Changes in Women's Hours of Market Work: The Effect of Changing Returns to Experience*

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Abstract

Over the past several decades in the US, married women's hours of market work increased significantly. I argue that changes in behavior by married women with children account for much of this change. In particular, the pattern of married women's work hours over the life cycle has changed substantially. In the past, married women of childbearing age tended to specialize in childrearing and home production activities at the expense of engaging in market work. Now, they do not curb the hours worked on the market.

What factors contribute to this change in behavior? In this paper, I focus on relative changes in returns to experience as an explanation. I quantitatively assess how these changes in returns to experience contributed to changes in married women's life cycle profiles of hours worked. I build a life-cycle model with human capital accumulation and home production in which the basic unit of analysis is a married couple with children, and calibrate it using data from the 1970s and 1990s. I show that changes in returns to experience account for a large part of the observed change. Moreover, according to the model, the increase in returns to experience accounts for roughly half of the increase in the female/male wage ratio that is found in the data. I also show that a decline in the gender wage gap, holding returns to experience constant, cannot explain the change in the shape of women's life cycle profiles. Although the focus of the analysis is the labor supply behavior of women, the model also makes predictions about the behavior of men that are consistent with the data.

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1 Introduction

An important trend in American society in the last several decades has been the dramatic increase in married women's hours of market work. This trend has been particularly prominent for married women with young children. Another change that has been documented by other researchers is that the returns to labor market experience have increased more for women than for men between the 1970s and 1990s[1]. In this paper, I argue that this change in relative returns to experience is a key factor in accounting for the change in hours of work for married women with young children. The logic behind my argument is straightforward. In the 1970s, married women would temporarily cut back on market work during child rearing years. One cost of this withdrawal is the loss in accumulated labor market experience. Since this cost has become greater in the 1990s, we would expect married women to decrease the extent of their reduction in market hours.

In this paper, I document these facts and develop a model to quantitatively assess the consequences of the increase in returns to experience for married women's hours of work over the life cycle. Although the focus of the analysis is the labor supply behavior of women, the model also makes predictions about the behavior of men that are consistent with the data. In particular, I build a life-cycle model with human capital accumulation and home production in which the basic unit of analysis is a married couple with children. Parents allocate their time between market, home, and leisure activities. Childcare is produced through a combination of parental time and market goods and services. Human capital is accumulated through learning-by-doing. As a consequence, wage profiles are determined endogenously. Since the focus of the analysis is the change in life cycle behavior of married women with children, I abstract from modeling fertility and marriage decisions[2].

Using this model, I analyze how the change in the returns to experience affect life cycle profiles of earnings and hours worked. The basic strategy is to parametrize the model using data from the 1970s and then ask how the model's predictions change when we allow for changes in the returns to experience to their values for the 1990s[3]. The estimates of the human capital accumulation technology are taken from a companion paper (Olivetti [2000]), where I use a semiparametric method to obtain estimates of the learning-by-doing human capital production function parameters for both men and women in the 1970s and in the 1990s. The estimates are corrected for the sample

[1] See O'Neill and Polachek [1993], Blau and Kahn [1997], and Olivetti [2000].

[2] For a survey of life cycle models of fertility, see Hotz, Klerman, and Willis [1997]. More recently Greenwood, Güner, and Knowles [1999] built an overlapping generation model that incorporates both marriage and fertility decisions.

[3] This approach is similar to the one adopted in Rios-Rull and Regalia [1999] to investigate the causal relationship between the narrowing of the gender gap and the increase in single female households.

selection and simultaneity bias that arise in this dynamic context, and are based on PSID data.

The simulation results show that the relative change in returns to experience can account for most of the observed change in average hours worked for married women. Consistent with the data, the model predicts only modest changes in the life cycle profiles of hours worked for men. The model also has interesting implications for the gender wage gap. Because wages are endogenous, increases in hours of work for women will also lead to higher wages for women. According to my simulations, the increase in returns to experience can also account for roughly half of the decrease in the gender wage gap between the 1970s and the 1990s. This is consistent with the estimates obtained by O'Neill and Polachek [1993].

A second possible explanation for the increase in women's work hours that is related to changes in the wage structure is the decline in the gender wage gap. I can also use my model to evaluate the consequences of a pure change in the gender wage gap, holding returns to experience constant. While I find that this change can account for a small increase in hours of work for married women, it cannot account for the large increase observed for married women with young children. In particular, the pure change in the gender wage gap cannot explain the change in the shape of married women's life cycle profiles.

The paper is organized as follows. Section 2 documents facts about the change in married women's life cycle hours of work. Section 3 provides evidence of the relative increase in returns to experience by estimating a learning-by-doing human capital production function, which will be later used in the calibration of the full model. I present the life cycle model in Section 4. Section 5 discusses the functional forms and the calibration strategy. The results are described in Section 6. Section 7 presents the general equilibrium version of the model and discusses the results obtained. Finally, I provide some concluding remarks in Section 8.

2 Changing Patterns in Women's Market Work

One of the striking changes in the labor market over the last three decades has been the dramatic increase in hours worked for women. In particular, average hours worked per adult female increased by 43% between 1970 and 1990. At the same time, average hours worked per adult male basically remained constant (they increased by 0.43%) between the two periods. Over this time period, many characteristics of the female population changed substantially, such as educational attainment, fertility, marital status and out-of-wedlock childbearing[4]. The purpose of this section is to document that a key component of the increase in women's hours worked is the drastic change in the behavior

[4] For a detailed description of the change in women's labor force participation and related issues, see Hotz, Klerman, and Willis [1997].

of married women with children holding other characteristics, such as education and number of children, constant.

The extent of the increase in women's work hours is even more dramatic when we disaggregate the data by age and compare different demographic groups. Table 1 summarizes percentage changes in average hours worked per person by age, gender, marital status, and presence of children.

Table 1: Percentage change in average hours worked per person by age 1970 vs. 1990

		25-34	35-44	45-54
married men		-0.12%	-0.43%	-1.5%
married women		96%	70%	49%
single women		3%	9%	-0.1%
married women	with kids<6	134%	117%	53%
	with kids 6-17	55%	61%	58%
	NO kids <18	36%	40%	37%

Source: 1970 and 1990 Census data

The entries in the table are based on 1970 and 1990 Census data[5]. Average hours worked per married women increased by 96% for the 25 to 34 age group, and by 70% for the 35 to 44 age group. At the same time, for the same age groups, average hours worked by single women and married men remained constant or decreased slightly.

Within the group of married women, the bulk of the increase is experienced by mothers with children of preschool age, with the average number of hours worked per person more than doubling. In particular, married mothers aged 25 to 34 worked on average 134% more hours in the 1990s than they did in the 1970s. For the age group 35 to 44, average hours per person increased by 117%[6]. At the same time, married women with no children less than 18 years old experienced the smallest percentage increase in the average number of hours worked among married women.

This drastic increase is still observed when we control for education and number of children less than 6 years old. For instance, the largest increase in average hours worked per married woman with young children occurs for 25 to 34 year old high school graduates, with the average hours worked increasing by 185%[7]. Moreover, for the same age group, average hours worked by married

[5] Census data are taken from McGrattan and Rogerson (1998).

[6] Married women with young children also experienced one of the largest increases in the female/male pay gap (Waldofogel [1998]).

[7] For the same demographic group, the average hours worked by college graduates increased by 120%.

women with exactly one child increased by 144%. The increase is even larger, 179%, for married women with two children less than 6 years old.

Between 1970 and 1990 the demographic distribution of young women changed substantially. In particular, the fraction of married women with children in preschool age declined, whereas the fraction of single women in the population doubled[8]. Simple calculations show that the change in the demographic composition of the female population between 25 and 44 years of age can account only for about 24% of the total increase in hours of market work. The increase in hours of market work by married women with children explains 70% of the remaining residual. At the same time, the increase in hours of work by single women can only account for about 3% of the change[9]. This fact reinforces the observation that the increase in average hours of work by young women is mainly due to a change in the working behavior of married women with children.

A different way of looking at this phenomenon is from the perspective of a change in life-cycle profiles of hours worked. In fact, the extent of the change in average hours worked suggests that the life-cycle behavior of married women has changed substantially. Figure 1 plots the age profiles of weekly hours worked per person from the Census data. As Figure 1 displays, in the 1970s, the age profiles of hours worked per person are double-peaked for married women. Women work more hours at the beginning of their adult life, then temporarily withdraw from the labor market when having children, and eventually engage again in market activities as the children grow older. This is the "typical" shape of women's profiles, as pointed out since the work on women's earning and labor force participation by Mincer [1962 and 1974], and Mincer and Polachek [1974]. As shown in Figure 1, this seems not to be the case anymore in the 1990s. In particular, not only does the average number of hours worked per married women increase for every age group, but the 1990s profile has the single-peaked shape, which typically characterizes men and single women.

Figure 2 reinforces this observation by studying the life cycle hours profiles of married mothers with children of preschool age. Clearly, the slope of the age profile also changes for married mothers. This suggests that the 1990's pattern of work hours over the life cycle is not caused by the fact that women postpone their decision to have children or choose not to have children. Indeed, during the 1990s, labor market activities are no longer crowded out by childrearing activities[10]. The

[8] In particular, the fraction of married women with children in preschool age declined by 30% for the age group 25 to 44 whereas the fraction of single women in the same age group more than doubled.

[9] The percentages for single women with and without children are 2% and 4% respectively.

[10] Note that, the data on average hours worked per person include changes in both the extensive and the intensive margin. The age profiles of labor force participation are almost flat (slightly decreasing) in the 1970s, but they are concave in the 1990s. The age profiles for average hours worked per worker (the intensive margin) are similar to the ones per person: not only are more women working in the 1990s even if they are married or have children, but when such women are already working, they also do not decrease the hours they work to the same extent they did in the

comparison between hours profiles for different demographic groups further clarify the extent of the change. To this effect, Figure 3 (a and b) compare Census data in 1970 and 1990 for married men and women, married mothers, and single women. As pointed out, married women and married mothers of young children show a behavioral profile different from that of men and single women in the 1970s. In the 1990s, the gap between average number of hours worked by married women and by married men decreases, and married women's age profiles have the same shape as men's and single women's profiles. Marriage and motherhood seem to play a much smaller role in women's labor decisions.

Although the facts presented are based on cross-sectional data, the same pattern is observed for life-cycle histories. McGrattan and Rogerson [1998] study the change in life-cycle hours across cohorts. Using Census data for the years 1950-1990, they use different extrapolation procedures to construct complete life-cycle profiles for several consecutive cohorts of men and women. Figure 4 presents the women's life-cycle profiles for a sub-set of 10 year cohorts (it is based on Chart 3 in their paper). These extrapolated profiles represents how the work life-cycle profiles would appear if the demographic trends of the 1950-90s were to continue for a longer time. The figure clearly shows the change in the shape of the life cycle profiles for women. In particular, profiles for average hours worked are still double-peaked for the 1926-1935 generation, which corresponds to women between 35 and 44 years of age in the 1970 Census. This considerable time reallocation by age is an important determinant of the strong trend we observed at the aggregate level.

To summarize, a key aspect of the drastic increase in hours worked by women is the change in the slope of work hours profiles for married women with young children between 1970s and 1990s. This change is observed even if we control for changes in the demographic composition and in observed characteristics, such as schooling and fertility, over this time period. In this work, I show that a plausible and indeed important explanation for the change in this pattern is the change in relative returns to experience that occurred between the 1970s and the 1990s.

3 Why? The Change in Relative Returns to Experience

To explain this behavior, the current literature focuses on changes in observed characteristics such as women's schooling and work experience, changes in fertility, family dissolution, and a general decline of the gender wage gap. Although these changes have contributed to the increase in women's labor force participation, at least to a first approximation, they seem to play a lesser role in explaining the change in the life cycle hours profile for married women. For instance, we could think that if family dissolution is more likely, women will continue to work in order to insure against future

1970s.

losses of income. Yet the divorce rate is roughly constant between 1970 and 1990 and thus it cannot be hold responsible for the change in the pattern of work hours over the life-cycle[11]. With respect to fertility, as argued in the previous section, the change in women's profiles is observed for married mothers of children less than 6 years old of age. Thus, the change in fertility also seems to play a secondary role. With regards to schooling, the change from double-peaked to single-peaked age-profiles is observed within education groups. Once more, the increase in educational attainment also seems to be of second-order importance. Finally, with regards to the decline in the gender wage gap, I will show later in the context of my model that this induces an increase in average hours worked for every age group, but that it cannot explain the change in the shape of the work hours age profiles[12].

