to 150 DM. This means it takes about 20 years to close the earnings gap resulting from the labour market interruption and subsequent work reduction after the birth of the second child.

The situation is similar for women and men with intermediate and high education (see figure 5). The monthly earnings of men increase continuously, while the earnings of women are substantially lower at the beginning of the life cycle, but increase faster and the decrease at the end of her career. Differences between the education groups result, first, from longer education and therefore later labour market entry and, second, from the different timing of the children's births. Aside from this, it is striking that mid-educated women without children reach the earnings level of men between the ages of 35 and 45, and that only the earnings of older women fall below those of men. For women with a post-secondary degree, however, even without children earnings are always lower than for men, as was observed for low-educated women.

Figure 5: Simulation of gross monthly earnings of men with intermediate and high education, women without children and women with children (in DM)



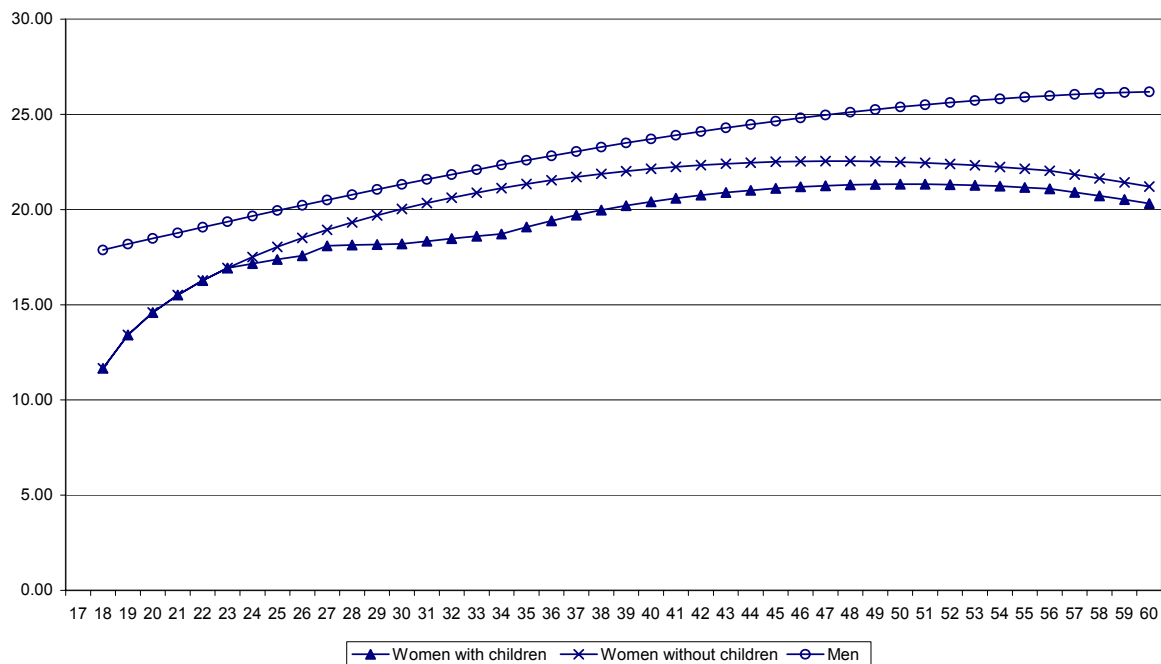
High Education



4.3 Hourly wages over the life cycle

For our investigation, it is of special interest how labour market interruptions and employment reductions influence hourly wage rates. Therefore we look in the following at the development of wages. At first we investigate one education type, the low-educated, and compare again men, women without children and women with children (see figure 6). As can be already seen from the development of monthly earnings, men's hourly wage rates also increase continuously, from 18 DM per hour at the age of 18 up to 26 DM at the age of 60. For women without children we observe the familiar hump-shaped curve. At the age of 18 women start with a wage of 12 DM per hour, which is only two thirds of men's wages. Compared to men, however, this wage rate increases more strongly. At the age of 47 women's wages are 22.55 DM, only slightly lower than the men's wage rate of 25 DM, but after that the wage rate of women decreases until it reaches 20.30 DM for 60-year-old women.

