Explaining Changes in Female Labour Supply in a Life-cycle Model

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Abstract

In this paper we study the life cycle labour force participation of three cohorts of American women: those born in the 1930s, 1940s and 1950s. We first document the large shifts in labour supply behaviour among these three cohorts. We then use a life cycle model with endogenous female labour force participation, consumption and saving choices to search for an explanation. The dynamics of labour supply depends on child costs (relative to earnings), returns to experience and the rate of depreciation of human capital when out of the labour market. We calibrate the model to match the behaviour of the middle cohort and investigate which changes in the main determinants of labour supply could have accounted for the substantial increase in labour supply in the early part of the life cycle observed for the youngest cohort. We conclude that shifts in the cost of children relative to life time earnings are the most likely explanation.

JEL: D91, J22, J13
Keywords: female participation, saving, life-cycle, childcare costs

Explaining Changes in Female Labour Supply in a Life-cycle Model[1]

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1 Introduction

Female labour force participation and labour supply, in the US, as in many other developed countries, has changed dramatically over the last 30 years. If one compares the labour supply behaviour of the cohorts of women born in the 1930s (such as Elizabeth Dole), 1940s (Hillary Clinton) and 1950s (Oprah Winfrey) in its various dimensions, two main features emerge. First, comparing the Elizabeth Dole cohort to the Hillary Clinton one, we can see a substantial shift of the age profile of labour supply: the Clinton cohort worked more than the Dole cohort. However, the shape of the age profile does not change much. In particular, in both profiles we observe low participation (relative to other ages) corresponding to child rearing years. When comparing the Hillary Clinton cohort with the Oprah Winfrey one, we see that the low participation rates associated with the "fertility years" are no longer present. The aim of this paper is to propose a life cycle model of labour supply and saving that could account for these dramatic changes. We explore whether changes to some specific parameters and exogenous variables of this model can generate the patterns observed in the data. Or, to use a different perspective, we want to quantify the size of changes in these variables that would be needed to explain the observed patterns.

The main change in labour supply behavior in the data is on the

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extensive margin. We consider a number of possible determinants of these changes in participation. First, wages may have increased relative to the fixed cost of participation. For example, the costs of child-care may have fallen. This would lead to greater participation at all ages and especially among mothers of infants. Second, on-the-job learning or the return to experience may have increased. As argued by Olivetti (2001), this increases the opportunity cost of reduced labor supply. Third, the depreciation of skills that occurs if an individual is not participating may have increased. Finally, we look at other possible explanations, such as an increase in the age of mothers at childbirth and an increase in uncertainty over husband's income. Our structural model of life-cycle behavior attempts to evaluate these alternative explanations.

Obviously, wages are likely to be an important determinant of female labour supply. However, by looking at the dynamics of wages alone, it is difficult to disentangle the return to experience, the depreciation rate of human capital and the extent of participation bias (selection). Moreover, the interactions of these effects with other important determinants (such as fertility patterns, the cost of children, uncertainty, and so on) even in a simple life cycle model can be quite complex and difficult to quantify. The main purpose of this paper is to build a realistic life-cycle environment in which we can explicitly model the participation choice. We then calibrate the model to fit the behaviour of a given cohort and experiment with changes in the basic determinants of labour supply to determine which are more likely to yield the profiles of other cohorts.

In our life cycle model households face uncertainty about the wages of the husband and the wife; maternity is exogenously given and children impose some monetary fixed cost when mothers decide to work. Decisions are taken at an annual frequency. The model takes into account returns to experience as a result of participation and depreciation of human capital when labor market interruptions are made. Households are able to save and borrow and women choose whether or not to work. The ability of saving and borrowing makes our model different from Eckstein and Wolpin (1989) and van Der Klaauw (1996), who estimate structural models of females' employment decision in the first case and females' employment and marital status decisions in the second case imposing that consumption coincides with income. Without the saving choice, the only way to intertemporally substitute consumption would be through changing labor supply and hence, in a model with returns to experience, the future wage rate. Saving is potentially a more flexible tool for intertemporal substitution and therefore ignoring it might overstate the importance of labor supply choices in life-cycle smoothing.

We calibrate our model by matching simulated participation profiles to observed participation profiles We use observed profiles from the cohort born at the start of the '40s for our calibration. We then explore the role of different factors in shaping changes of the life-cycle wage profile and participation profile.

Pencavel (1998) and Coleman and Pencavel (1993) report age profiles for participation similar to those we report. The facts on employment are not in dispute. More controversial is understanding the data on wage profiles, on depreciation of human capital and on the underlying question of why participation has changed. Mincer and Pollachek (1974) and Mincer and Olfek (1982) discuss the extent of human capital depreciation under different assumptions on the permanence of depreciation. We report some statistics that are relevant for the depreciation of human capital when out of the labour force showing that rates of wage depreciation appear to have increased. However, without a tightly specified structural model of participation it is hard to identify separately the depreciation rate from the participation choice.

Olivetti (2000) suggests that changes in wage profiles across cohorts reflect a change in the return to experience. The evidence we present is somewhat weaker: first, the cohort effect which leads to an increase in the return to experience can plausibly be interpreted as a year effect with wages in the 1980s growing faster than in previous periods. Second, wage growth seems to have benefited those who have worked only intermittently as well as those who have worked full time.

There is now a substantial literature addressing the underlying question of why participation has changed. For example, Olivetti (2001) uses a four period model and the estimates of the returns to experience in Olivetti (2000) to show the effect that increases in the returns to experience have on hours worked by women. Greenwood and Seshadri (2002) measure the impact of technological progress on the increase in women's participation. Jones, Manuelli and McGrattan (2003) investigate the effect on average hours worked by women of the decrease in the wage gender gap as well as the effect of technological progress. Caucutt, Guner and Knowles (2001) explore the interaction between wage inequality, marrige, fertility and employment decisions of young women. The contribution of the current paper is primarily to use a realistic life-cycle model of saving and participation to compare alternative explanations.

The paper is organized as follows. In Section 2 we describe the data that motivates the paper, in particular female employment behavior. In particular, we focus on the behaviour of three cohorts: those of women born in the 30s, 40s, and 50s. In Section 3 we describe the model and we compare with the literature. In section 4 we report simulations for individuals with different parameter specifications. We describe first the parameters we use for uncertainty, returns to experience, depreciation, child costs, maternity age and preferences. Second, we describe our baseline simulations, showing participation statistics and life-cycle profiles. In section 5 we carry out comparative statics for different variables and in Section 6, we discuss the implications of our simulations for explaining the observed changes in participation described in Section 2.

2 Data

The aim of this section is to illustrate the main facts about female labour supply and about a number of variables that are likely to be important determinants of labour supply choices. Clearly, as we discuss below, some of these variables could be jointly determined with labour supply either at the individual level - such as fertility - or in a general equilibrium setting, such as wages.

The main data sources we use is the PSID. In particular, we use the PSID core sample, including the SEO low income sample. In all our computations we use the PSID weights. As the focus of this paper is a life cycle model, we follow three different cohorts of women over the observed part of their life cycle. The first cohort is made up of women born between 1934 and 1938 and is therefore observed between (median) ages of 35 and 60. The second cohort contains women born between 1944 and 1948 and is observed between ages 25 and 50, and the third cohort contains those women born between 1954 and 1958 and is observed between ages 25 to 40. Sample sizes are reported in Table 22 in the Appendix. While we do not observe the complete life cycle profiles for each cohort, each cohort overlaps, at some ages, with the others. With the important caveat that different cohorts are obviously observed at the same age at different points in time, these overlaps can be informative about possible differences in life cycle profiles. On the other hand, we should keep in mind the impossibility of disentangling, without additional information, year, age and cohort effects.

We concentrate on married women. It is well known that the key factor underlying the increase of female employment in the US over the last decades is the change of married women's behavior. The main issue is whether the trend towards marrying later might affect or bias our results. We start our descriptive analysis with labour supply variables. We then move on to wages and to other variables, such as fertility, child care arrangements and so on, that might be relevant for labour supply choices.

2.1 Facts to explain: Employment

We start our analysis by looking at the life cycle profiles of hours worked. In Figure 1, we plot average hours worked for the three cohorts, averaging over both workers and non workers. In this figure we first see a pattern that we observe repeatedly. Two features stand out. First, there is a large increase across cohorts in the number of hours worked by women, especially if we compare the first and third cohort. Second, the difference in the life cycle profile between the second and third cohort: whilst the difference between the two cohorts is quite large early in the life cycle when participation is much higher for the third cohort, by age 37 the difference between the two cohorts is minimal.[5]

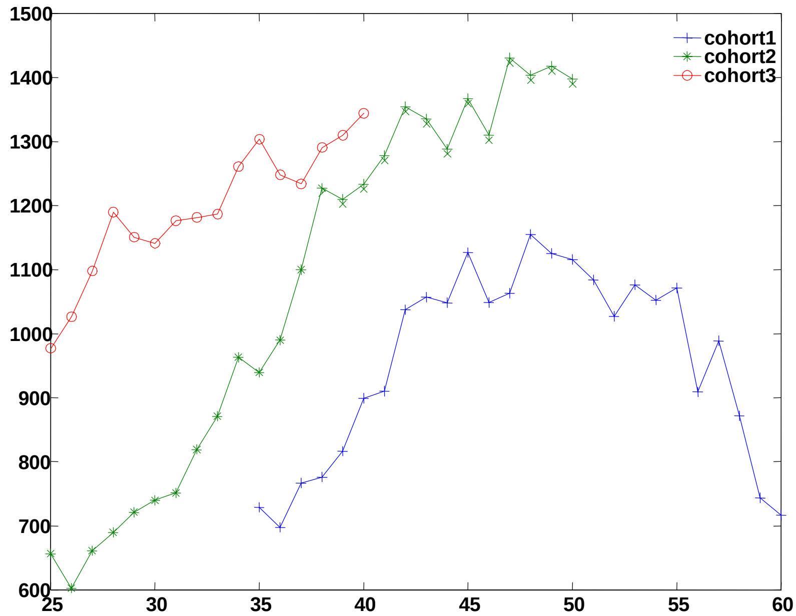


Figure 1: Average Hours Worked

In Figure 2, we report average hours worked by women who work.