In this work, I propose the change in relative returns to experience as a crucial determinant of the observed change in hours of work for married women with young children. Intuitively, the increase in returns to experience increases the opportunity cost of temporarily dropping out of the labor force. Higher returns to experience make it too costly for mothers to temporarily withdraw from the labor market in order to provide "full-time" childcare.

Starting with the work by Katz and Murphy [1992], several researchers have documented an increase in the return to experience within gender and education groups. Prior studies provide evidence that, over the past decades, returns to experience have been increasing more for women than for men[13]. In particular, O'Neill and Polachek [1993] use PSID data for the period 1976 to 1987 to investigate the main factors that contributed to the one percent yearly decrease in the gender wage gap experienced in the US since 1976. Their estimates show that the average annual change in returns to experience over this time interval has been positive both for men and for women. Furthermore, the average change in returns for women of all experience levels was more than twice as much as the average change for men. For younger workers (i.e., workers with less than 15 years of experience), the relative increase in women's returns to experience was four times as big as it was for men. Blau and Kahn [1997] provide estimates of female and male Mincer earning

[11] The divorce rate is about 4 per 1000 population in 1970. It increases to 4.7 in 1990.

[12] Among other explanations for the general increase in women's labor force participation proposed in the context of dynamic GE models, Greenwood, Seshadri A., and Yorukoglu [2001] study the effect of technological advancements embodied in consumer durables on the increase in married women participation since 1950. Jones, McGrattan and Manuelli [2001] investigate the effect of the decline in the gender wage gap on the time series of female hours of market work for both married and single women.

[13] These studies show that the increase in return to experience and the increase in actual experience for women explained a large portion of the decreasing gender wage gap. Among the factors that are mentioned as a possible cause of this behavior are, de-unionization, occupational shift, and the decrease in blue collar wages. For an extensive discussion on the dynamic of the gender wage gap see Goldin (1990), Smith and Ward (1984), and O'Neill (1985).

equations for 1979 and 1988 using PSID data. Their results show that, although both female and male returns to experience increased over this time period, women's returns to full time experience increased more than men's did. According to their estimates, women's returns doubled whereas men's returns increased only by 9%. Also, women's returns are higher than are men's returns in the 1990s. This is due to the fact that the problem of non random selectivity into the sample is not taken into account in the estimation.

I use panel data to explore how the relationship between past wages and hours worked and current wages through learning-by-doing evolved over the past decades[14]. This analysis is carried out both within and between gender groups. To this effect, Olivetti[2000] implements a semiparametric estimator for the human capital production function parameters that corrects for the sample selection and simultaneity bias that arise in this dynamic context. Here I present the estimates of the learning-by-doing human capital production function parameters that will be later used to calibrate the model. The specification of the human capital production technology studied is the following:

$$\theta_{i,t+1} = ((1-\delta) + \eta\left(a_{it}\right) n_{i,t}^{\psi})\theta_{it}\epsilon_{it+1} \tag{1}$$

where θ_{it} is the human capital stock at time t, a_{it} the age of an individual at time t, and ϵ_{it+1} an individual-specific unobservable productivity shock. According to this specification, human capital is accumulated through learning-by-doing. That is, the stock of human capital of an individual of age $a+1$ at time $t+1$ is given by the previous period human capital minus depreciation, plus an increasing function both of his/her stock of human capital and of the total number of hours worked in the previous period. Marginal returns to one extra hour of work are represented by the first derivative of this function, and are proportional to $\eta\left(a_{it}\right)\psi$, where $\eta\left(a_{it}\right)$ is allowed to include a pure age effect in the estimation[15]. As a consequence of this assumption, incentives to accumulate human capital may change as individuals age. The parameters of the production function are estimated separately by gender for the 1970s and the 1990s using PSID data. Thus, although men and women are characterized by the same functional form of the human capital production function, the parameters are allowed to differ by gender and time. An analogous human capital production function is structurally estimated by Imai (1999) for prime-age men in the context of a partial equilibrium model. Shaw (1989) also estimates a similar life cycle model for prime-age men, although she considers the law of motion for human capital to be quadratic for both hours worked and human capital stock plus a cross product term.

Since the human capital stock is not observed, equation (1) cannot be estimated directly. How-

[14] The existence of learning-by doing in terms of dynamic model of labor supply is documented by Altug and Miller [1998], Imai [1999], and Chang, Gomes, and Schorfheide [2000].

[15] Since the youngest individuals in the sample are 20 years old, I use $a_{it} = age_{it} - 20$ in the estimation.

ever, we do observe wages. As is typical in the literature on human capital, wages can be defined as the product of the individual human capital stock times the rental rate of human capital in the economy. That is, for the i-th individual: $\omega_{it} = \theta_{it} R_t$. The rental rates differ by gender. Multiplying both terms by the rental rate R_{t+1}, substituting $\omega_{it} = \theta_{it} R_t$, and taking logs:

$$\ln \omega_{it+1} = \ln \omega_{it} + \ln \left((1-\delta) + \eta (a_{it}) n_{it}^{\psi} \right) + \pi_{t+1} + u_{it+1} + v_{it+1} \tag{2}$$

where $\pi_{t+1} = \ln \frac{R_{t+1}}{R_t}$ represents the rate of growth of rental rates of human capital, v_{it+1} are i.i.d. measurement errors, and the individual-specific productivity shocks $u_{it+1} = \ln (\varepsilon_{it+1})$ are correlated over time[16]. In this context, an individual's wages are observed only if he/she works in the labor market, and the labor supply decision is one of the inputs in the production of human capital. Both decisions may depend upon individual specific productivity, given by u_{it+1}. This generates a selection and a simultaneity problem in estimating the parameters of the production function. Following the estimation procedure discussed in detail in the companion paper, this equation is estimated by nonlinear least squares. The estimation procedure corrects for these two potential sources of bias[17]. The correction is important because failing to make it would always generate larger estimated rates of return to experience for women than for men[18].

The equation is estimated for four subsamples. The first two include males and females surveyed yearly for the time period 1970 to 1977, the 1970s; the second and third males and females for the period 1990 to 1997, the 1990s. Time dummies are introduced in order to capture the year-to-year variation in the returns to human capital, π_t[19]. In this section, I present the results obtained when I restrict the depreciation rate δ, and the exponent ψ to be the same for both men and women (in the 1970s and in the 1990s), and I assume that $\eta (a_{it})$ is a quadratic function of age (that is, $\eta_g (a_{gt}) = \eta_{g0} + \eta_{g1} a_{gt} + \eta_{g2} a_{gt}^2$ where $a_{gt} = age_{gt} - 20$, $age = 20, 21, 22, ...$). These assumptions are made in order to obtain realistic age-earning profiles under the assumptions on preferences that will be used later in the model[20]. Table 2 presents the results when I set $\psi = 0.4$, $(1-\delta) = 0.8$,

[16] That is, conditional on all the information known at time t, u_{it+1} is distributed according to the generic conditional c.d.f. $F(.|u_{it})$. This is more general than assuming fixed effects.

[17] The estimation algorithm and the results are described in detail in Olivetti [2000]. In particular, following Olley and Pakes [1996], the unobservable shock is substituted with a orthogonal polynomial series in the observables (specifically hours worked at $t+1$, and hourly wages at $t+1$).

[18] For instance, Blau and Kahn [1997] found that women's returns to full time experience are 25% higher than are men's in 1989.

[19] The labor supply variable is annual hours worked. Real hourly wages are obtained by dividing annual real earnings by annual hours worked. Reported nominal wages are deflated by the Consumer Price Index. The base year is 1992.

[20] The result described in this section, and the simulation results are robust to the choice of the constraints on the

and estimate the remaining parameters.

Table 2: Human capital production estimates

	1970s		1990s	
	men	women	men	women
η_0	0.0149 (7.3e-04)	0.0114 (0.0015)	0.01576 (8.4e-04)	0.0143 (0.00115)
η_1	-2.67e-04 (5.99e-05)	-1.19e-04 (1.3e-06)	-2.52e-04 (7.2e-06)	-1.89e-04 (1.13e-05)
η_2	4.3e-06 (1.3e-06)	-6.29e-07 (1.9e-07)	3.51e-06 (2.3e-07)	7.43e-07 (1.04e-08)

These estimates will be used later to calibrate the model. The marginal return to experience is given by the function $\frac{d\ln\left(\frac{w_{it+1}}{w_{it}}\right)}{dn_{it}} = \frac{\psi\eta(a_{it})n_{it}^{\psi-1}}{(1-\delta)+\eta(a_{it})n_{it}^{\psi}}$. Figure 5 plots the marginal returns to experience against annual hours for an average age of 35 years. Although my estimation procedure is different, the estimations for returns to experience are consistent with those documented by Blau and Kahn [1997] and O'Neil and Polachek [1993] based on the same definition of full-time work experience[21]. The estimated values unambiguously display a higher relative increase in returns to experience for women. The figure clearly shows that women's marginal returns to experience increased relatively more for women than for men between the 1970s and the 1990s. In particular, women's returns to experience increase by 25%, whereas men's returns increase only by 6%. For this particular age group, women's returns in the 1990s are very similar to men's returns in the 1970s.

Although here I am taking the change in the technology for human capital accumulation as exogenous, the results indicates the necessity to go one step further and study the determinants of the relative larger increase in women's returns to experience. In general the increase in returns to experience can be attributed to technological change that favors more skilled workers. Technological progress favorable to women's characteristics can contribute to the relative increase in women's returns to experience[22]. Other possible explanations are the change in the distribution of female workers by occupation and the decline in discrimination against women, in particularly against

parameters of the human capital production function. Moreover, they are consistent with the unrestricted estimation results described in the companion paper. Such results show that both female and male human capital depreciate at a faster rate in the 1990s than in the 1970s.

[21] I will restrict our attention to full-time workers. Full-time workers are defined as individual who worked at least 1500 hours a year. This definition is consistent with the one used in Blau and Kahn and O'Neill and Polachek.

[22] For instance, Galor and Weil [1996] study the causes of the decrease in the gender wage gap, and explore the possibility that technological progress tends to reward attributes in which women have a comparative advantage.

married women and married mothers. Regarding the first explanation, women earned access to jobs where labor experience is more important. As for the second, a reduction in discrimination could have occurred as a direct result of the activity of government agencies (e.g. the Equal Employment Opportunity Commission). Although studies of government antidiscrimination activities do not find such activities had any impact in the 1980s, the study of the legal suit against sexual discrimination brought (and won) before the Supreme Court seem to indicate that such activities became more effective in the mid-Eighties. The investigation of the causes of the relative change in returns is left for future work.

4 The Life-Cycle Model

In order to quantify the contribution of the relative change in returns to experience to the change in married women's life cycle profiles of hours worked, I develop a life-cycle model with human capital accumulation and home production where the basic unit of analysis is a married couple with children. Parents allocate their time between market, home and leisure activities and human capital is accumulated in the form of learning-by-doing[23]. Childcare is produced through a combination of parental time and markets goods and services. Thus, the parents' time allocation decision is key to the analysis. There is no uncertainty in the model, individuals have perfect foresight about the length of their lifetime. I assume price taking behavior. Individuals take as given both the rental rate of human capital, that differs by gender, and the real interest rate. Due to the learning-by-doing nature of the process of human capital accumulation, earning profiles are endogenously determined in equilibrium. The labor supply decision in one period not only affects current earnings, but also determines wages at later ages. This framework differs from other models of married women's life-cycle labor force participation with endogenous wages mainly on two dimensions: the specification chosen for the process of human capital accumulation, and the fact that labor supply and earnings are jointly determined over the life-cycle both for husband and for wives[24]. In what follows I describe the model in detail and define the equilibrium.

4.1 Demographics

The basic unit of analysis is a married couple. Fertility is exogenous. A couple is assumed to have two children (one male, one female) in the second period of life. Individuals live for six periods,

[23] Shaw (1989) and Imai (1999) estimate life-cycle models with *learning-by-doing* human capital accumulation. They restrict their attention to prime-age men.

[24] For estimable dynamic models of married women's labor force participation with endogenous wages, see Altug and Miller [1998], Eckstein and Wolpin [1989], and Moffitt [1984a].

where one period in the model corresponds to ten years. I do not explicitly model the first two (ten year) periods of agents' life when children live with their parents. They become adults in the third period as a married couple. Every couple dies at the end of period six.