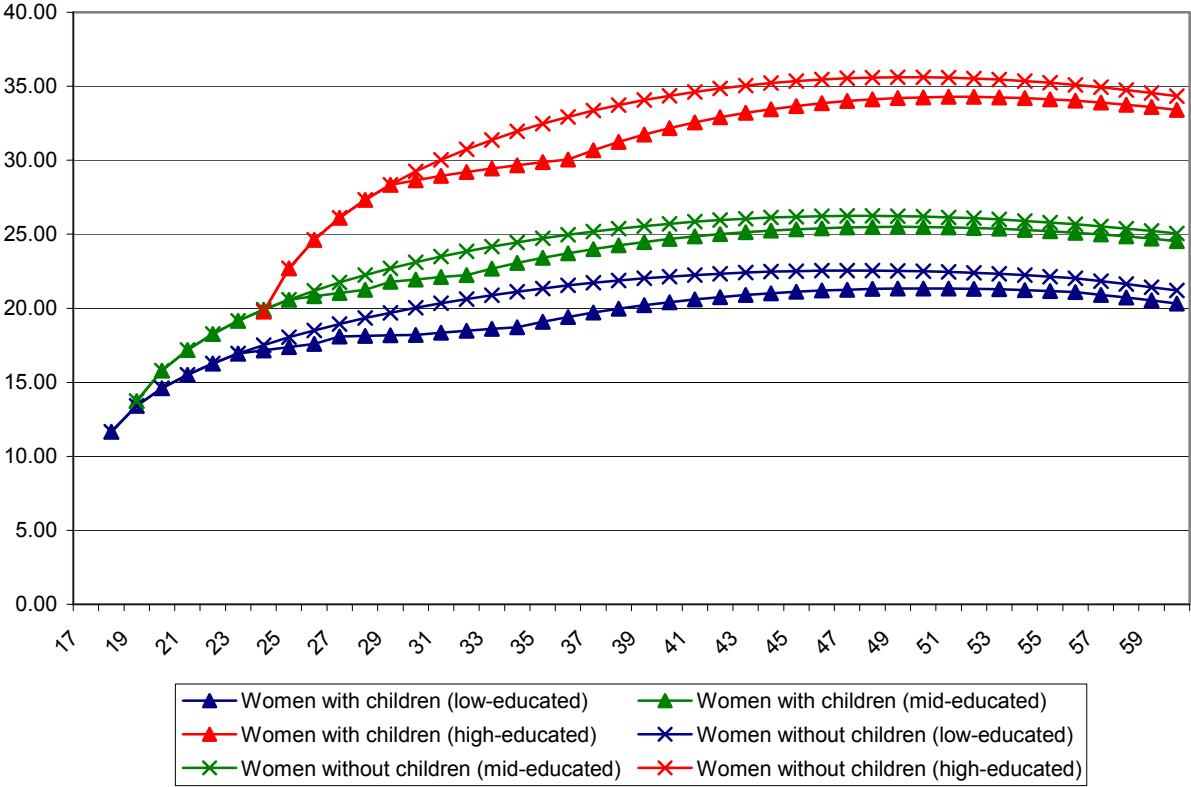
Figure 6: Simulation of hourly wage rates for low-educated men, women without children and women with children (in DM)



For women with low education we observe a slackening of wage increases after the birth of each child. After the first maternity leave and during the following part-time employment there is still a modest increase in the wage rate, but while the wage rate of women without children increases by 1.60 DM from age 23 to 26, the increase for mothers is only 0.60 DM. Wages stagnate after the second maternity leave, while they grow continuously for women

without children. Only after the age of 35, when the typical low-educated woman starts working full time again, do the hourly wages converge again. The difference decreases from more than 2 DM per hour to 0.90 DM, but the wages of women with children remain below those of women without children for the rest of their careers.

Figure 7: Simulation of hourly wage rates of women with children and without children (all education types, in DM)



After describing the development of hourly wage rates for one education type, we now compare the courses for all types (see figure 7). For this we focus on the description of women’s wage rates. The development of men’s wage rates is similar for all education groups, with men’s wages usually higher than women’s. The only exception – as already described for monthly earnings – is that the wages of mid-educated women between 35 and 45 are nearly the same as those of men. As shown above, the wages of low-educated women is something below 12 DM when they start to work, but by the very next year they increase to 13.40 DM. Even a bit higher is the wage of mid-educated women, who start working at this age, which means that the wage rate of women with intermediate education, even at the beginning of their career, is higher than that of women with low education at the same age.

The age at which women with a post-secondary degree enter the labour market is 24. At this age low-educated women have a head start on work experience. Nevertheless, the starting wage of high-educated women is higher than the wage of low-educated women, and only a bit lower than the wage of mid-educated women of the same age. Just one year later women with high education have the highest wages by far, although the others have more labour market experience. The differences between women with children compared to women without children with the same education are minor. For high-educated women, however, the slightly wave-like development that can be observed for the other groups is lacking, due to the one year of full-time employment the latter experience before their second maternity leave begins.