[5]It is possible that the increases in participation that we show here are due to year effects, with participation simply being higher in more recent years. This explanation would suggest that wages were higher for the youngest cohort in the early years of working life than for older cohorts. We show in figure 8 below that real wages are, if anything, lower for the younger cohort.

We observe that differences across cohorts are much smaller now, suggesting that the main change in women's labour supply behaviour is in participation decisions. This supposition is confirmed in Figures 3 and 4 which refer to employment rates and full time employment rates respectively. In the former case a woman is classified as employed if she works at least 100 hours per year, while in the latter she is considered working full time if she works at least 1,500 hours per year. Both figures show large differences in employment rates across the different cohorts. Again, it is interesting to note that the main differences between cohorts 2 and 3 are observed from age 25 to age 35. For cohort 2, employment rates are low but increasing from age 25 to age 35, corresponding to child rearing years. However, for the youngest cohort, participation rates are less correlated with women's age.

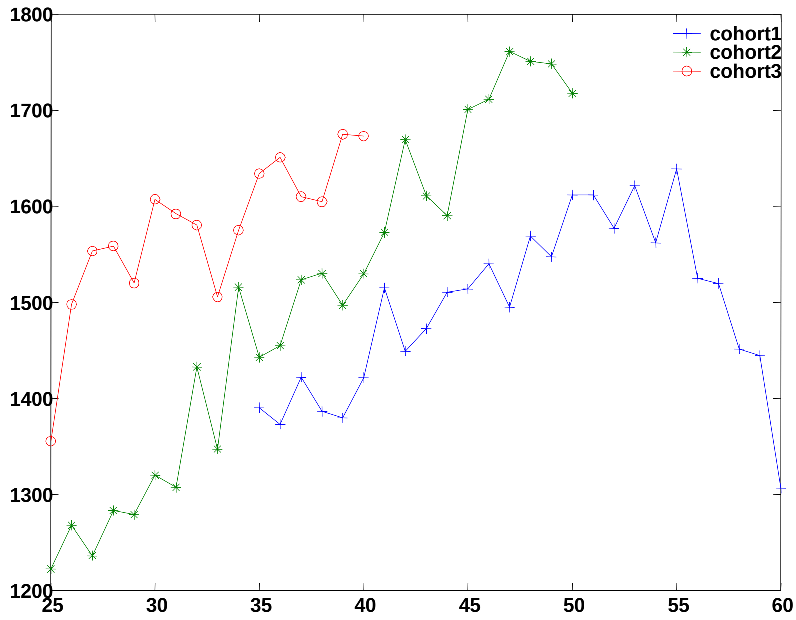


Figure 2: Average Hours Worked, Employed Women Only

Next, we focus on the early part of the life cycle and relate labour supply behaviour to fertility behaviour. In Figures 5 and 6, we plot employment rates and full time employment rates for mothers of

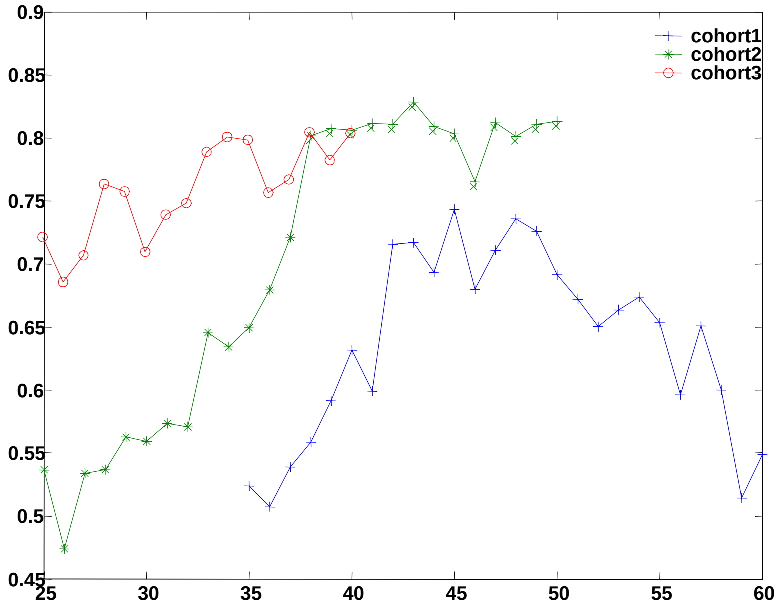


Figure 3: Employment Rate

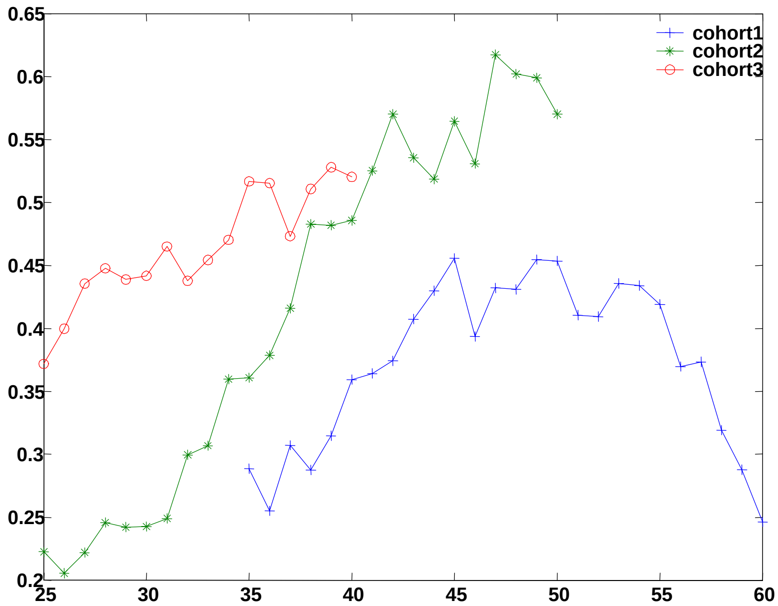


Figure 4: Full-Time Employment Rate

children younger than 3. As from age 35 on there are very few observations, we restrict our comparison to ages 25 to 35 so we only have observations for cohorts 2 and 3.

The difference between the two cohorts is remarkable. In cohort 3 as many as 65% of mothers with a child less than 3 are working, while the same figure for cohort 2 is only 45%. This evidence is consistent with some facts reported by the US Census Bureau, reproduced in figure 7. They consider women that were mothers in four different periods 1961-65 (cohort 1), 1971-75 (cohort 2), 1981-85 (cohort 3) and 1991-95 and look at employment decisions before and after childbirth. Figure 7 shows that the first two cohorts were unlikely to have returned to the labor market a year after birth. However, for the two youngest cohorts employment rates three months after childbirth are similar to those two months before.

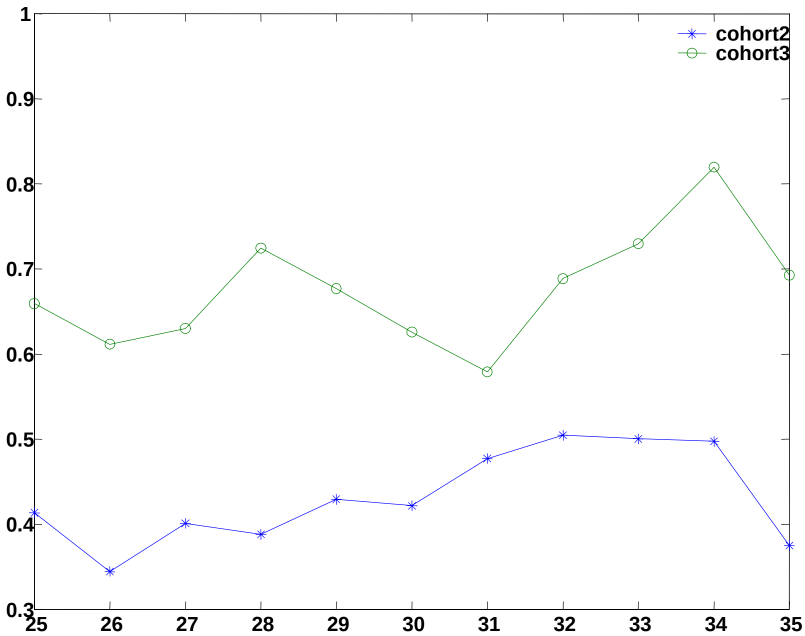


Figure 5: Employment Rates of Mothers of Children less than 3 yrs

The women belonging to the three cohorts we are studying are very different in many dimensions. A very important one is their education achievements. The members of the youngest cohort are much more educated than their predecessors: in the Current Population Survey, only 20% of the women belonging to our cohort