According to this framework the adult life-span is forty years long (four 10-year periods). I would refer to adults as individuals in the age range 20 to 60. Hence, the first adulthood period corresponds to the age range 20-29, the second period (i.e. the parenthood period) corresponds to age 30 to 39, and so forth. Kids leave their parents household at age 20 and become adult as a married couple. Agents "die" at age 60.

4.2 Time allocation

Each agent is endowed with one unit of time in every period of his/her life. In the first and fourth period he/she decides to allocate his/her time between market and leisure activities. In the second and third period, when children are present in the household, time is also allocated to the (home) production of childcare.

4.3 Preferences

I assume that each couple has preferences over joint consumption, husband's and wife's leisure, and children's quality. Preferences are given by:

$$\sum_{t=1}^{N} \beta^{t-1} \left(U \left(c_t, \ell_{mt}, \ell_{ft} \right) + V \left(x_t \right) \right)$$

where c_t represents family consumption, ℓ_{mt} is husband's leisure, ℓ_{ft} is wife's leisure, x_t represents children's "well-being" and β $(0 < \beta < 1)$ is the discount factor.

4.4 Childcare production:

Child quality is produced using a combination of mother's and father's time and services purchased on the market. A key element in the production of childcare is the degree of substitutability between parental time and market services. More formally I assume:

$$x_t = X_t \left(h_{ft}, h_{mt}, s_t \right) \qquad t = 2, 3$$

where h_{mt} is the fatherly time spent in childcare, h_{ft} represents motherly time spent in childcare and s_t is the input of market goods and services. As mentioned above, the production of childcare takes place only during the second and third period of a married couple's life. The function X is allowed to change over time. In particular, I assume that as the children grow older the amount of parental time needed in the production of the children quality decreases whereas more market inputs are needed[25].

4.5 Human capital accumulation

I assume that agents accumulate human capital via a process of learning-by doing[26]. In particular, human capital next period depends on the amount of human capital accumulated up to the current period and on the number of hours worked in the market in the current period. That is,

$$\theta_{gt+1} = G_g\left(\theta_{gt}, n_{gt}\right) \qquad \forall t,\ g \in \{f, m\}$$

where n_{gt} is hours of market work by an individual of gender g at time t, and θ_{gt} is the human capital stock of an individual of gender g at time t. The human capital production function may differ for males and females. A married couple is indexed by its initial stock of human capital $(\theta_{m0}, \theta_{f0})$. In this framework the wage of an individual of gender g at time t (ω_{gt}) is given by the product of the individual current human capital stock (θ_{gt}) times the gender-specific rental rate of human capital (π_g) which is common across all agents.

4.6 Household decision problem

Given prices π_g and R and the initial stock of human capital a household solves the following decision problem:

$$\max \sum_{t=1}^{N} \beta^{t-1}\left(U\left(c_t, n_{mt}, n_{ft}\right) + V\left(x_t\right)\right)$$

$$\begin{aligned} s.t.\ \sum_{t=1}^{N} \frac{(c_t + s_t)}{(1+R)^{t-1}} &\leq a_0 + \sum_{g\in\{m,f\}} \sum_{t=1}^{N} \frac{\omega_{gt} n_{gt}}{(1+R)^{t-1}} \\ \theta_{gt+1} &= G\left(\theta_{gt}, n_{gt}\right) \qquad g \in \{f, m\} \\ n_{gt} + \ell_{gt} + h_{gt} &= 1 \qquad g \in \{f, m\} \\ a_0 &= a_{N+1} = 0 \end{aligned}$$

where $\omega_{gt} = \pi_g \theta_{gt}$ is the hourly wage of a worker of gender g at time t, π_g is the gender-specific efficiency wage, R is the rental rate of capital, and the adult life-span N is equal to 4 (10 year)

[25] Moffitt [1984b] and Hotz and Miller [1988] make similar assumptions for the childcare production function. Also in Weiss and Gronau [1981] as children grow older women's productivity at home decreases.

[26] As discussed in Section 3 several studies have documented the role of past labor supply as a determinant of current wage. In particular, both Altug and Miller [1998], and Imai [1999] find a significant learning-by-doing effect.

periods. I assume that married couples begin their life with no asset and they consume everything they have during the last period of their life (no bequest).

5 Functional Forms and Parametrization

This section describes the functional forms used in the simulation, the strategy adopted to calibrate the model and the resulting parameter values used in the simulation.

5.1 Functional Forms

5.1.1 Preferences

As it is standard in the literature on labor supply, I assume that preferences are separable in consumption and leisure and also across time. In particular, I assume period utility functions of the form:

$$\begin{aligned} U\left(c_t, n_{mt}, n_{ft}, h_{mt}, h_{ft}\right) &= \ln c_t - A\left(\frac{(n_{mt}+h_{mt})^{\alpha_m}}{\alpha_m} + \frac{(n_{ft}+h_{ft})^{\alpha_f}}{\alpha_f}\right) \\ V\left(x_t\right) &= b \ln x_t \end{aligned}$$

where $A > 0$ and $\alpha_g > 1$, $g \in \{f, m\}$. To be noticed, in this model $\sigma_g = \frac{1}{\alpha_g - 1}$ cannot have the same interpretation as in a model with exogenous wage profiles since here the intertemporal elasticity of substitution changes over the life cycle. As mentioned above x_t represents children welfare. The parameter b represents the weight that parents give to the enjoyment of children welfare.

5.1.2 Childcare production

The literature provides little guidance in modeling the childcare production function. There is no evidence on the shape of this function, although the degree of substitutability between maternal time and market produced goods and services should play an important role[27]. Hence I assume a constant elasticity of substitution production function, since it provides a parsimonious representation of childcare production. I consider the following functional form:

$$x_t = (\gamma_t h_t^{\rho} + (1-\gamma_t) s_t^{\rho})^{\frac{1}{\rho}}$$

[27] Moffit (1984b) explicitely consider the substitution possibilities between parental time and market goods and services in the production of childcare.

where $\frac{1}{1-\rho}$ is the elasticity of substitution between maternal time, h_t, and market goods and services such as day care, s_t, in the production of childcare[28]. Weights on inputs of production , γ_t, are allowed to change over time. That is, as the children grow older we expect that a relatively bigger amount of market goods and services (i.e. college tuition and fees, etc.) as compared to parental time is used as an input in the production of children quality[29].

5.1.3 Law of motion for human capital

I use the functional form discussed in Section 3:

$$\theta_{gt+1} = \theta_{gt} (1 - \delta_g) + \eta_g (a_{gt}) \theta_{gt} n_{gt}^{\psi_g}$$

According to this specification human capital is accumulated through learning-by-doing, that is the future stock of human capital is an increasing function of the current human capital stock and of the current number of hours worked[30]. Moreover, human capital depreciates at a constant rate δ_g. Returns to experience are represented by the first derivative of this function, and are proportional to $\eta_g (a_{gt}) \psi_g$. $\eta_g (a_{gt})$ is allowed to be a quadratic function of age in order to match the age-earnings profile observed in the data. That is:

$$\eta_g (a_{gt}) = \eta_{g0} + \eta_{g1} a_{gt} + \eta_{g2} a_{gt}^2$$

where $a_{gt} = age_{gt} - 20$, $age = 20, 21, 22, ...$

5.2 Parametrization

The basic strategy is to parametrize the model using data from the 1970s, and then ask how the model's prediction change when we allow for changes in the returns to experience to the values

[28] We can easily consider a more general childcare production function that include also fatherly time. Although we would need to make assumptions on the degree of substitutability between motherly and fatherly time. In this case the function would generalize to:

$$x_t = \left(\gamma_t \left(h_{ft}^{\sigma} + h_{mt}^{\sigma} \right)^{\frac{\rho}{\sigma}} + (1 - \gamma_t) s_t^{\rho} \right)^{\frac{1}{\rho}}$$

where $\frac{1}{1-\sigma}$ is the elasticity of substitution between motherly and fatherly time. In a different context, Merlo and Echevarria (1999) find that women will entirely bear the time cost associated with child rearing as the equilibrium outcome of a Nash bargaining problem of intrahouseld decision making.

[29] Hotz and Miller (1988) show that the childcare intensity in motherly time declines as the children ages, $a_t = \delta^{t-1} a$. The assumption that $\delta \neq 0$ cannot be rejected. δ is significantly different from 1.

[30] To be noticed, as in Weiss and Gronau (1981) the production is linear in past period human capital stock. Under this assumption it is possible to separate the effect of labor supply on the level and on the rate of growth of earnings.

estimated for the 1990s. The baseline economy, the 1970s, is calibrated to the PSID data in the following way. First, the parameters of the learning-by-doing human capital production function are set to their 1970s estimated values for men and women. The remaining parameters are chosen to match the 1970s work hours and hourly wage profiles for married women and married men. Given the parameters obtained for the baseline economy, I change the parameters of the human capital production function to their 1990s estimated values and study the model's prediction in terms of age profiles for hourly wages and hours worked. I also consider a second experiment where, given the baseline economy parameters, the female/male gender differential is changed to its 1990s values. Finally, I compute and compare the contribution of the relative change in returns to experience, and of the decline in the male/female wage gap, to the observed change in the life-cycle pattern of work hours for married women and men.

5.2.1 The data

The model is parametrized to the annual hours worked and hourly wage age-profiles for married men and married women as in the PSID data for 1973[31]. I will refer to these data as the 1970s. The actual 1970s age-profiles for average annual hours worked per person, and hourly wages are summarized in Table 3. The hourly wages are computed as weighted averages where the weights $\lambda_i = \frac{f_i n_i}{\sum_i f_i n_i}$ where f_i represents the number of people who worked n_i annual hours on the market.

Table 3: Annual hours worked per person and hourly wages, PSID 1973

	Annual Hours		Hourly wage	
age	men	women	men	women
20-29	2072.0	969.0	13.1	9.1
30-39	2260.2	674.0	16.4	8.2
40-49	2273.8	708.0	18.4	8.3
50-59	2057.5	654.0	17.0	8.6

The pattern of work hours for married women displays the "double-peaked" shape described in Section 2 whereas men's hours worked age-profile displays the typical "single-peaked" shape.

[31] PSID data on annual hours worked and hourly wages are used in order to be consistent with the human capital production function estimates.

5.2.2 Preferences

The parameter α_g and the disutility of labor A are set to mimic the actual age profiles for average hours worked and hourly wages for both men and women in the 1970s. The discount rate β is set to be equal to $\frac{1}{1+R}$ where $R = (1+r)^{10} - 1$ is the compounded real interest rate. That is, we assume the rate of time preferences and the real interest rate to be equal over the (10 year) time period. This is consistent with the data when we control for changes in family size over the life cycle[32].

5.2.3 Childcare production

To my knowledge there is no evidence about a correct range of values for the parameter representing the elasticity of substitution between maternal time and market produced goods and services. In the following we set the parameter representing the elasticity of substitution, ρ, and the relative weight on motherly time and market good and services, γ_t, in order to match the hours and wages age profiles for both men and women in the 1970s.

5.2.4 Human capital accumulation

The estimated values for the human capital production function parameters are reported in Table 4. As discussed on Section 3 these estimates are corrected for the sample selection and simultaneity bias using the procedure described in Olivetti (2000). They are restricted such that the depreciation rate δ, and the exponent ψ are the same for both men and women (in the 1970s and in the 1990s). This assumption is made in order to obtain realistic age-earning profiles under the assumptions on preferences used in the model[33]. They correspond to a female/male differential in the rate of returns to experience of about 0.7.

Table 4: 1970s human capital production function parameter estimates

	$(1-\delta)$	η_0	η_1	η_2	ψ
men	0.8	0.0149	-0.0002673	4.3e-06	0.4
women	0.8	0.0114	-0.000119	-6.29e-07	0.4

[32] As in Attanasio (1999) and Attanasio and Browning (1992).

[33] In particular, the estimates must be constrained to obtain a small value for the ratio $\left(\frac{\delta}{\eta_0}\right)^{\psi}$, to generate incresing age-earning profiles and interior solution for both men's and women's working hours. Any combination of the fixed parameters such as the ratio is small enough would have the same properties.

Since the estimates are obtained using yearly data, I rescale them to the 10 years period using the following procedure. Given that the number of hours worked is constant over the (10 years) period, I simply iterate the yearly law of motion over the ten years period for the (constant) number of hours worked[34].

5.2.5 Rental rates

In the simulation I set the real interest rate, r, to 5% annually. The compounded interest over the ten years period is therefore equal to 0.62. The gender-specific rental rates for human capital are set so that wages in the first period are equal to the average hourly wage for young men and women aged 20-29 as found in the PSID. The ratio $\frac{\pi_f}{\pi_m}$ represents the "pure" gender wage differential. I will refer to this ratio as to the 1970s gender wage differential[35].