Thus, the central results are that the hourly wage gap between high-educated women with and without children becomes relatively high, while the smallest wage gap can be observed for women with middle education, and the difference of wages is the highest for women with low education, because those who have children leave the labour market for three years after the birth of their second child.

4.4 Lifetime earnings

The simulated monthly earnings are now used to calculate lifetime earnings. To do this we multiply monthly earnings by thirteen to simulate full-time or part-time employment, or by twelve for minor employment. Then these yearly income values are simply added up over the entire simulated life cycle. Based on this calculation, low-educated men receive gross lifetime earnings of 2.1 million DM; men with intermediate education, 2.2 million DM; and highly educated men, 2.8 million DM (see table 3). Because these results are based on the discussed simulations, it is taken into account that people with higher education enter the labour market later. Nevertheless, the higher the education level, the higher the lifetime earnings. This is also the case for women with children and women without children. Women without children receive lifetime earnings of about 1.8 million (low education), 2.1 million (intermediate education) and 2.6 million (high education). Over the life cycle, mid-educated women, i.e. those with *Realschule* diploma or *Abitur* plus vocational training, if they don't have children, earn about the same as men with only a *Hauptschule* diploma plus vocational training. Childless women with a post-secondary degree earn even more than low-educated men.

If we compare the lifetime earnings of women without children with men for each education level, then the largest difference is observed for low education. Low-educated women without children earn more than 300,000 DM less than men with the same education;

they receive only 85% of the lifetime earnings of men, even if they do not have children. For intermediate education the gap is the smallest. Women without children reach 94% of the lifetime earnings level of men. The absolute difference, at 132,000 DM, is only half as high as for women with low education. For women with a post-secondary degree, the relation to men is slightly lower at 93%, but the gap in absolute terms is 203,000 DM, considerably larger because of the higher income level, but smaller than for low education.

Table 4: Simulated lifetime earnings, differences and discrimination

	Low education		Intermediate education		High education	
	1000 DM	in %	1000 DM	in %	1000 DM	in %
Lifetime earnings						
men	2,108	100	2,269	100	2,816	100
women without children	1,798	85	2,136	94	2,613	93
women with children	1,471	70	1,916	84	2,272	81
Differences						
men vs. women with children	637	100	352	100	545	100
men vs. women without children	310	49	132	38	203	37
women without children vs. women with children	327	51	220	62	341	63
wage effect	99	16	62	18	100	18
participation effect	228	36	158	45	242	44
Discrimination						
Total		30.2		15.5		19.3
pure gender effect		14.7		5.8		7.2
child care effect		15.5		9.7		12.1
wage effect		4.7		2.7		3.5
participation effect		10.8		7.0		8.6

Source: GSOEP 1991-2000, Germans residing in West Germany, own calculations

If a woman has two children, then her lifetime earnings are lower because of the discussed employment interruptions. Low-educated women with children earn only 82% as much over their lifetimes as their counterparts without children; for intermediate education this percentage is 90%; for women with high education, 87%. Again, the differences for mid-educated women are smaller than for the other groups. This is the case in both relative and absolute terms. Because of child rearing they lose only 220,000 DM, while this difference is 327,000 DM for low-educated women and 341,000 DM for women with a post-secondary degree.

These differences can be divided in two parts. First, lifetime earnings are lower, because the labour market participation of women with children is lower than of those without children. Second, there is the indirect effect on hourly wage rates discussed above, which is induced by the reduced labour market experience. To distinguish between these two effects, it is possible to use a similar computation method as for the Oaxaka-Blinder approach (see above), because it is:

$$h_{noc} \cdot w_{noc} - h_{ch} \cdot w_{ch} = h_{noc} \cdot (w_{noc} - w_{ch}) + (h_{noc} - h_{ch}) \cdot w_{ch}, \quad 14$$

where h_{noc} is labour market participation measured in hours, w_{noc} the wage rate of women without children (*no children*), and h_{ch} and w_{ch} the labour market participation and wage rate of women with *children*. Then the first term on the right hand side of equation 14 can be interpreted as the (indirect) wage effect and the second as the (direct) participation effect. Based on that separation, the result is that for all education types about 70% of the earnings gap between women with and without children is caused by the participation effect, and the remaining 30% by reduced labour market experience.