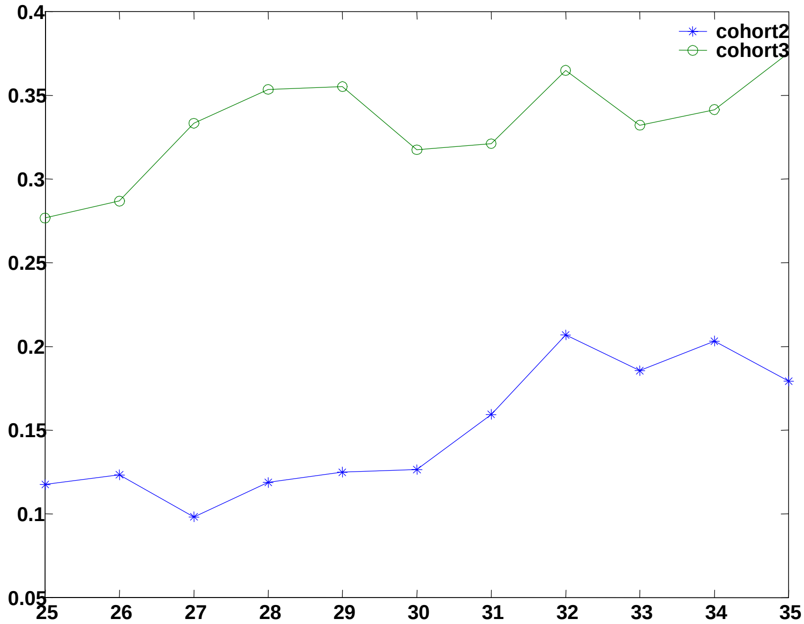


Figure 6: Full-Time Employment Rates, Mothers of children less than 3 yrs

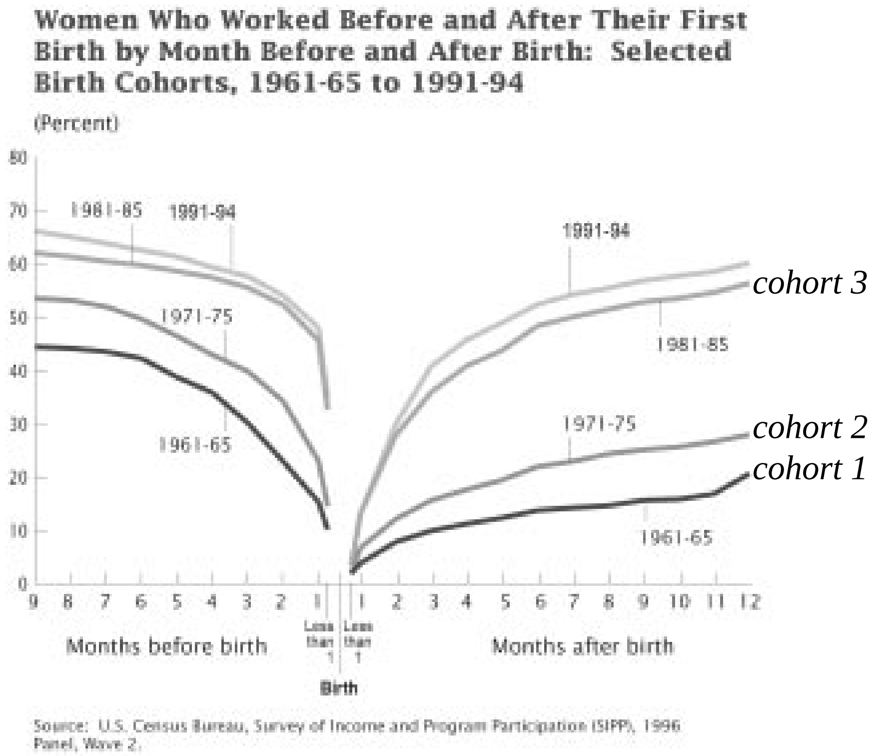


Figure 7: Speed of Return After Childbirth

1 had more than high school education. This percentage increased to 26% for the second cohort and to 41% for the third cohort. It could be the case that part of the observed increase in women employment rates was due to a composition effect. However, when re-doing the exercise for different education groups, we find that the trends just discussed can be observed at different education levels. We report the evidence on labour supply (and wages) by education in the Appendix.

Figures 5 and 6 showed the importance of the changes in the behaviour of mothers in explaining the different participation rates of cohorts 2 and 3. To complement that evidence, in Table 1 we compute, for cohorts 2 and 3, the percentage of women that exit from the labour market for each age between 26 and 32. The table shows that a smaller fraction of cohort 3 women exit the labour market at each age. We show in the appendix that these differences still exist when we condition on education group. Once out of the labour market, women belonging to the two cohorts also differ in terms of the amount of time they stay out of the labour market. In Table 1 we report the median duration of time out of the labour market by age of exit for women who return by age 40 and also for all women who exit (ie including those who we do not observe returning). We also include duration statistics pooling together all women who exit at or before age 32. Finally, we report the fraction of women that return to the labor market before age 40. Conditioning on exit, women in cohort 3 return to work somwhat faster than cohort 2, but the difference is small. The main difference between cohorts is in the rate of exit.

2.2 Wages

The price of human capital is obviously determined in equilibrium by the interaction of demand and supply of the relevant factors. For an individual, however, it could be argued that the path of wages is given. As we discuss in the next section, current wages are not the only important determinant of the participation decisions in a life

Table 1: Rate of Exit and Duration of Exit

Age	*Cohort 2*				*Cohort 3*			
	Fraction	*Duration*			*Fraction*	*Duration*		
	of workers	*All*	*Reentering*		*of workers*	*All*	*Reentering*	
	that exit	*Median*	*Mean*	*Median*	*that exit*	*Median*	*Mean*	*Median*
26	0.27	3	3.0	2	0.16	2	2.6	1
27	0.15	4	3.2	2	0.12	1	2.1	2
28	0.15	7	4.6	3	0.07	3	3.2	2
29	0.16	3	3.9	2	0.10	4	2.0	1
30	0.20	3	3.2	2	0.14	2	1.6	2
31	0.14	7	4.0	2	0.10	2	2.6	1
32	0.15	4	2.9	2	0.10	4	2.1	1
All		3	3.5	2		2	2.3	1

We report numbers up to age 32 only in order to keep sample size large enough. As cohort 1 is only observed from age 35 onwards, the interesting comparison is between cohorts 2 and 3.

time framework. Dynamic aspects, such as the return to experience and the depreciation of human capital when not participating in the labour market are also likely to be important determinants. For this reason, in this section we look at the life cycle profile of wages for our three cohorts of women.

While life cycle profiles for wages are informative about the return to human capital for women who work, two important caveats should be kept in mind when looking at these pictures and thinking about the role wages could play in determining participation. First, it is not clear whether the observed profile was actually rationally predicted by the decision makers at the time the labour supply decision was made. We already mentioned the existence of macro effects: a future increase (or stagnation) in wages for a given cohort is not necessarily anticipated. Second, the pictures we construct do not necessarily reflect the average (or median) offer wage, which is the one relevant for the decision: selection into employment is not random and can induce important biases.

Figure 8 plots for each of the three cohorts, the median female hourly wage against age. In the Appendix we report similar pictures for different education groups. Cohort 3 appears to face a much steeper wage profile in the early part of the life-cycle than cohort 2.

This may be interpreted as an increase in the return to experience. However, it is difficult to separate out the cohort and year effects. In particular, all three profiles of wages exhibit sizeable increases in the second half of our sample period. During the first half of the sample, which covers the 1970s and for which we only observe cohort 1 and 2, real wages were basically flat. This is particularly apparent for the high educated women (figure 27 in the appendix). For the high educated women belonging to cohort 1 median real wages were actually declining during the first part of the sample. By the time cohort 3 comes in, and starts enjoying relatively fast growth of real wages, the wages of cohort 1 and 2 also start increasing. Of course the three cohorts experience these changes in real wages at different ages. To stress how difficult is to interpret these patterns, in Figure 9 we plot median wages for the three cohorts against time, rather than age. The synchronization in the dynamics of the wages for the three cohorts apparent in this picture might suggest we should attribute all or part of the increase in wages to aggregate factors that move the wages of women belonging to all cohorts.

In addition to the impossibility of disentangling age, time and cohort effects, the life cycle profiles in Figure 8 are only partially informative about the return to experience because at each age we average the wages of women with different levels of labour market experience. In order to have additional information on the returns to experience we plot, for each cohort, two life cycle wage profiles. At each age we compare the wage of all women with the wage of those women that have been observed since age 25 and have been not had more than one year off work. These two profiles, plotted in Figure 10, are observed from age 26 to age 39 and give an idea of the return to experience faced by these cohorts. Computing the 'return to experience' as the difference between these two profiles has an important advantage relative to the profiles in Figure 8 and some drawbacks. The advantage is that, to a certain extent, year effects are common to the two profiles and might be 'differenced out'. However, we do not take into account the duration of spells