5.2.6 Initial condition

The initial levels of human capital, θ_{m0} and θ_{f0}, are both set equal to one. Thus I assume that men and women in the 1970s do not differ in terms of their initial level of human capital. The female/male differential is captured by the market premium to female and male human capital. I also assume that households start their adult life with no asset.

6 Results

In this section the results of the calibration are presented, and the 1970s predicted age-profiles for hourly wages and work hours are compared to the 1970s data both for married men and for married women. Second, I present the results obtained when the returns to experience are set to their 1990s values keeping the remaining parameters of the baseline economy constant. The predicted age-profiles for wages and hours worked for 1970s and 1990s are compared to the corresponding actual age-profiles. Third, I study the effect of a decline of the gender wage gap, holding returns

[34] More in detail, the human capital stock at the end of period t is given by: $\theta_{gt} = \left[\prod_{j=t}^{t+9}\left((1-\delta_g)+\eta_g(a_{gj})\,n_{gt}^{\psi_g}\right)\right]\theta_{gt-1}$ $t = 1,..4$, where n_{gt} represents the average hours worked during the (10 year) period t. Also, since the estimates are obtained for annual hours of work the model prediction on n_{gt} is rescaled by multiplying by 5000 (assuming that the total time endowment of an individual is 5000 hours a year).

[35] I also run simulations under a different parametrization for the rental rates and the initial stock of human capital. In this case, the rental rates of human capital are normalized to one, whereas the θ_{g0}s are set to the average hourly wage for men and women aged 20-29 as found in the PSID (i.e. ω_{g1}). In this case $\frac{\theta_{f0}}{\theta_{m0}}$ represents the "pure" gender wage differential. The results obtained under this parametrization are equivalent to the ones described in the next section.

to experience constant. Then, I quantify and discuss the contribution of these two competing explanation to the change in the pattern of work hours over the life cycle for married women. The model also gives a prediction about the percentage increase in the female/male differential observed in the data that can be imputed to the relative change in returns to experience. Finally, in the last two sections, I briefly discuss the results obtained when the economy is calibrated to match the data for single female and male headed households and perform sensitivity analysis.

6.1 The baseline economy

Table 5 represents the parameters that characterize the baseline economy. The values chosen for α_m and α_f would imply an intertemporal elasticity of substitution around 0.49 for men, and 0.53 for women, although these parameters do not have a straightforward interpretation as intertemporal elasticity of substitution in this model since wage age-profiles are endogenous[36]. This is consistent with the finding, typical in the micro literature, that the female elasticity of substitution is generally bigger for women than for men. The values chosen for π_m and π_f give raise to a female/male gender wage differential equal to 0.69. As mentioned above, I refer to this ratio as to the 1970s "pure" gender gap.

Table 5: Model Parameters

Preferences		Rental Rates	
α_m	3.02	r	5% (yearly)
α_f	2.88	π_f	9.08
A	25	π_m	13.05
b	0.35	Initial conditions	
Childcare production		a_0	0
ρ	0.75	θ_{f0}	1
γ	$0.56, 0.23$	θ_{m0}	1

Figure 6 compare the model prediction and the actual data for the 1970s age profiles. Panel A displays the work hours age-profiles for married men and married women in the data and in the model. The crossed solid line and thick solid line represent the actual annual hours worked

[36] In the micro literature the estimates of the elasticity of substitution for men range between 0.1 and 0.45 (see, for example, Altonjj [1986] and Pencavel [1986]). For women there is a wide array of estimates for the intertemporal elasticity of substitution ranging from negative values to large and positive values (see Mroz [1987], and Killingsworth and Heckman [1986]).

respectively for married women and married men, the dotted and dashed lines are generated by the model. The predicted profiles closely approximate the actual profiles. For what concerns hourly wages (see Panel B), the model does quite well, although men's predicted hourly wages are slightly higher than the actual ones for the 40-49 and 50-59 age groups. Also, women's predicted age-profiles are decreasing whereas in the data they slightly increase for the age group 50-59. This is due to the fact that the system is over-identified. In fact, given the assumptions made for the real interest rate, the discount factor, the rental rates for male and female human capital, the initial condition for asset and human capital stock and the parameters of the human capital production function, we are left with seven free parameters and 14 data points. Thus the predicted age-profiles are slightly different from the actual ones.

The model also predicts concave profiles for total household consumption. The profiles are flat when we restrict our attention to consumption goods and services. This is not surprising since the rate of time preferences is assumed to be equal to real interest rate. Moreover, the model predicts a childcare consumption share of total household income around 6% in the first (10 year) period of children's life and of 7.5 percent in the second period. On average the model predicts a childcare expenditure share of 6.77%. Women spend 32% of period 2 working hours taking care of their children. In the second period the fraction of maternal time devoted to childcare decreases to around 3.7% of total hours worked.

6.1.1 Experiment 1: Change in returns to experience

In the following experiment the parameters of the human capital production function are changed to their 1990s estimated values for both men and women while keeping the remaining parameters constant to the baseline economy. I will compare the predicted change in age-profiles for married men and women to the actual change observed in the data. For what concerns the 1990s actual profiles for work hours and hourly wages I use PSID data for 1993. I will refer to these data as to the 1990s. The 1990s estimated parameters of the human capital production function are presented in Table 6.

Table 6: 1990s human capital production function parameter estimates

	$(1-\delta)$	η_0	η_1	η_2	ψ
men	0.8	0.01576	-0.000255	-9.8e-07	0.4
women	0.8	0.0143	-0.000189	7.43e-07	0.4

The estimates are obtained under the same assumptions as the 1970s estimates. In particular, δ and ψ are constrained to be the same as for the 1970s. These estimates generate a female/male differential in the rates of return to experience equal to 0.88. That is, men's returns at age 20 increase by 6% with respect to the 1970s estimates presented in Table 6, whereas women's returns increase by 25%.

The results are described in Figure 7. Panel A and C present the actual 1970s and 1990s age-profiles of average work hours per person, and hourly wages. Panel B and D present the predicted change. In all the graphs the dashed line represents 1990s men, the thick solid line 1970s men, the crossed solid line 1990s women, and the dotted line 1970s women. Panel A displays the change from the "single-peaked" to "double peaked" work hour age-profile for married women discussed in Section 2. As Panel B shows, given the parameters of the baseline economy, the change in rates of return to experience alone generates concave age-profiles for married women's hours worked. Moreover, the predicted average hours worked in the different age groups are of the same magnitude as the observed 1990s averages. At the same time, consistent with the data, the model predicts only modest changes in the life cycle profile of hours worked for men. This is mainly due to the fact that men are already working fourty percent of their time in the baseline economy.

For what concerns wages (see Panel C and D), the change in profiles generated by the model goes clearly in the same direction as the actual change, although the 1990s profiles do not perfectly match what you observe in the data. Both men's and women's profiles are steeper in the 1990s than in the 1970s. Moreover, married women's age-profile for hourly wages increases with age as compared to the decreasing profile of the baseline economy. These results clearly show how changes in returns to experience alone can generate substantial changes in women's labor force participation over the life cycle.

Although the 1990s model has the same prediction as the baseline model for consumption profiles, household consume more now since they have more income. Moreover, the model predicts a childcare consumption share of total household income around 7.3% in the first (10 year) period of children's life, and of 7.4% in the second period. The model generates a total childcare expenditure share of 7.38% in the 1990s. Overall the total childcare expenditure share is less then one percentage point (of total household income) higher in the 1990s than in the 1970s. The childcare expenditure share is higher in the first period of children's life in the 1990s as compared to the 1970s, whereas it is lower in the second period. The fraction of time women spend in childcare drops dramatically. Women spend only 6% of their period 2 working hours providing childcare (from a 32% in the 1970s). In the second period of children's life the fraction of maternal time spent in childcare activities drops to 0.003% of total hours worked.

6.1.2 Experiment 2: Change in the "pure" gender wage gap

In the second experiment, I change the rental rates to female and male human capital to their 1990s values, holding the returns to experience and the remaining parameters constant. In particular, I set $\pi_f = 10.053$ and $\pi_m = 13.26$, thus the "pure" gender wage differential, that is the ratio $\frac{\pi_f}{\pi_m}$, is equal to 0.8. This is equivalent to an increase in the female/male ratio by 16%.

Figure 8 presents the results for this experiment. As described in the previous section, Panel A and C presents the actual change of age-profiles of work hours and hourly wages. Panel B and D presents the predicted change. The change in the pure wage differential generates an increase in average hours worked per person for every age group but it cannot explain the change in the shape of the age profile. Moreover, although women's hourly wages increases the profile still decreases in age. In this case married men's behavior does not change much between the 1970s and the 1990s. Both the work hours and the earnings age-profile are almost unaltered.

Household consumption and savings profiles are almost identical to the 1970s profiles. The childcare expenditure share slightly increase. The model predicts a childcare consumption share of total household income around 6.4% in the first (10 year) period of children's life, and of 7.5% in the second period. The model generates a total childcare expenditure share of 6.96% in the 1990s as compared to 6.77% in the 1970s. The fraction of time women spend in childcare drops. Women spend only 19% of their period 2 working hours providing childcare (as compared to 32% in the 1970s). In the second period of children's life the fraction of maternal time spent in childcare activities drops to 0.7% of total hours worked. Although in the simulation the gender-specific efficiency wage are simply set in order to reproduce the "pure" female/male wage differential for young workers in the 1990s, the model generates an average female/male wage ratio over all age groups that closely matches the one observed in the data.

To conclude, I also consider the joint effect of an increase of both the gender wage gap and the returns to experience to their 1990s value. In this case, the model generates larger average work hours than those observed in the data for every age group. This seems to suggest that the two explanations explored in this paper interacts to generate a further increase in average hours worked by women over the life cycle. The intuitive explanation is that in this case not only women's learning-by-doing profile is steeper than in the 1970s, but also they are initially better off in terms of their human capital. Men slightly decrease their average hours worked. Figure 9 presents the results for this experiment.

6.2 Discussion

The change in relative returns to experience have a strong impact on married women's hours worked age-profiles. On the contrary, at least under this specification, the decline in the gender wage gap seems to play a much smaller role in explaining the increase in women's hours of work. In order to give a quantitative assessment the contribution of these two competing explanation I compare the percentage change in average hours worked per person observed in the data to the one generated by the model. The information is disaggregated by age. Table 7 summarizes the results.

Table 7: Percentage change in average hours worked per person (married women)

	20-29	30-39	40-49	50-59
Data	35%	117%	102%	68%
Model: returns only	14%	112%	102.6%	97%
Model: gender gap only	3.75%	20.56%	12.23%	12%

In the first experiment the model can account for about 95% of the observed increase in average hours worked per person observed in the data for the age group 30-39. For the age groups 40-49, and 50-59 the generated increase in average hours worked is even larger than the increase observed in the data. On the other hand, the change in the gender wage gap alone, only accounts for a small fraction of the increase in average hours worked. Indeed, hours worked increase for every age group but the change cannot generate the change in women's profiles. Although surely there are many other factors that contributed to the change in women's labor force participation, the relative change in returns to experience seems to be a very important determinant of this change. Indeed, the relative change in returns to experience explains about 81% of the total increase in average hours worked by women aged 20-39 generated by the experiment where both the gender wage gap, and the returns to labor market experience are set to their 1990s values. The decline in the gender wage gap can merely generate a 16% increase in hours worked for the same age group.

The model also allow to measure the contribution of the relative change in returns to experience to the decline in the gender wage gap observed in the data. According to the model the increase in returns to experience alone accounts for about 42% of the increase in the female/male wage ratio found in the data. Since this is the model with endogenous wage profiles, it is worthwhile to compare the female/male wage differential by age group predicted by the model for the 1990s (when only returns to experience are changed) with the values observed in the data. The results are summarized in the following table:

Table 8: Gender wage differential by age, actual and predicted profiles

	data	model
20-29	.786	.764
30-39	.684	.611
40-49	.586	.501
50-59	.457	.447

Entries in the table represents the female/male wage differential actual and predicted. Average wages by gender are weighted by the fraction of hours worked by each group with respect to the total hours worked in the population. The model matches quite well the observed age-specific female-male wage differential.