In sum, total discrimination of women with children compared to men with the same education level, measured as the relative gap between lifetime earnings, is 30.2% for low education, 15.5% for intermediate education and 19.3% for high education. This total can be divided into the pure gender gap, which is the difference between the lifetime earnings of women without children and men, and an additional child-rearing effect, which is the difference between the earnings of women with and without children. For the education type *Hauptschule* plus vocational training (low education) there is a pure gender effect of 14.7%, even before any of the women have children. If low-educated women have two children, this percentage increases by a further 15.5%. Of the latter, about 5% is based on the reduced labour market experience and about 10% on the reduced labour market participation during the child-rearing period.

We found the lowest degree of discrimination against women of intermediate education. i.e. *Realschule* plus vocational training. Without children the difference to lifetime earnings of men is not more than 5.8%. If two children were born, the income gap is enlarged by a further 9.7%, with 7% caused by the participation and 2.7% caused by the indirect wage effect. Finally, high-educated women without children earn 7.2% less than men, and a further 12.1% less if they have two children (participation effect 8.6% and wage effect 3.5%).

5 Summary and conclusion

Discrimination against women is usually measured in terms of hourly wage rates. The aim of this paper was to broaden this point of view and to quantify income differences between men and women with the same educational level in terms of lifetime earnings, with a focus on the effect of employment reductions because of child rearing.

In summary we establish that there are considerable differences between the lifetime earnings of men and women. For low education (*Hauptschule* plus vocational training) the

difference between the lifetime earnings of men and women with two children is over 600,000 DM. Low-educated women who have borne two children earn 30.2% less than men with the same educational level. With a difference of about 350,000 DM or 15.5%, in absolute terms and relative terms women with intermediate education (*Realschule* or *Abitur* plus vocational training) experience the lowest earnings gap. For women with a post-secondary degree, the numbers lie between the two extremes, at about 550,000 DM and 19.3%.

The difference due to a pure gender effect can be determined by comparing the differences of the simulated lifetime earnings of men to those of women without children, and a child-rearing effect by comparing women with children to women without children. For low education the effects are roughly equal at about 300,000 DM each. For the higher educated groups the child-rearing effect is greater than the pure gender effect.

The child-rearing effect has two sources. First, income is lower, because employment is reduced during the child-rearing period. This explains about 70% of the child-rearing effect. The rest is an indirect effect, which is the consequence of reduced labour market experience and thus lower human capital, which lead to lower wages. As shown, the wage gap decreases during the life course, but the wages of women with children remain below the wages of women without children.

In Strengmann-Kuhn/Seel (2004: 69ff.) we also investigate the effect of taxes and transfers, which can reduce these differences. If we assume separate income taxation for men and women, then the relative difference between men and women with children with low education decreases from 30.2% to 25.9%, for intermediate education from 15.5% to 12.5%, and for high education from 19.3% to 15.1%. If we assume further that the entire child allowance and parental allowance goes to the mother, differences decrease even further. However, even under this radical assumption, the gap between women and men with low education is still 14.9%, but with intermediate education the difference is only 2.5%; with high education it amounts to 6.6%.

When we simulate household incomes of families with and without children, it can be shown that the income loss caused by child rearing is indeed compensated by taxes and transfers (see Strengmann-Kuhn/Seel 2004: 77ff.). Households with children actually receive a slightly higher net lifetime household income than households without children – with “life” meaning the career period from age 17 to age 60.

However, even though the household incomes are more or less the same, in families with children more people have to live on this income. To take that into account we also calculated

equivalent incomes (see Strengmann-Kuhn/Seel 2004: 78ff.). The result is that there are still considerable differences, even after taking taxes and transfers into account. Thus the lifetime average (from age 17 to age 60) of simulated net equivalent income for households with children lies between 16.7% and 18%, or between 470 DM and 649 DM below the average net equivalent income of households without children. For low education, we found that for our typical cases the net equivalent income is only slightly over the poverty threshold, and that poverty is avoided only through state transfers. Even the simulated net equivalent income of families with intermediate qualifications lies only slightly above the poverty threshold during the child-rearing period. Over a longer period families with children have a net equivalent income which is at most half as high as couples with the same education but no children.

For all these results it must be emphasised that the group with the lowest education, namely the households with neither vocational training nor a school diploma, is excluded from our analysis. For this group, for which we can assume even lower income, the result would be that the income usually lies below the poverty line, even when the father is employed. Aside from this, we have to underline that our focus is on what we call *typical* cases. However, that means that there is a variance around our simulated results, which has the consequence that our assumptions also include a significant poverty risk for low- and mid-educated families with young children. Furthermore, our assumptions posit relatively linear, positive life courses devoid of unemployment, divorces, single parenthood or other problems. In reality, this means that the income profile looks worse in these cases than for the cases in our simulations.

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