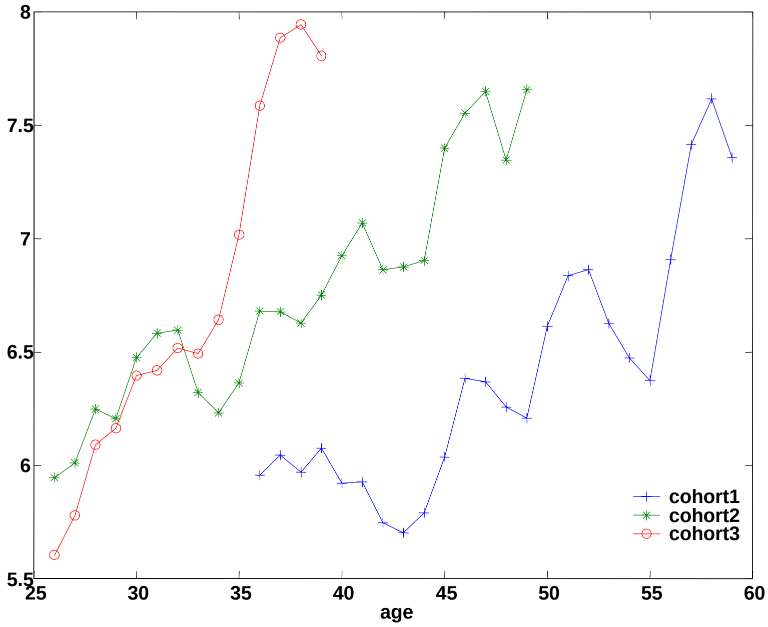


Figure 8: Median Hourly Wage by Age

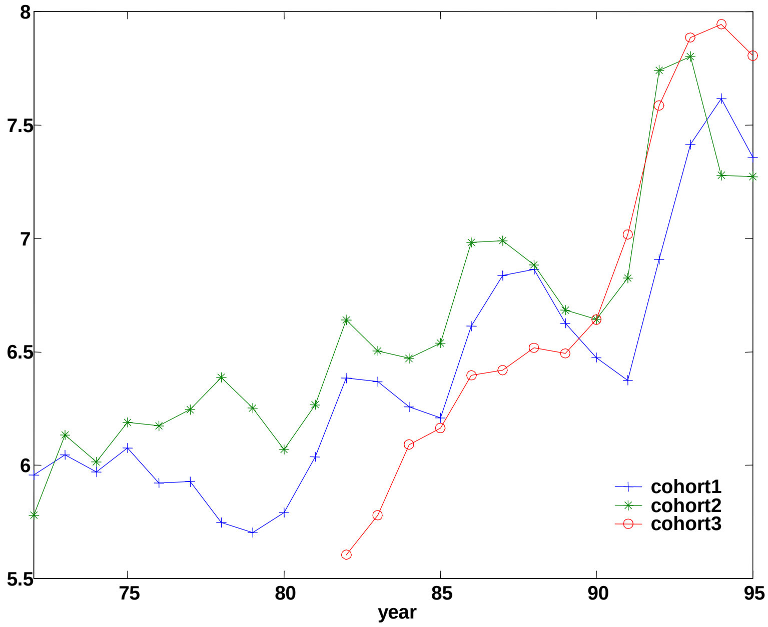


Figure 9: Median Hourly Wage by Year

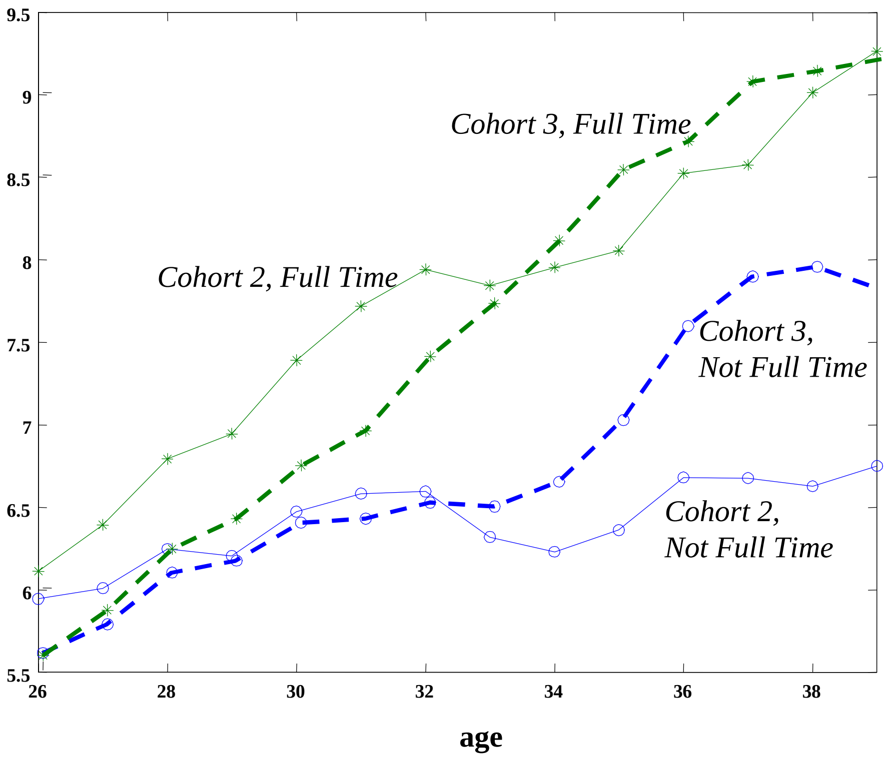


Figure 10: Returns to Experience for Cohort 2 and 3

out of the labour force and we know these to be shorter for cohort 3. Moreover, we ignore selection (and possible changes in it). Perhaps surprisingly, in these figures we do not find very strong differences in this particular measure of return to experience between cohort 2 and 3.

A potentially important determinant of the participation decision is the depreciation of human capital when out of the labour force. A clean estimate of a depreciation model is remarkably hard because of the selection problems involved: one only observes the wage of women who decide to go out and then to come back. There will be women who have not gone out because of the depreciation and, more importantly, women who have not come back because of the extent to which their human capital had depreciated. Without a structural model of participation, it is not possible to solve these selection issues. Nonetheless, in this section we look at what happens to the wages of women who have exited the labour market and decided to reenter after an interruption, and return to calibrating the depreciation rate in section 3. Our exercise is similar to the one performed by Mincer and Polachek (1974) and Mincer and Olfek (1982). In particular, we follow women that have employment interruptions and who are observed before and after the interruption. In Table 1, we report the average level of wages before and after the interruption for these two cohorts, as well as median depreciation. The last row includes depreciation rates for all women who exit at or before age 32. Depreciation rates are marginally higher for Cohort 3, and the difference between cohorts is greater for high educated women, as shown in the Appendix. We calculate an exponential depreciation rate

$$\delta = 1 - \left(\frac{w_{t+k}}{w_t}\right)^{\frac{1}{k}}$$

where k is the duration of an exit that began in period t. This calculation controls for the shorter duration of unemployment observed in cohort 3 that was reported in table 1. Median depreciation rates in cohort 3 are higher at almost all ages than in cohort 2, but sample sizes are small. Further, we do not know how long the depreciation lasts on return to work.

We are of course aware of the limitations of these measures. In particular, there is a selection bias that can give misleading returns to experience and penalty of employment interruptions. For example, if returns to experience are greater in the younger cohort, then individuals may be more willing to suffer an initial wage loss on return to work..

2.3 Fertility and child care arrangements

Fertility behaviour is obviously important for labour supply decisions, either as a determinant or as a joint decision variable. The cost of children can be an important indirect determinant of labour supply decisions. In Figure 11, we plot the average number of children aged less than 17 present in the household against their mother's age. From the figure the massive decline in fertility is apparent: at

Table 2: Wage Depreciation

Age	*Cohort 2* # *obs*	*W Bef*	*W Af*	*Median* δ	*Cohort 3* # *obs*	*W Bef*	*W Af*	*Median* δ
26	46	6.1	5.8	-0.04	25	4.7	5.4	-0.11
27	26	6.5	4.8	0.05	32	4.3	3.4	0.18
28	17	7.5	5.6	0.04	14	7.3	6.4	0.19
29	16	5.3	4.7	0.04	15	8.0	6.8	0.06
30	19	4.4	4.6	-0.01	13	7.1	3.5	0.26
31	10	7.2	6.7	-0.02	11	4.1	1.6	0.02
32	12	5.2	6.0	-0.08	12	4.5	4.7	0.00
All	143	6.07	5.19	0.04	121	5.74	4.94	0.10

The depreciation rate for a particular individual is calculated as $\delta = 1 - (w_{t+k}/w_t)^{1/k}$ where k is the duration of an exit which occured in period t. We then calculate median δ over individuals by age.
Negative numbers for δ indicate wage growth.

age 35 a woman of cohort 1 had on average 3 children living with her, while at the same age a woman belonging to cohort 3 had less than 2.

As in other developed countries, the reduction in the number of children happened at the same time as a substantial delay in the birth of the first child. Using the PSID 1993 additional fertility module, we can calculate, for each of our three cohorts, the proportion of women that have their first child in any given age interval. The numbers reported in Table 3 are revealing: in cohorts 1 and 2, 30% of women had their first child between 18 and 22; this percentage falls to 26% for cohort 3. On the other hand, while only 29% of cohort 1 women had their first child when aged over 26, that percentage goes up to 37% for cohort 2 and to 41% for cohort 3. These proportions are similar to the data from the National Vital Statistics System published by the US Department of Health and Human Services (DHHS, 1989).

We have shown that the increase of mothers' employment might be behind a large part of the increase of women employment over time. It is therefore worthwhile looking at the availability and cost

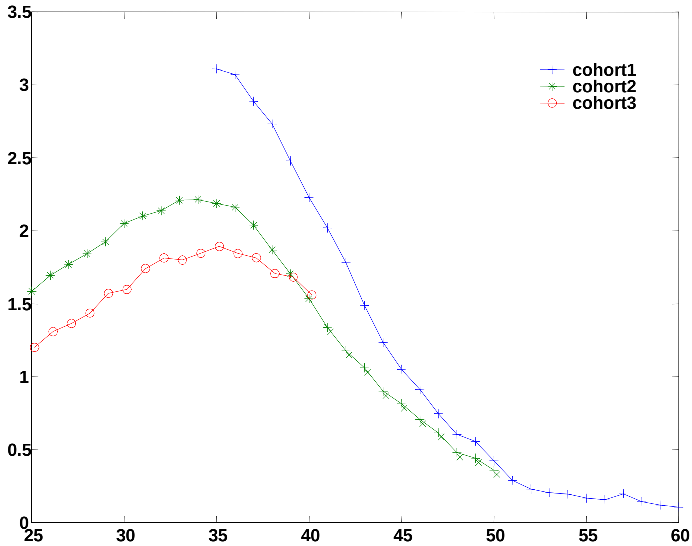


Figure 11: Average Number of Children Younger than 17, per Household

Table 3: Distribution of Maternity Age

Maternity Age	*Percentage of Women*		
	Cohort 1	*Cohort 2*	*Cohort 3*
$18 - 22$	31	30	26
$23 - 26$	40	33	33
$27 \leq$	29	37	41

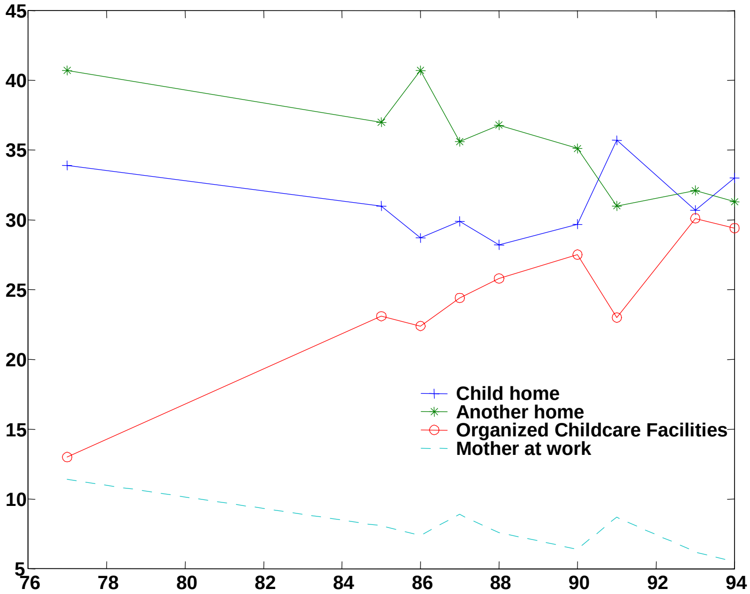


Figure 12: Child Care Arrangements

of child care arrangements. Figure 12 uses data from the US Census Bureau to show child care arrangements used by mothers over time. The figure shows the large increase in the use of organized child care facilities.[6]

Child Care costs can be substantial. In 1999, according to the Child Care Bureau of the US Department of Health and Human Services, Child Care costs varied between $300 and $700 per month per child. Concerning these costs, Ferrero and Iza (2002) argue that recent skill-biased technological change, which implies an increase of the skill premia and a relative decrease in the market price of child-caring with respect to female mean wages, could contribute to explaining the increase in women's employment rate. Ahn and

[6]The fiscal treatment of Child Care Costs also changed over the period. In 1954 a deduction for employment related care expenses was established. The deduction became a credit in 1976 and in 1981 the limits where $2400 for one child and $4800 for two or more. In 2002 these figures were raised to $3000 for one child and $6000 for two. These increases do not even make up for inflation. Family income determines the percentage of child care expenses that can be claimed for credit (between 20 and 35%). The credit is not refundable which keeps the lowest-income families from benefiting.