The model also make predictions about children welfare. Under experiment I, children's equilibrium lifetime well-being increases by 28% with respect to the baseline economy despite a decline of the share of motherly time spent in childcare by eighty percent. The increase in family income allows family to substitute motherly time with market produced goods and services in the production of childcare. Under the second experiment, children welfare slightly increases (by 0.3%) even if motherly time spent in childcare drop by fourty percent. Thus, children's welfare does not decline as a consequence of the increase in hours worked on the market by mothers. Moreover, despite the extent to which family substitute parental time with market good and services, the childcare expenditure share increases only slightly in both experiments (up to one percentage point under experiment I). The small increase is consistent with what is found in the PSID data when we compute the childcare expenditure share of family labor income for married household aged 30-39 with young children. The model also generates values of the childcare expenditure share that are consistent with data from the 1970s and the 1990s[37].

6.3 Single Household

I also study whether the observed change in returns to labor market experience can predict changes in the work hours age profiles for single men and women that are consistent with the data. To this aim, I parametrize the model to match the age profiles for hours of work and hourly wages for single female and single male headed household given the 1970s estimates of the human capital production function. As previously discussed, in 1970 single women displayed a work hours age

[37] Anderson and Levine [1999], using 1990-1993 SIPP data, find that families with at least one child under 13 spend, on average, 7% of their family income in childcare, whereas family with at least one child under 6 spend on average 7.7% of their income. I find similar values by computing the same shares using the PSID data for 1973 and the 1993.

profile similar to the one of men. Moreover, lifetime average hours worked by single men and single women only slightly increased between 1970 and 1990. The experiments show that the model is capable of reproducing this feature of the data. In particular, this is true for a range of values of the intertemporal elasticity of substitution parameter (ranging from 0.84 to 5.6). The values of the intertemporal elasticity of substitution needed to match the 1970s data for single are slightly higher than those needed to match the behavior of married couples.

The results for one of these experiments are presented in Figure 10. Panel A presents the actual change of age-profiles of work hours for single men and women. Panel B presents the change predicted by the model. As in the previous experiments, the 1970s economy is parametrized in order to match the 1970s profiles for single men and single women. The model can match the shape in the work hours age profiles for both gender and the relative change in their 1990s profiles although the predicted increase in average hours worked per person is larger than what is observed in the data.

6.4 Sensitivity Analysis

In this section I study the sensitivity of the results to changes in some of the parameters used in the calibration exercise. I perform the analysis by recalibrating the economy to the 1970s and then by changing the returns to labor market experience to their 1990s values. This allow to study whether the result (i.e. the strong contribution of the change in returns to labor market experience) is robust to the parameters chosen in the calibration exercise. In particular, I will study the robustness to changes in the real interest rate, the female/male wage ratio and the intertemporal elasticity of substitution for both men and women.

In the literature[38], the female/male wage ratio for the 1970s ranges from 0.6 over all age groups to 0.764 when focusing on workers aged 20 to 24 and controlling for education, race and full-time labor market participation. Therefore, I recalibrate the economy setting $\frac{\pi_f}{\pi_m} = 0.6$ in the first case, and $\frac{\pi_f}{\pi_m} = 0.764$ in the second case. Under the first parametrization the model can account for about 66% of the observed increase in average hours worked per person observed in the data for the age group 30-39. In the latter case the model accounts for 97.6% of the increase. Moreover, given the baseline economy discussed in Section 6, I show that in order for the increase in the female/male wage ratio to generate the change in the slope of the work hours age profiles observed in the data a female/male ratio equal to 1.9 would be needed. In fact, when the rental rates to human capital for men and women are the same we still observe double-peaked profiles for women's hours of market work. Hence, the increase in the female/male gender wage gap seems to play a secondary role in explaining the change in the working behavior of women over their life cycle.

[38] See Smith and Ward (1984), Goldin (1989).

I also study the sensitivity of the results with respect to the real interest rate by setting the annual real interest rate r equal to 4% and 6% respectively. The model is not very sensitive to changes in the real interest rate (indeed the values of the preferences and childcare production parameters needed to match the 1970s economy change only slightly). In both cases, I obtain results roughly equivalent to the ones obtained when I set the yearly real interest rate, r, to 5%.

For what concerns the intertemporal elasticity of substitution, in the micro literature the estimates of the elasticity for men range between 0.1 and 0.45 (see, for example, Altonjj [1986] and Pencavel [1986]). In the macro literature higher values of the elasticity are typically used to calibrate the model or estimate it (Imai [1999] obtains an elasticity estimate equal to 5.967 for prime-age men, Eichenbaum, Hansen and Singleton [1984] obtain a value around 5, Prescott (1986) uses 2 in his calibrations exercise). For women there is a wide array of estimates for the intertemporal elasticity of substitution ranging from negative values to large and positive values (see Mroz [1987], and Killingsworth and Heckman [1986]). In general, there has been consensus that female labor supply wage elasticities are larger in absolute value than men's. As a consequence, I perform two experiments. In the first one I set both men's and women's elasticities to "low" values (0.3 and 0.35 respectively). In the second experiment I choose "high" elasticities (1.2 and 1.3 respectively). In both cases, the model generates a change in hours of market work over the life cycle of the same order of magnitude as the ones described previously. That is, the change in returns to labor market experience generates an increase in life time average hours of market work around 90% whereas an increase in the female/male wage gap can only explain approximately 20% of the total increase.

7 The General Equilibrium version of the model

I now turn to the general equilibrium version of this model to study how the implications of the model change when prices are endogenous. I find a small general equilibrium effect. Equilibrium rental rates are very similar in magnitude to the ones chosen for the life cycle version of the model. The rental rate of physical capital is slightly higher than in the life cycle model, whereas the rental rates of human capital are slightly lower.

The following assumptions are made. There is no bequest. Parents consume all their assets in the final period of their life. There is no population growth; in every period the oldest couple die and it is replaced by the oldest children that become adults. There is a Uniform distribution of agents for every age group that is time invariant. The rental rate of human capital for men and women and the real interest rate are determined endogenously in equilibrium as the result of a firm's maximizing behavior. Labor of different ages is assumed to be homogeneous but male and female labor are heterogeneous. Aggregate labor is the sum of efficiency units of work.

In what follows I first describe the assumptions made about the production side of the economy. Second, I define the equilibrium of the model. Finally, results are presented in the last section. I only study the steady state equilibrium (i.e. factor prices are constant over time).

7.0.1 Technology

Output is produced by using efficiency units of female and male labor, and capital as inputs. There is a constant return to scale production technology given by:

$$y = F\left(H_m, H_f, K\right)$$

where H_m and H_f represents aggregate efficiency units of labor for men and female. Each period the physical capital depreciates. The rate of capital depreciation is denoted by δ_k.

Below, I formulate the recursive version of the model and provide the equilibrium definition. In this economy the agents individual state variable is given by $z_t = (a_{t,}\theta_{mt}, \theta_{ft})$. Given that the value function in the terminal period is set equal to zero, the optimal decision rules $c\left(z_t\right)$, $s\left(z_t\right)$, $n_{gt}\left(z_t\right)$, $h_{gt}\left(z_t\right)$ $g \in \{f, m\}$ solve the following dynamic programming problem:

$$W_t\left(z\right) = \max\left(U\left(c_t, \ell_{mt}, \ell_{ft}\right) + V\left(x_t\right)\right) + \beta W_{t+1}\left(z'\right)$$

subject to the period constraints.

7.1 Equilibrium

A stationary equilibrium is a list of functions $\{c\left(z_t\right), s\left(z_t\right), n_{mt}\left(z_t\right), h_{mt}\left(z_t\right), n_{ft}\left(z_t\right), h_{ft}\left(z_t\right)\}$, $\pi_m, \pi_f, r, K, N_m, N_f$ and initial condition $z = z_0$ such that:

1) optimization.

$c\left(z_t\right), s\left(z_t\right), n_{mt}\left(z_t\right), h_{mt}\left(z_t\right), n_{ft}\left(z_t\right), h_{ft}\left(z_t\right)$ are optimal decision rules;

2) competitive inputs markets.

$\pi_m = F_1\left(H_m, H_f, K\right)$
$\pi_f = F_2\left(H_m, H_f, K\right)$
$r = F_3\left(H_m, H_f, K\right) - \delta_k$

3) market clearing

$\sum_{t=0}^{N} \mu_t \theta_g\left(z_t\right) n_g\left(z_t\right) = H_g \qquad g \in \{m, f\}$

$\sum_{t=0}^{N} \mu_t a(z_t) = K$
$\sum_{t=0}^{N} \mu_t (c(z_t) + s(z_t)) = F(H_m, H_f, K) - \delta_k K$

where μ_t is the fraction of individual of age t. The first condition simply describes the optimal decision rules. Taking prices and initial condition as given, agents solve their decision problem. The second condition requires rental rates of capital and of labor to be equal to their marginal product. Market clearing conditions require that 1) the aggregate labor input in efficiency units equals the labor inputs summed over the population; 2) asset holdings are sufficient to keep total capital constant over time; 3) aggregate consumption must be equal to total output minus the amount of capital that depreciates. Since the model displays interior solution the number of hours worked in each ten-year period can be interpreted as the average amount of time that is worked by a male or female individual (or alternatively, as the average number of years of work experience).

7.1.1 Results

The functional forms chosen for the production function and its parametrization are discussed below. The calibration strategy followed is similar to the one described for the life-cycle model. Aggregate output is produced according to the following Cobb-Douglas production function:

$$y = \Phi K^{\gamma} (\phi_m N_m + \phi_f N_f)^{1-\gamma}$$

That is, I assume complementarity between male and female labor. In the absence of evidence about this issue this specification provide a reasonable starting point. The values of ϕ_g are chosen such that $\frac{\phi_f}{\phi_m}$ equal the gender wage differential in the 1970s. That is, $\frac{\phi_f}{\phi_m}$ =0.69 as in the PSID data for the 1970s[39]. Moreover, the capital share γ is set to 0.36 as it is typical in the literature[40]. The depreciation rate is set to 10% yearly which is equivalent to a period depreciation $\delta_k = 0.6$. The parameter Φ is a scale parameters and is set to 6 to match the order of magnitude of hourly wages in period 1. I run the simulations for the same set of parameters discussed in the previous section. In this case the discount factor is set to be $\beta = 0.94$ over the 10 year periods. This is equivalent to a yearly discount factor of 0.994 that is in the range found for economies without mortality uncertainty[41].

[39] O'Neill (1985) measure the gender wage gap for white workers adjusted for differences in hours worked to be equal to 0.669. The gender wage ratio is adjusted by multiplying unadjusted earning ratio by race and sex-specific ratios (male-to-female) of average hours worked per week by workers on full-time schedule (non-agricultural).

[40] For a discussion of standard calibration procedures in overlapping generations economies see Auerbach and Kotlikoff [1987], and Rios-Rull [1996].

[41] Hurd [1986].

The results obtained for the baseline economy are very similar to the results obtained for the life-cycle model. The equilibrium real interest rate for the 1970s baseline economy is equal to 7.2% (yearly) whereas the equilibrium wages for male and female are equal to 12.29 and 8.62 respectively. That is the real interest rate increases with respect to the life cycle economy whereas the efficiency wages are lower. The fact that we obtain a relatively high real interest rate is a typical problem of the life cycle economy.

As for the partial equilibrium model I run two experiments. In the first case the parameters of the human capital production function are set to their estimated 1990s value keeping the remaining parameters constant. In the second case the ratio $\frac{\phi_f}{\phi_m}$ is set to its 1990s value whereas the other parameters are set to the 1970s baseline economy.

In the first experiment the 1990s economy accumulates relatively more human capital with respect to physical capital. Hence the equilibrium real interest rate is higher than in the baseline economy, whereas the equilibrium efficiency wages is lower by gender. The equilibrium real interest rate increases to 8.1%, whereas the rental rates of human capital are equal to 11.65 for men, and to 8.23 for women. For what concerns the second experiment, the real interest rate slightly decreases to 7.1%, the equilibrium rental rates for male efficiency units decrease to 12.36, whereas for women it increases to 9.88. This is not surprising since this is the result of an increase in the female/male wage ratio. The predicted profiles for hours worked are summarized in Figure 11. Also in this case, the relative increase in returns to labor market experience can account for a large fraction of the increase in average hours worked. The decline of the gender wage gap increases average hours worked for every age group but it cannot generate a change in the slope of the work hours age profiles.

8 Conclusion

This paper investigates the change of patterns of work hours over the life cycle for married women and married mothers of children in preschool age. In particular, it focuses on the relative increase in women's returns to experience as one possible explanation for the change. A GE model is built in order to quantitatively assess the contribution of changes in the rate of return to experience, and of the decline of the gender wage gap, to the change in married women's life cycle profiles of hours worked. The results show that the relative change in returns to experience can account for a large fraction of the observed change in average hours worked for women. Moreover, the model also allows us to quantify how much the relative increase in returns to experience contributes to the decline of the gender wage gap that is found in the data. The results also show that the decline of the gender wage gap cannot explain the change in the shape of women's life cycle profiles. Consistent with the data, the model predicts only modest changes in the life cycle profiles of hours worked for men and single women.

There are several different directions for future research. An interesting extension is to endogenize fertility, and study how the change in relative returns to experience affects both the decision to have children and the timing of births. Also, the model can be readily extended to conduct policy experiments on how childcare subsidies influence the labor force participation of married mothers. This is of particular interest in order to understand cross-country differences in childcare arrangements and in women's experiences on the labor market. At a different level, as briefly discussed in Section 3, it is important to thoroughly investigate the causes of the relative change in returns to experience. Among the possible alternative explanations for this change are technological progress favorable to women's characteristics, the change in the distribution of female workers by occupation, and the decline in discrimination against women, particularly against married women and married mothers of young children.

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Figure 1: Weekly average hours worked per married woman

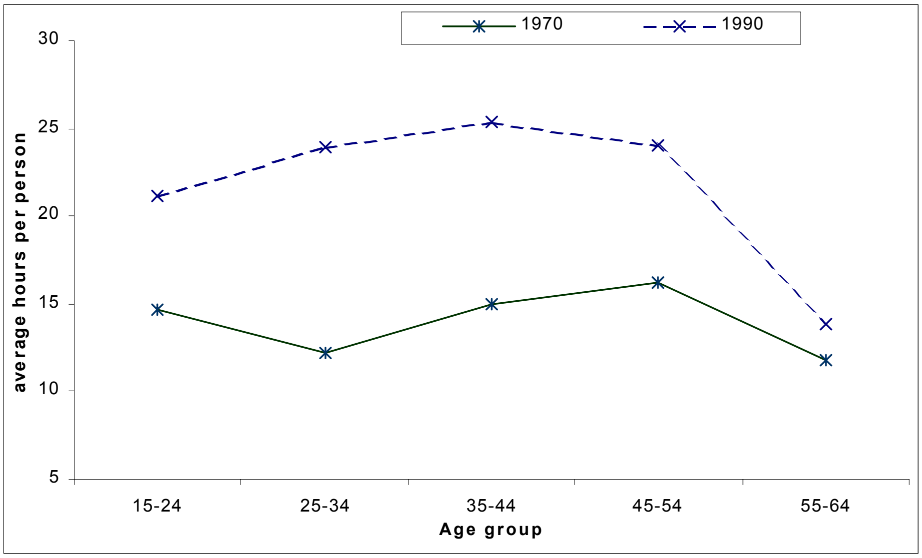


Figure 2: Weekly average hours worked per married mother, children less than 6 years old

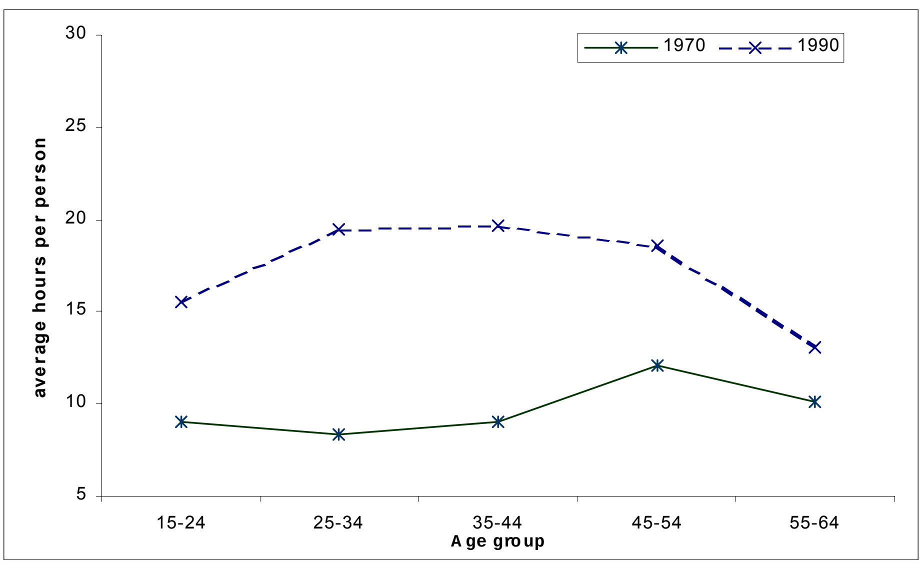


Figure 3a: Weekly average hours worked per person: Census 1970

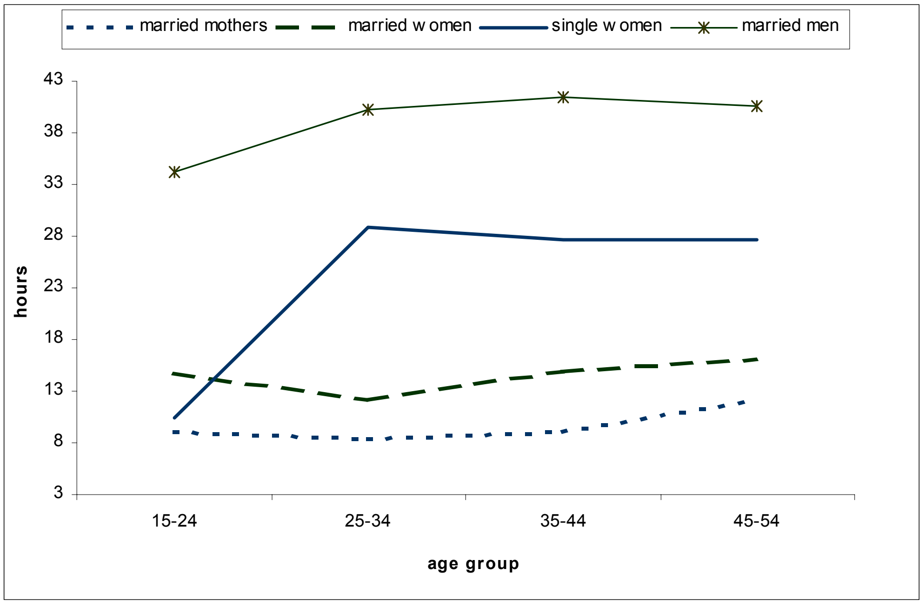


Figure 3b: Weekly average hours worked per person: Census 1990

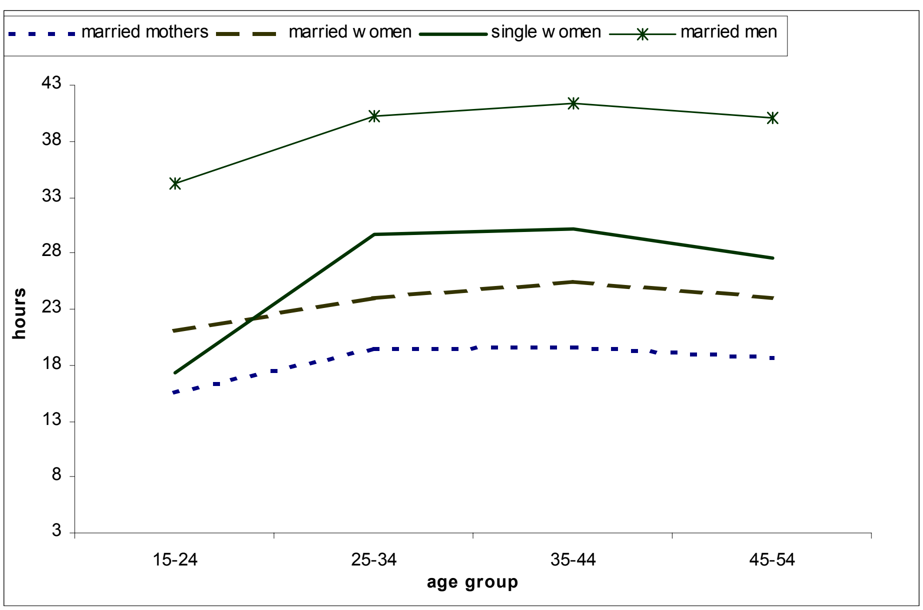
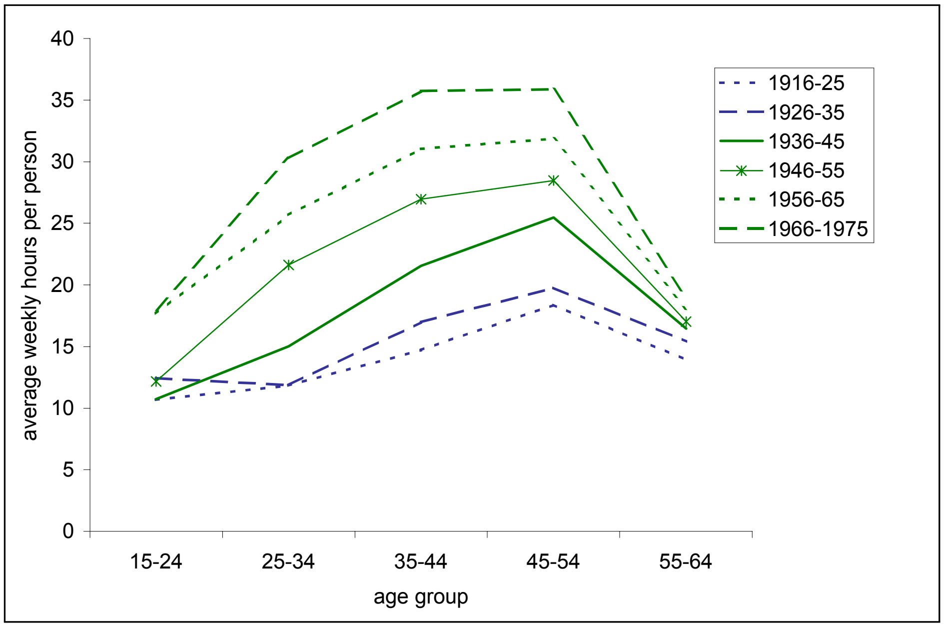


Figure 4: Life cycle average weekly hours worked per women



Source: Mc Grattan and Rogerson [1998]

Figure 5: Marginal returns to experience

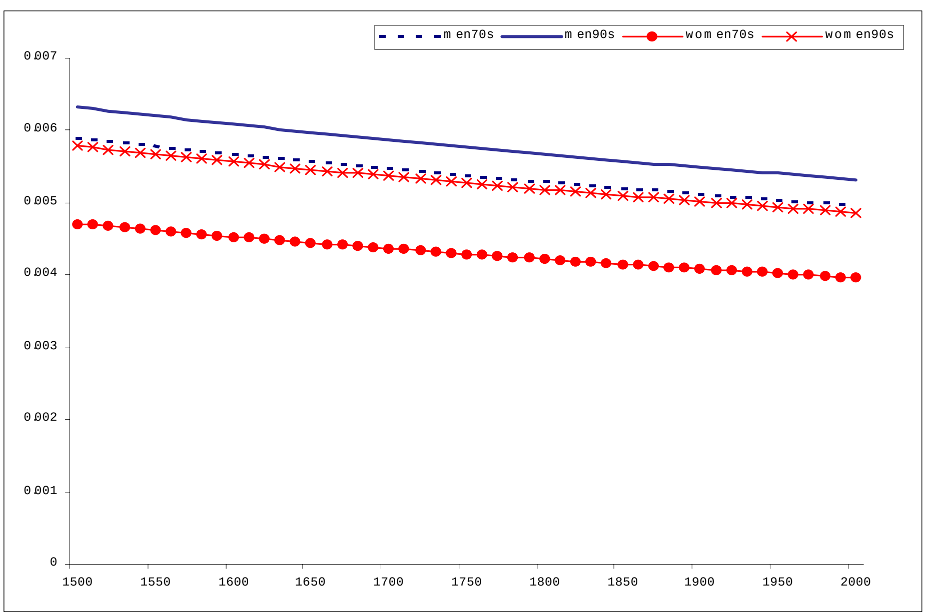
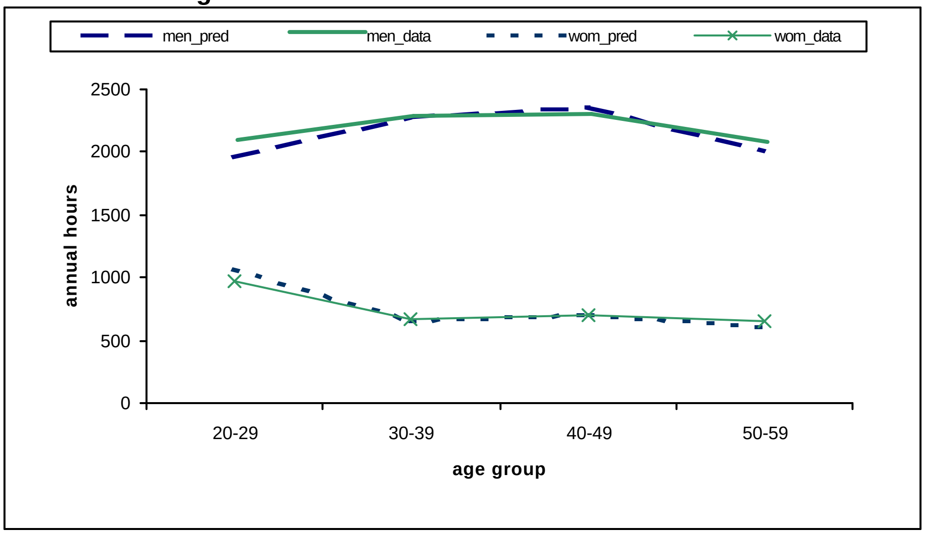