Mira (2002) argue that there was a decline in the price of child care relative to female wages based on Blau (1992).[7] Historically child care subsidies have not been important. The Child Care and Development Fund is the major source of Federal child care assistance for low and moderate income families and yet in 1998 only 15% of eligible children actually received help through the program.

To provide additional evidence on the decline in child costs relative to women earnings, we use more detailed information on child care expenditure that can be obtained from the BLS Consumer Expenditure Survey, which collects detailed information on consumption expenditure by US households. Unfortunately the CEX is only available since 1980. We consider households, observed between 1980-1984 and between 1998-1999, where the reference person or the spouse is a working woman with children between 0 and 7. We construct the ratio of child cost expenditure to female earnings and run a Tobit regression of this ratio on the log of annual number of hours worked, the number of children between 0 and 3 and the number of children between 4 and 7 years of age. In addition to these variables, we introduce a dummy for the late 1990s year. In Table 4 we report the results of two regressions: the first for mothers with at least a child aged 0 to 3, the second for mothers with at least a child aged 4 to 7. In both columns we see that the coefficient on the late 1990s is significantly negative, indicating a decline in the ratio of child care costs to women earnings, even after controlling for differences in the number of hours worked. The decline is particularly large for younger children. A similar exercise can be executed in the PSID. If we compare the ratio of child care cost to women earnings in 1975 and 1988 we find that, conditional on having positive costs, the ratio is considerably higher in 1975 than 1988, even after controlling for the number of hours and number of children.[8]

[7] Blau (1992) reports that real wages of child care workers, as well as other workers, were flat from 1976 to 1986.

[8] Interestingly, the fraction of working women reporting a positive amount of child care costs is higher in 1988 than in 1975.

Table 4: Tobit for Changes in Childcare Costs

Dep Var: Childcare cost / woman's earnings

	# children age 0-3 > 0	*# children age 4-7 > 0*
Log hours	-0.029	- 0.023
	(0.006)	(0.003)
# of children 0-3	0.057	0.076
	(0.017)	(0.006)
# of children 4-7	0.035	0.048
	(0.011)	(0.009)
Year>1997	-0.236	-0.050
	(0.036)	(0.012)
constant	-0.163	-0.123
	(0.048)	(0.028)
Number obs	9201	10438
Pseudo R^2	0.0098	0.0375

CEX data.

The introduction of maternity leaves in the US is very recent. It took place in 1993 when the Family and Medical Leave Act was approved. Even then, the approved period of maternity leave was 12 weeks, the lowest of the OECD and does not mandate paid benefits during the period. However, the existence of maternity leave can help women to reconcile employment and maternity. The availability of maternity periods allows women time out of the labour force around childbirth without compelling them to quit their jobs. Indeed, as shown in figure 7, the increase in maternity leave is associated with women returning to work after child birth more quickly.[9]

[9] A further issue that could affect married women's employment decision is the risk of divorce. When married women face uncertainty on their future marital status and the accumulation of labor market experience has a return in terms of higher future wages, they have an additional incentive to participate in the labor market. Several papers support this link between marital risk and employment of married women, Peters (1986), Parkman (1992), Sander (1985), Sen (2000) and Sánchez-Marcos (2002). According to OECD figures, divorce rates in the US have increased from 2.2% in 1960 to 4.8% in 1990. In this paper, we do not consider at all the effects of divorce risk.

3 Model

In this section we describe the model we use to explain the changes in female labour supply. We assume that unitary households maximize expected lifetime utility. The utility function is intertemporally separable and instantaneous utility depends on household consumption per adult equivalent and the labour supply choice of the wife. We assume that all households have two adults and that husbands always work and receive earnings that are determined by a stochastic process introduced below. We do not model fertility choices: for this reason we take the shortcut of considering the arrival of the two children as given and simultaneous. Obviously a more realistic model would consider the two children to be spaced within a period of a few years. Such an exercise would not change substantially the essence of our results. Children do not have a direct effect on utility (except for deflating consumption by their adult equivalent). However, they do affect the fixed cost of work.

In particular, we consider an individual household with an instantaneous utility function of the form

$$u_t = u(c_t, P_t, e_t)$$

where P_t is a discrete $\{0, 1\}$ female labour supply choice, c_t is total household consumption and e_t is the number of adult equivalents in the household. The household is assumed to maximize lifetime expected utility,

$$\max_{c,P} V_t = E_t \sum_{s=t}^{T} \beta^{s-t} u(c_s, P_s)$$

where β is the discount factor and E_t the expectations operator conditional on information available in period t. We use a utility function of the form

$$u(c_t, P_t) = \frac{\left(\frac{c_t}{e_t}\right)^{1-\gamma}}{1-\gamma} \exp(\psi_1 P_t) - \psi_2 P_t \tag{1}$$

As we use values of $\gamma > 1$, we constrain $\psi_1 > 0$ so that participation reduces the utility of consumption. Consistent with the estimates in Browning and Meghir (1991), utility is not homothetic. Consumption is equivalised by the factor e_t which depends on the age and number of children. We use the McClements scale to determine e.[10]

The intertemporal budget constraint has the form

$$A_{t+1} = R\left(A_t + \left(y_t - F\left(a_t\right)\right) P_t + y_t^m - c_t\right) \tag{2}$$

where A are beginning of period assets, R is the interest rate, F the fixed cost of work which depends on $a_{t,}$ the age of the child. Female earnings are given by y_t, and husband earnings are given by y_t^m. In any period, individuals are able to borrow against the minimum income they can guarantee for the rest of their lives. Notice that this feature differentiates our model substantially from those used by Eckstein and Wolpin (1988) and van der Klaauw (1996) who rule out any borrowing or saving. As we discuss below, this difference can be substantial.[11] When we constrain borrowing, we add the constraint: $A_t \geq 0$. When we rule out any borrowing or saving, we impose that $c_t = \left(y_t - F\left(a_t\right)\right) P_t + y_t^m$.

We model the fixed cost associated with children following Hotz and Miller (1988), who specify the functional form for the time cost of children as

$$G\left(a_t\right) = \theta \phi^{a_t - 1} \tag{3}$$

and estimate parameters θ and ϕ to match the time cost associated with child care for children of different ages. The price of this time cost is then given by p, giving an expression for the fixed cost of

[10] According to the McClements scale, a childless couple is equivalent to 1.67 adults. A couple with one child is equivalent to 1.9 adults if the child is less than 3, to 2 adults if the child is between 3 and 7, 2.07 adults if the child is between 8 and 12 and 2.2 adults if the child is between 13 and 18. As we mention in the text, we assume that each couple has two children who arrive at a predetermined age and leave at age 18.

[11] The price we pay for allowing borrowing and saving is that the model becomes too cumbersome to estimate structurally as done by Eckstein and Wolpin and by van der Klaauw.

work

$$F\left(a_t\right) = pG\left(a_t\right), \tag{4}$$

Female earnings, y_t, are subject to transitory shocks, ε_t, and permanent shocks, v_t, and are given by

$$\ln y_t = \ln y_0 + h_t - \delta_T I\left(P_{t-1} = 0\right) + v_t + \varepsilon_t \quad \text{where } \varepsilon_t \sim N\left(-\frac{\sigma_\varepsilon^2}{2}, \sigma_\varepsilon^2\right) \tag{5}$$

$$v_t = v_{t-1} + \xi_t \quad \text{where } \xi_t \sim N\left(-\frac{\sigma_\xi^2}{2}, \sigma_\xi^2\right) \tag{6}$$

where h_t is the level of human capital at the start of the period. If individuals have not participated in the previous period, they have to pay a premium on their wage for one period for reentry, given by δ_T. We think of δ_T as the temporary depreciation in skills associated with a period out of the labour force, as estimated by van der Klaauw (1996).

Human capital evolves with employment decisions in the following way

$$h_t = h_{t-1} + \left(\eta_0 + \eta_1 t\right) I\left(P_{t-1} = 1\right) - \delta_P h_{t-1} I\left(P_{t-1} = 0\right)$$

$$\eta_0 > 0, \ \eta_1 < 0$$

We think of δ_P as the permanent depreciation in human capital associated with non-participation, as discussed and estimated by Mincer and Polachek (1974) and Mincer and Olfek (1982). The two forms of depreciation of human capital (temporary and permanent) have very different effects on participation choices. We do not model direct investment in human capital (such as schooling decisions or on the job training), which are extensively discussed in Mincer and Polachek (1974) and Mincer and Olfek (1982).

The process of human capital accumulation is important to our model. One issue is whether the increase in human capital associated with working diminishes with the level of human capital. A related issue is whether this increase depends on age. Eckstein and Wolpin (1989) and van der Klauw (1996) assume that the increase in human capital diminishes with the level of human capital. Olivetti (2000) assumes the increase in human capital diminishes with age, but not with the level of human capital. As in Olivetti, we assume that the increase in human capital depends on age only, with the increase in human capital decreasing with age if $\eta_1 < 0$.

Since we assume men always work, male earnings are given by

$$\ln y_t^m = \ln y_0^m + h_t^m + v_t^m + \varepsilon_t^m \quad \text{where } \varepsilon_t^m \sim N\left(-\frac{\sigma_{\varepsilon,m}^2}{2}, \sigma_{\varepsilon,m}^2\right) \tag{7}$$

$$v_t^m = v_{t-1}^m + \xi_t^m \quad \text{where } \xi_t^m \sim N\left(-\frac{\sigma_{\xi,m}^2}{2}, \sigma_{\xi,m}^2\right) \tag{8}$$

$$h_t^m = h_{t-1}^m + (\eta_0 + \eta_1 t) \tag{9}$$

We assume that the return to experience for men is the same as the return to experience for women in our baseline. However, when considering changes to returns to experience, we hold the return for men constant.