Figure 6. The Baseline Economy

Panel A. Average annual hours worked: model vs data for the 1970s



Panel B. Hourly wages: model vs data for the 1970s

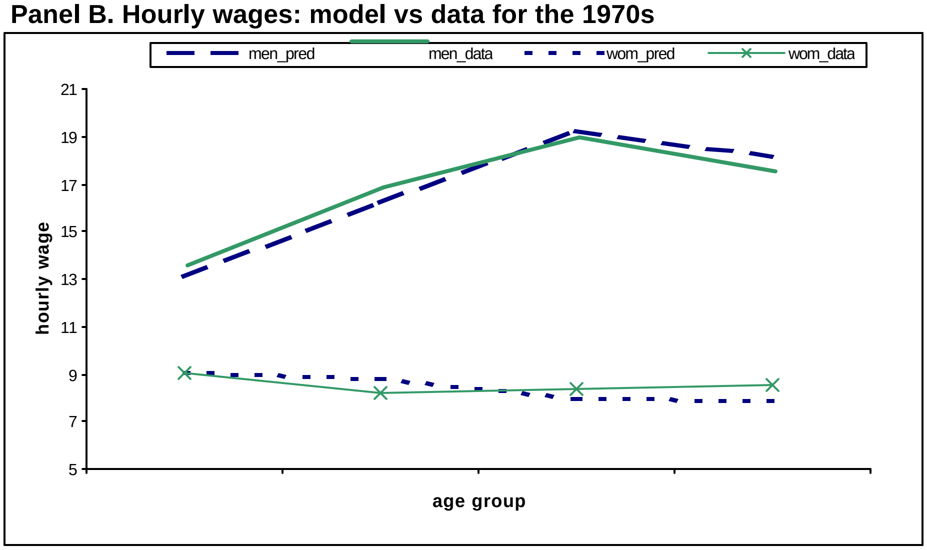
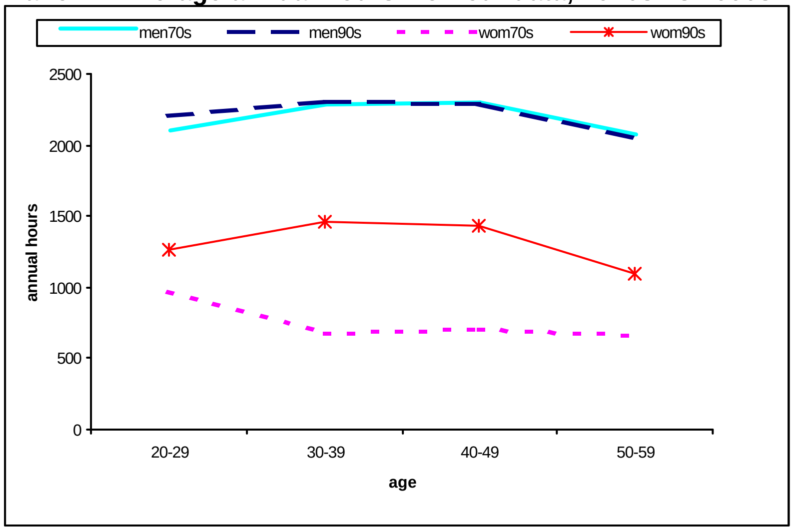
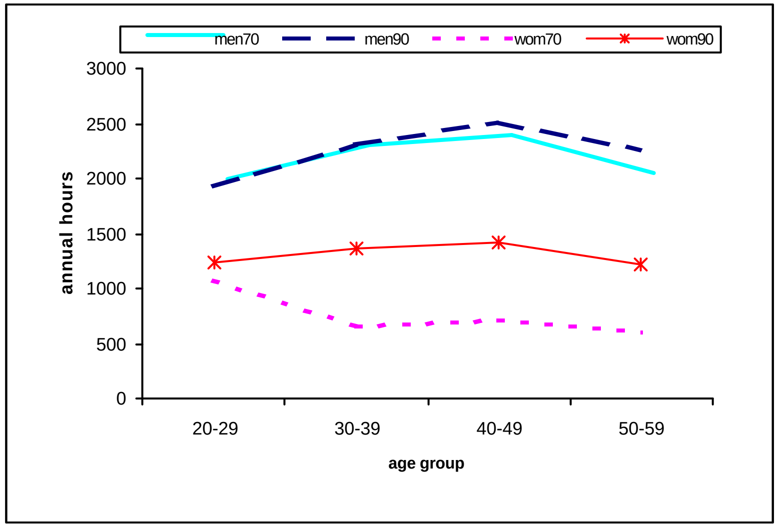


Figure 7. Experiment I: Change in relative returns to experience

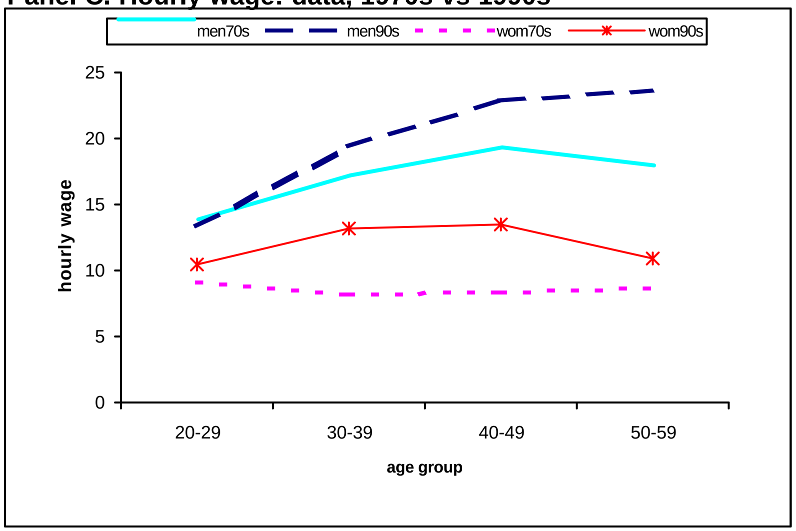
Panel A. Average annual hours worked: data, 1970s vs 1990s



Panel B. Annual hours worked:model, 1970s vs 1990s



Panel C. Hourly wage: data, 1970s vs 1990s



Panel D. Hourly wage: model, 1970s vs 1990s

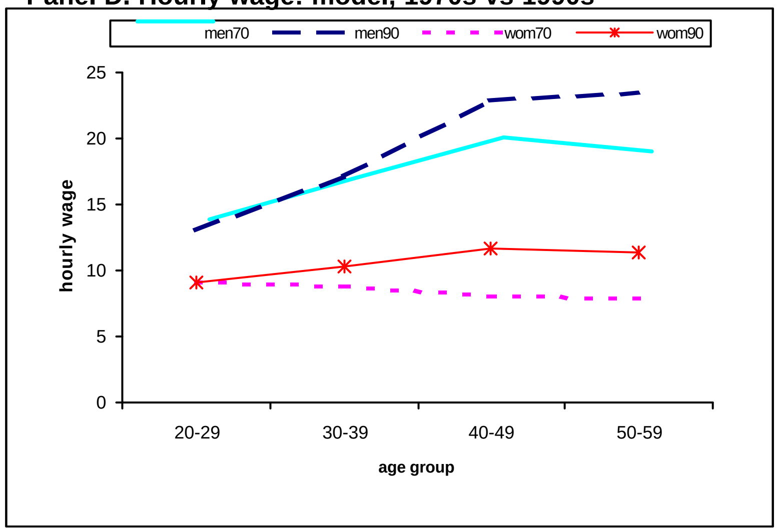


Figure 8. Experiment II: Change in wage gender gap

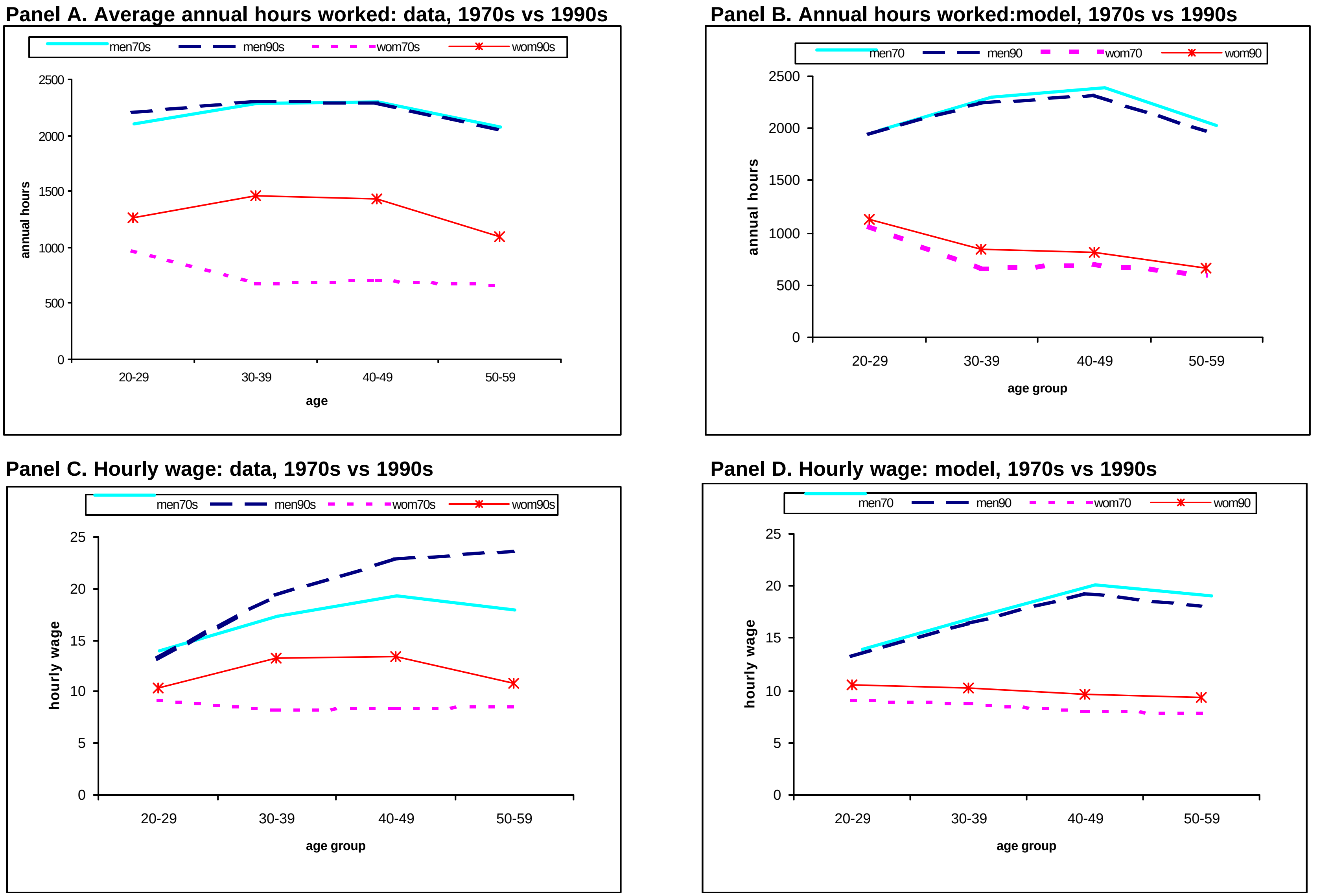
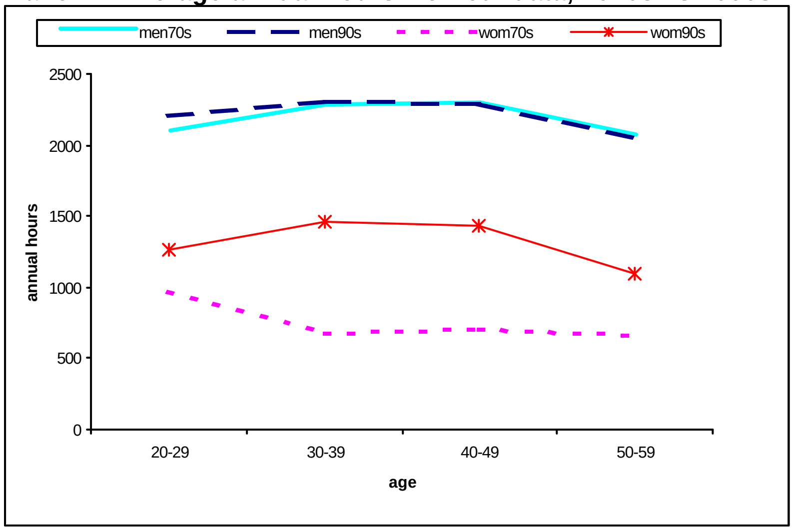
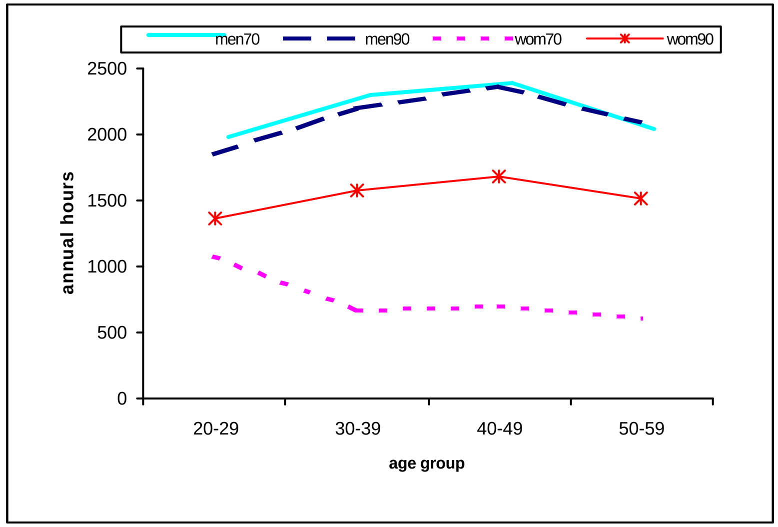