In each period, if the woman chooses to participate, the value function is given by

$$V_t^1(A_t, v_t, P_{t-1}, h_t) = \max_{c_t}\left\{u(c_t, P_t = 1) + \beta E_t\left[\max\left\{\begin{array}{c} V_{t+1}^0(A_{t+1}, v_{t+1}, P_t = 1, h_{t+1}) \\ V_{t+1}^1(A_{t+1}, v_{t+1}, P_t = 1, h_{t+1}) \end{array}\right\}\right]\right\} \tag{10}$$

If she chooses not to participate, the value function is given by,

$$V_t^0(A_t, \nu_t, P_{t-1}, h_t) = \max_{c_t}\left\{u(c_t, P_t = 0) + \beta E_t\left[\max\left\{\begin{array}{c} V_{t+1}^0(A_{t+1}, \nu_{t+1}, P_t = 0, h_{t+1}) \\ V_{t+1}^1(A_{t+1}, \nu_{t+1}, P_t = 0, h_{t+1}) \end{array}\right\}\right]\right\} \tag{11}$$

The decision of whether or not to participate in period t is determined by comparing $V_t^0(A_t, \nu_t, P_{t-1}, h_t)$ and $V_t^1(A_t, \nu_t, P_{t-1}, h_t)$. The participation choice and the consumption choice in t determines the endogenous state variables (assets, human capital and the reentry decision) at the start of the next period. The non-concavity in the value function induced by the discrete participation decision is smoothed out by the presence of sufficient uncertainty. We check that this holds in the numerical solution of the problem discussed in the appendix.

One of the main differences between our model and those estimated in the literature by Eckstein and Wolpin (1988) and van der Klaauw (1996) is the inclusion of saving and borrowing as a choice variable. This has a number of implications: first, the utility cost of non-participation is lower in our model because consumption can be smoothed over time through saving. The presence of husband earnings means consumption is not as variable as the wife's wage income, but, without savings, consumption will still be highly sensitive to the participation choice because of the budget constraint. Since we observe periods of non-participation, a model without saving that tries to match the data on non-participation would imply the direct utility benefit of non-participation to be large, the negative impact on future wages of non-participation to be small and childcare costs to be large. Without these features, individuals would not be willing to accept the consumption loss in a given period and the variability in consumption across periods implied by non-participation. On the other hand, if individuals are able to save or borrow, the income loss in a particular period associated with non-participation in that period can be spread over the life-cycle.

While allowing individuals to save adds an element of realism to our model, the assumption that they can borrow up to the present discounted value of their minimum earnings can be an unrealistic assumption. It is possible that individual households are prevented from borrowing large amounts at the current interest rate because of imperfections in credit markets. The presence of such borrowing constraints is likely to have a particularly strong effect on young households. As we focus on the behaviour of relatively young individuals (mothers), we check how our results change when we do not allow any borrowing. For comparison with some of the previous literature, we also simulate a version of the model in which we prevent intertemporal trades alltogether.

4 Baseline Parameters and Simulations

In this section, we describe the parameters we use in our baseline model. We then show the life-cycle profiles implied by these parameters. We calibrate the model parameters to fit the life cycle profile of cohort 2. In the next section, we carry out comparative statics exercises and discuss the implications of changing the baseline parameters for female participation.

4.1 Baseline parameters

In Table 5, we report the parameters we use in our baseline simulations. The first column contains those parameters that have been measured directly in the data or come from other studies, while the second column contains those that have been calibrated to statistics in the data.

Table 5: Baseline Parameters

Exogenous Parameters		*Calibrated Parameters*	
σ_{ξ}^2	0.031	δ_P	0.02
$\sigma_{\xi,m}^2$	0.031	p	18.0
γ	1.5	ψ_1	0.1
β	$\frac{1}{1.02}$	ψ_2	0.001
k	24		
R	1.015	η_0	0.065
δ_T	0.0	η_1	-0.00108

The parameters used to match the data are the utility cost of working (given by 2 parameters), the depreciation rate, returns to experience and the price of child-care. As discussed below, the returns to experience parameters are set using observed wage profiles. Table 6 reports the statistics that the remaining parameters are calibrated to, together with the simulated values for those statistics in our baseline model. The statistics we match are the average participation across the life-cycle, average participation rates by mothers with children less than 3, the ratio of participation in the year before child birth to participation in the year after, and finally, the median duration of exit for those who leave employment following childbirth. We are comparing the median duration of exit, rather than the mean, to avoid assigning values to individuals who we never observe returning to work.[12] In comparing average participation rates of mothers of children younger than 3, we include all mothers age less than 36 in order to make our sample size large enough. In the table, we also show the statistics for cohort 3. These show that the level of participation has not changed markedly, but participation of mothers has increased and women return to work faster. The aim of section 5 on comparative statics is to show what changes may induce the observed changes in these statistics.

Table 6: Baseline Model and Main Statistics

	Baseline	*Data, Cohort 2*	*Data, Cohort 3*
Participation	0.68	0.70	0.76
Part Kid	0.44	0.44	0.67
Ratio B/A	2.03	1.80	1.22
Median duration of exit	4	4	3

The row *Participation* reports the average participation rates of women across all ages. The rorw *Part Kid* reports participation rates for mothers of children aged 3 or younger. The row *Ratio B/A* reports $\frac{\text{Participation Before Childbirth}}{\text{Participation After Childbirth}}$. Median duration is for all women who exit at childbirth.

Uncertainty Values for the variances of permanent shocks are taken from Meghir and Pistaferri (2004). In our baseline parameterisation, we only allow for permanent shocks. For both adults, the variance of the permanent shocks, σ_ξ^2, are assumed to be constant across the life-time and we assume that shocks to the earnings of the husband and wife are uncorrelated. In the

[12] For cohort 2, taking all women who exit before age 32, median duration is 3. However, in the simulations, we are looking only at women who exit at age 24 and so we set our statistic for median duration to 4.

comparative statics, we consider the impact on female participation of changing uncertainty about husband earnings. The omission of temporary shocks for women earnings was done only to simplify the computations. Once we had calibrated the model, we calculated the participation statistics allowing for transitory shocks (as estimated by Meghir and Pistaferri, 2004) and the statistics were little changed: the main change was that participation by mothers of children age 3 or less fell to 0.41 from the baseline of 0.44.[13]

Interest Rate and Discount Rate. We assume a discount rate equal to 0.02, which is slightly higher than the interest rate, fixed at 0.015.

Risk aversion. In the utility function (1), the coefficient of relative risk aversion, γ, is set to 1.5. This value is consistent with the evidence on the elasticity of intertemporal substitution in the US provided by Attanasio and Weber (1995).

Average age of maternity. In the baseline we assume that two children are born when the mother is 24, which is approximately the average first maternity age for women of Cohort 2. We experiment below with delays in maternity age.

Returns to Experience and Depreciation As we mentioned in Section 3, there are three issues to address in the accumulation of human capital: first, how fast does human capital accumulate when working; second how fast does human capital depreciate when not working; and third, how permanent is the depreciation. We set on-the-job accumulation so that the earnings growth experienced by a worker who participates in every period matches the PSID data, controlling for cohort effects. For a worker who participates from age 22 to 62, annual earnings double, with earnings growth being fastest when young.

[13]The degree of the persistence of income shocks is important. If shocks were *i.i.d.* but with a high variance per period (this is necessary to keep the variance of lifetime earnings constant), participation is high across the life-cycle as individuals face large amounts of ongoing uncertainty. With persistent shocks, the uncertainty translates into heterogeneity late in life. These considerations are important because of the assumption of the absence of persistence of shocks in Eckstein and Wolpin (1989) and van der Klaauw (1996).

The equation for the accumulation of human capital in Section 3 is given by

$$h_t = h_{t-1} + (\eta_0 + \eta_1 t)\, I\,(P_{t-1} = 1) - \delta_P h_{t-1} I\,(P_{t-1} = 0)$$
$$\ln y_t = \ln y_0 + h_t - \delta_T I\,(P_{t-1} = 0) + \nu_t + \varepsilon_t \qquad (12)$$

In table 7, we report the extent of the returns to experience by varying η_0 and showing the effect that being out of the labour force has on lifetime earnings assuming zero depreciation: $\delta_P = 0$ and $\delta_T = 0$. We consider 3 years out - this value is the median length of exit, conditional on reentering employment, for cohort 2. The importance of returns to experience is best illustrated by the difference between the cost of exit in the two columns.

Table 7: Earnings Cost of Labour Market Interuptions

	3 years at 24	*3 years at 24* $\eta_0 = 0$
$\eta_0 = 0.03$	0.13	0.09
$\eta_0 = 0.065$	0.18	0.09
$\eta_0 = 0.1$	0.23	0.09
Eckstein and Wolpin	0.11	0.09
der Klaauw	0.13	0.10

The table shows the fraction of lifetime earnings that are lost in each scenario. These calculations assume no uncertainty over wages and depreciation rates are set to zero.

These calculations assume that wages are known with certainty. The effect of uncertainty and, therefore, ex-post heterogeneity, is to introduce selection into the exit decision. In particular, individuals who exit tend to be those with (ex-post) lower wages. For these women, earnings foregone will be lower than shown above suggesting that these are over-estimates of the monetary cost paid by those who choose to exit. Olivetti (2000) estimates the return to experience, but looking at the effect of varying hours of work, rather than participation. This means we cannot use her estimates for looking at the effect of non-participation on human capital: if we took her estimates as being relevant for the participation choice, then a spell of 3 years out of the labour force at age 24 would cost 54% of lifetime earnings.

Returns to experience in our baseline are greater than those estimated in Eckstein and Wolpin (1988) and van der Klaauw (1996). As discussed above, the estimates of the cost of being out of the labour force in those papers are likely to be underestimates of the true costs: they are determined by the fraction of individuals who do not participate and, given that consumption equals income in those models, it is hard in a dynamic programming model to induce individuals to choose not to participate unless the cost of doing so is small. In section 5 we show the effect of taking these lower estimates of the returns for participation in our model: in the presence of saving, there is too much exit from the labour force if there is no depreciation and the returns to experience are low.

In our baseline, we calibrate the permanent depreciation rate to be $\delta_P = 0.02$, and we fix the transitory depreciation rate at $\delta_T = 0.0$. In Mincer and Polachek (1974) there is only permanent depreciation, δ_p, which they estimate to be around 1.5% per year. There is no controlling for selection issues in that paper but their estimates are the only ones available for the permanent depreciation. Van der Klaauw (1996) and Keane and Wolpin (1997) assume there is only transitory depreciation, δ_T, and in Eckstein and Wolpin (1988) there is no depreciation. Mincer and Olfek (1982) estimate both δ_p and δ_T and find δ_T to be important. Mincer and Olfek (1982) also discuss whether the depreciation rate is not constant. In particular, they discuss the possibility that depreciation rates increase with duration of exit. We discuss the implications of such depreciation in section 6.

In table 8, we show the effect on the cost of time out of the labour force for different values of permanent depreciation, ignoring uncertainty. The striking point about this table is how fast the cost of exit increases with permanent depreciation whether or not there are returns to experience. The table does not report differences in earnings loss associated with increases in transitory depreciation.

This is because such increases make almost no difference to the earnings loss associated with exit. This is simply because we are considering life-time earnings and in a life-cycle context, the value of δ_T is the one-off cost of returning to work.[14]

Table 8: Human Capital Depreciation: Earnings Cost of Labor Market Interruptions

	3 years at 24	*3 years at 24* $\eta_0 = 0$
$\delta_P = 0.0$	0.18	0.09
$\delta_P = 0.01$	0.21	0.12
$\delta_P = 0.02$	0.24	0.15
$\delta_P = 0.04$	0.30	0.20
$\delta_P = 0.06$	0.35	0.25
$\delta_P = 0.10$	0.43	0.33

No uncertainty over wages. In column 2, $\eta_0 = 0.065$.

Child Costs Equation (4) determines how the fixed cost of work varies with children. We take the parameters of the function G from Hotz and Miller (1988) who estimate $\theta = 660$ and $\phi = 0.89$ using 1970s data from the PSID. The child cost price p is set to capture both the direct cost associated with the child-care and additional loss associated with that child care.[15] As shown in Table 5 a value of this parameter equal to 18 is needed. Given this, the ratio of child-care expenses for a newborn to average annual earnings of a 30 year old women who has always worked is 46%. In Table 8 we calculate the net present value of the income path from taking a spell out relative to not doing so. If there were no utility cost of participation and no uncertainty, this opportunity cost of non-participation would determine the size of the fixed cost necessary to induce that spell of non-participation. Individuals may choose to work early on despite current earnings being less than the fixed cost if there is a significant

[14] Mincer and Polachek (1974) explore the issue of returning to work in between the arrival of children and show that investment in human capital is less by those who work at this stage. In the current paper, we abstract from this issue by assuming that each family has two children simultaneously.

[15] Including some kind of utility cost.

return to experience and they are able to finance this investment through borrowing.

Preferences The ψ_2 parameter reflects the direct utility cost of participating and it takes a value equal to 0.1 in our baseline. We could alternatively have a fixed cost of working in the budget constraint that is not child related. The ψ_1 parameter reflects the reduction in the utility of consumption caused by participation. Since $\gamma > 1$ and $\psi_1 > 0$, the marginal utility of consumption is greater when participating than when not participating, in other words, consumption and participation are complements in utility, as in van der Klaauw. Parameter ψ_1 takes the value 0.001 in our baseline.

4.2 Baseline life cycle profiles

Given the parameters in Table 5 we can simulate the model and generate life cycle profiles for some of the variables of interest. As we mentioned above, the baseline simulation allows for borrowing (up to the point that guarantees certain repayment) and lending. In addition to this simulation, we also report results on simulations that do not allow borrowing and simulations that allow neither borrowing nor saving. Figure 13 shows profiles of participation for the three sets of simulations. This Figure shows that in addition to matching the statistics in Table 6, the baseline model is able to reproduce the salient features of the life cycle profiles of Cohort 2 labour force participation shown in figure 3. In particular, the model generates the increase in participation rates with age following childbirth. We discuss the profiles without borrowing and without borrowing and saving below.

Figure 14 shows the average earnings profile under the assumption of full participation versus the average earnings profile for participating women. We can see that the selection effect means that average earnings of those actually participating are higher than the potential earnings of all women. Figure 14 also show the profile of fixed costs.

Finally, Figure 15 shows asset accumulation. In our model, individuals save prior to the arrival of children, then run down savings and borrow while children are young, particularly if not participating. As they get older, debt is paid off, and then individuals save to cover periods of non-participation at the end of the life-time (although there is no exogenous retirement). Figure 16 shows the extent to which borrowing and saving smooths consumption through periods of non-participation.

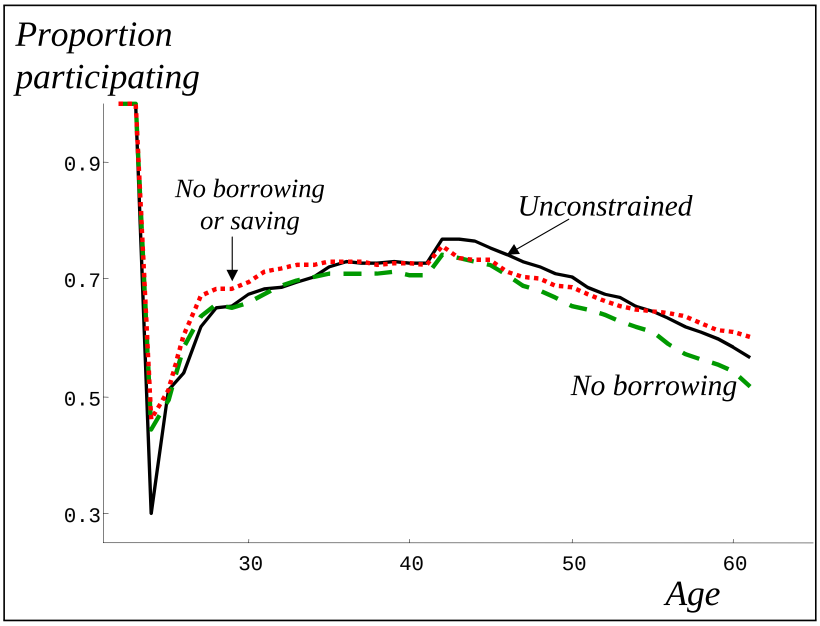


Figure 13: Simulated Participation Rates over the Life-Cycle

Restrictions to Intertemporal Trades Figures 13, 15 and 16 also present profiles when borrowing is constrained, and table 9 shows participation statistics. Figure 13 shows that the scenario without borrowing generates profiles for participation that are similar to those where borrowing is allowed, although the dip in participation at childbirth is less if borrowing is constrained. Asset profiles do of course differ, with individuals maintaining a buffer stock of saving if borrowing constraints are present, rather than borrowing against future earnings in the unconstrained case (figure 15).