Figure 9. Change in the rate of returns to experience and in the wage gender gap

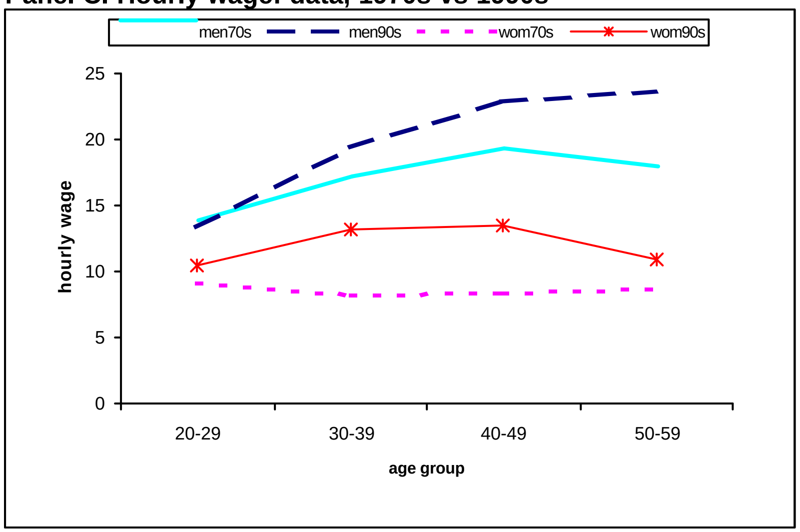
Panel A. Average annual hours worked: data, 1970s vs 1990s



Panel B. Annual hours worked:model, 1970s vs 1990s



Panel C. Hourly wage: data, 1970s vs 1990s



Panel D. Hourly wage: model, 1970s vs 1990s

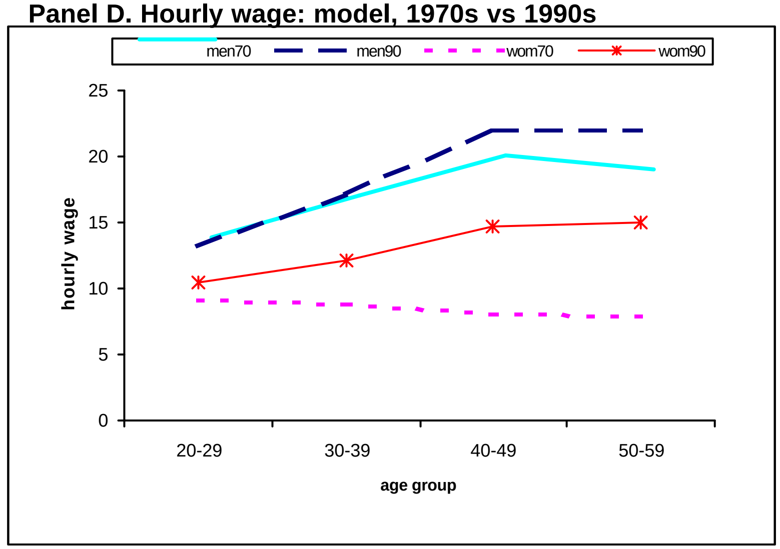
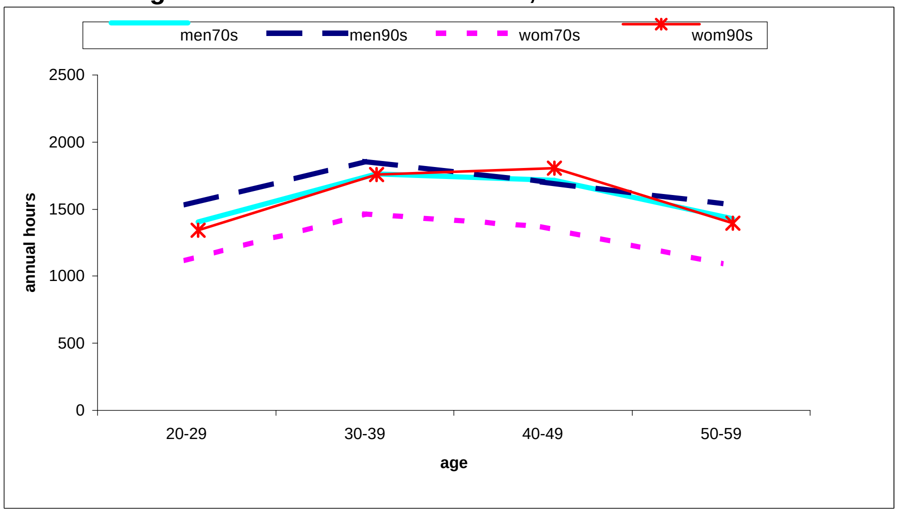


Figure10. Change in relative returns to experience: Single Households

Panel A. Average annual hours worked: data, 1970s vs 1990s



Panel B. Annual hours worked:model, 1970s vs 1990s

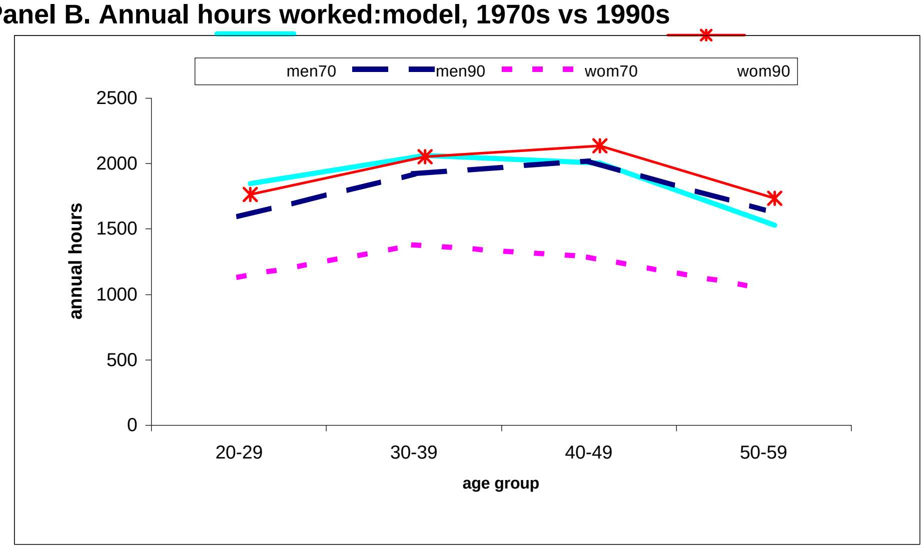
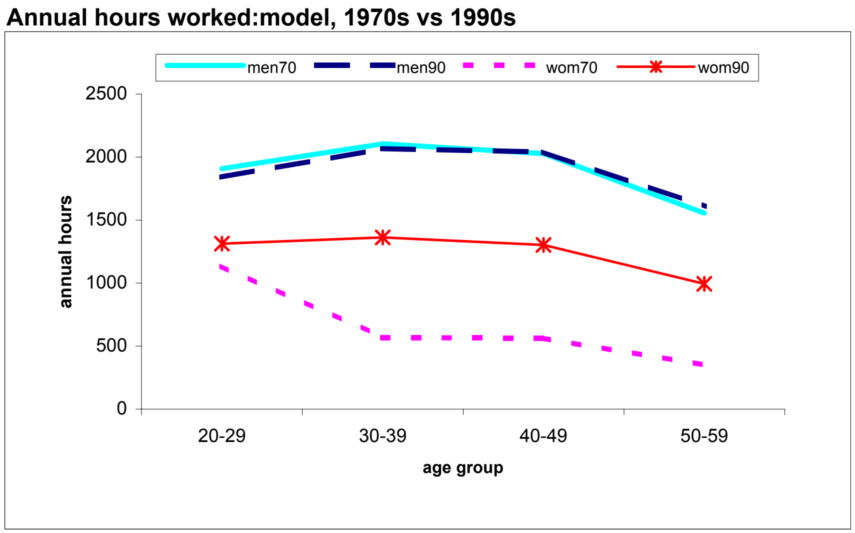
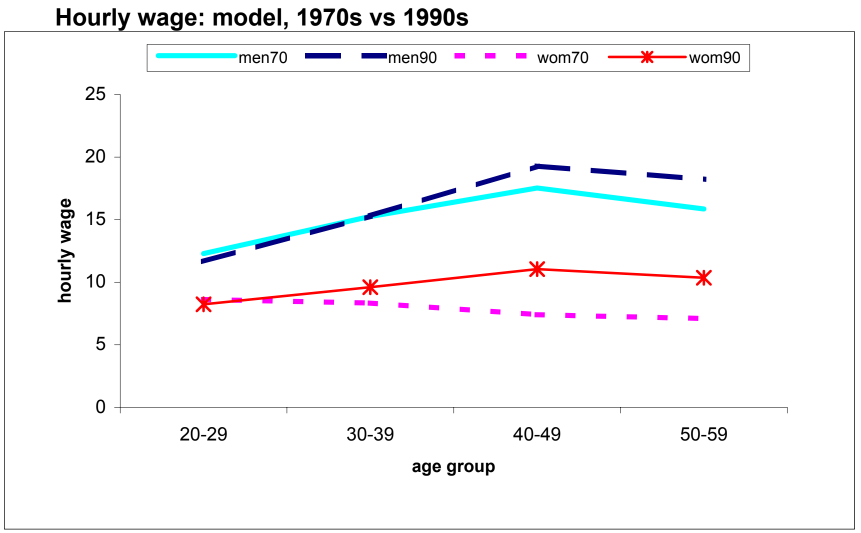


Figure 11: General Equilibrium Model

Panel A: Change in relative rates of return





Panel B: Change in gender wage gap