To compare our model to those of Eckstein and Wolpin (1989) and

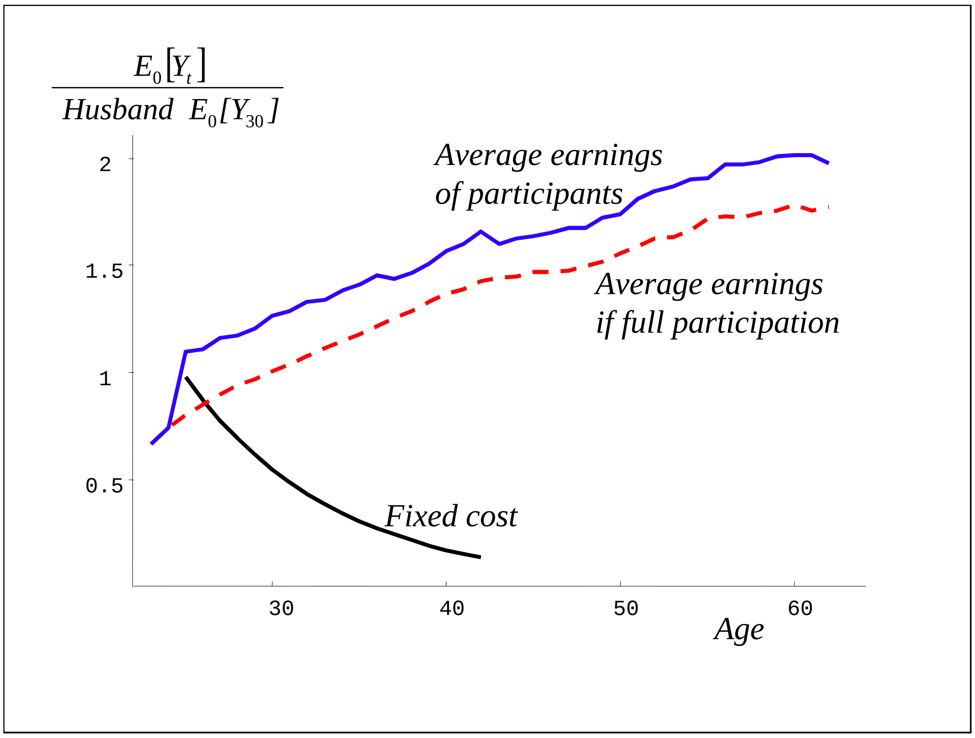


Figure 14: Simulated Earnings, Potential Earnings and Childcare Costs

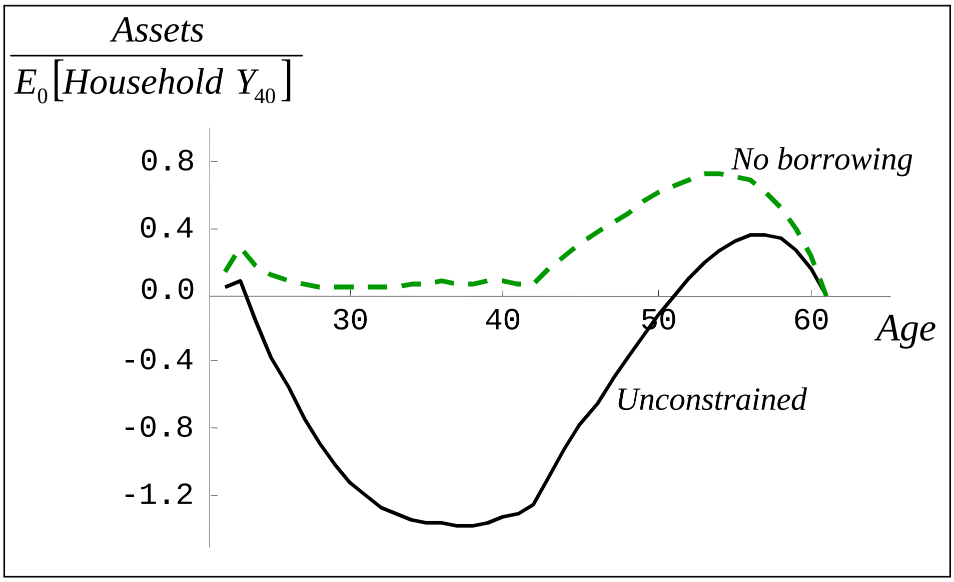


Figure 15: Simulated Asset Accumulation

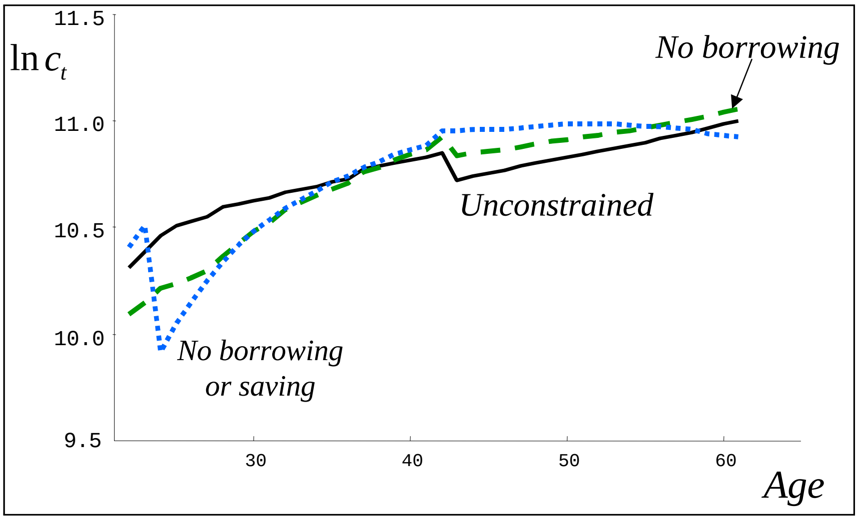


Figure 16: Consumption Profiles (Not equivalised)

Table 9: Participation Statistics with Borrowing Constraints

	Baseline	*No Borrowing*	*No Borrowing or Saving*	*Data Cohort 2*
Participation	0.68	0.68	0.69	0.70
Part Kid	0.44	0.51	0.52	0.44
Ratio B/A	2.03	1.99	1.96	2.03
Median duration	4	6	5	4

The row *Participation* reports the average participation rates of women across all ages. The rorw *Part Kid* reports participation rates for mothers of children aged 3 or younger. The row *Ratio B/A* reports $\frac{\text{Participation Before Childbirth}}{\text{Participation After Childbirth}}$. Median duration is for all women who exit at childbirth.

van der Klaauw (1996), we also run our baseline specification without the possibility of borrowing and saving. In Figure 13, we notice that participation in the model with no intertemporal trade is smoother over the life cycle than in the other two cases. Table 9 reports the calibration statistics from each of the three models: unlimited saving and borrowing, no borrowing, and no borrowing or saving. The main difference between the three scenarios is in the size of the fall in participation for mothers of children less than 3. The fall in participation is larger when borrowing is possible because, as shown in figure 16, the fall in participation does not translate into as large a fall in consumption as when borrowing is constrained. Similarly, as we show in section 5, the presence of borrowing constraints mean that larger changes in parameter values are necessary to generate the observed changes in participation profiles.

From this evidence, we can draw implications about the parameter values needed to calibrate to observed participation statistics under alternative assumptions on intertemporal trade. For instance, using our calibrated baseline parameters, we see that participation when children are less than 3 is too high if borrowing is constrained. Table 10 shows that in this case an increase in the non-additive utility cost, ψ_1 can decrease *"Part Kid"*. The non-additive utility cost makes non-participation and consumption closer substitutes and so consumption falling with non-participation does not have the same utility cost. This reduces participation at all ages, suggesting a smaller direct utility cost of participation is needed. We do not recalibrate explicitly the model under different assumptions about borrowing and saving. However, the evidence in Table 10 shows how the assumptions on intertemporal trade can be important for the estimation of preference parameters.

Table 10: Calibrated Preference Parameters

	Unconstrained		*No Borrowing*		*No Borrowing or Saving*	
	Part	*Part Kid*	*Part*	*Part Kid*	*Part*	*Part Kid*
ψ_1						
0.0	0.79	0.45	0.79	0.534	0.80	0.53
0.005	0.73	0.45	0.80	0.54	0.80	0.53
0.05	0.73	0.45	0.73	0.52	0.74	0.51
0.1	**0.68**	**0.44**	**0.68**	**0.51**	**0.69**	**0.52**
0.15	0.65	0.46	0.61	0.48	0.63	0.49
0.30	0.40	0.24	0.35	0.21	0.38	0.24
ψ_2						
0.0	0.77	0.46	0.76	0.52	0.77	0.51
0.0001	0.76	0.46	0.76	0.52	0.77	0.53
0.001	**0.68**	**0.44**	**0.68**	**0.51**	**0.69**	**0.52**
0.002	0.61	0.45	0.59	0.49	0.59	0.48
0.005	0.31	0.18	0.28	0.20	0.33	0.21
0.01	0.12	0.07	0.11	0.08	0.14	0.09

The column *Part* reports the average participation rates of women across all ages. The column *Part Kid* reports participation rates for mothers of children aged 3 or younger. The column *Ratio B/A* reports $\frac{\text{Participation Before Childbirth}}{\text{Participation After Childbirth}}$. Median duration is for all women who exit.

5 Explaining changes in female participation

In this section we describe the impact that changes in the economic environment have on female participation over the life-cycle.[16] Our main aim is to establish what are the most likely explanations for the change in the shape of the life cycle profiles of cohort 3 relative to cohort 2. In particular, we will focus on changes in child-care costs and return to experience. Our strategy is first to establish how much participation changes with given changes in the variable of interest. We then discuss what changes constitute plausible explanations for the observed changes in labour supply.

5.1 Child-care Costs

In Table 11 and Figures 17 and 18 we show how participation reacts to the price of child-care in our model. In the Table we report, for each level of child cost (and leaving the other baseline parameters unchanged), participation statistics for the baseline case and for the situation in which individuals are borrowing constrained. A reduction in child-care costs increases substantially participation by mothers of young children and has a small positive effect on overall participation. The reduction in child-care costs can therefore flatten the age - participation profile of young mothers, without having a substantial effect on the level of participation. For instance, moving from the baseline cost of 18 to a cost of 15.5 (or a bit above) essentially explains the difference in the participation rate of mothers of young children in the second and third cohort. On the other hand, median duration of exits does not decrease in the way we observe in the data. On the contrary, median duration, given our model of participation, increases rather than going down. We return to this issue in the next section.

If households are borrowing constrained, childcare costs must be higher to match the observed participation rate of mothers of young

[16] For each set of parameter changes, we present the baseline statistics in bold text in the tables and baseline profiles with solid lines in the figures.

children Further, a greater reduction in child care costs is needed to explain the change in participation. In particular, the participation rates of mothers of children aged 3 or less are less sensitive to child care costs if households cannot borrow. The main difference between the borrowing constrained and unconstrained cases, however, is that if individuals are borrowing constrained, median duration does not increase as child costs fall.

The change in median durations is partly a composition effect in that some women who would choose to exit in the baseline environment are no longer exiting. Offsetting this composition effect is the impact on behaviour of those who would choose to exit in both the baseline case and the case with lower childcare costs: reduced child care costs should induce shorter durations for those who exit. In the simulations without borrowing constraints, the composition effect dominates, whereas in the data and in the simulations with borrowing constraints, the behavioural effect appears to dominate.

5.2 Returns to experience

As suggested by Olivetti (2001), an increase in the returns to experience may affect labour supply. An increase in the return to experience has two effects: first, it increases the opportunity cost of not participating and second, it increases potential lifetime wealth. In carrying out comparative statics, we want to isolate these two effects. The increase in lifetime income means that the proportion of lifetime earnings that would be spent on child care are smaller and this makes the working decision during early motherhood less costly.

In Table 12 we report the same participation statistics reported in Table 11 for different returns to experience, without correcting for the change to lifetime wealth. We also report the effect of the increased returns on the opportunity cost of exit.[17] In Figures 19

[17] We increase the returns to experience through η_0, the parameter determining the increase in human capital that is indpendent of age. When we adjust η_0,we adjust η_1, the parameter determining the increase in human capital that is dependent on age, so that the marginal increase in human capital from working

Table 11: Participation Statistics varying Childcare Costs

p	*Part*	*Part Kid*	*Ratio B/A*	*Median Duration*
		Unconstrained		
12.0	0.78	0.89	1.19	18
14.0	0.78	0.86	1.21	15.5
15.5	0.76	0.79	1.29	18
16.0	0.71	0.53	1.86	5
18.0	**0.68**	**0.44**	**2.03**	**4**
20.0	0.67	0.34	2.79	3.5
22.0	0.64	0.25	4.09	3
		No Borrowing Allowed		
12.0	0.75	0.74	1.35	4
14.0	0.71	0.66	1.47	4
15.5	0.70	0.58	1.68	3
16.0	0.69	0.55	1.81	4
18.0	**0.68**	**0.51**	**1.99**	**6**
20.0	0.65	0.41	2.08	3
22.0	0.64	0.33	2.89	3

The column *Part* reports the average participation rates of women across all ages. The column *Part Kid* reports participation rates of mothers of children aged 3 or younger. The column *Ratio B/A* reports $\frac{\text{Participation Before Childbirth}}{\text{Participation After Childbirth}}$. Median duration is for all women who exit at childbirth.

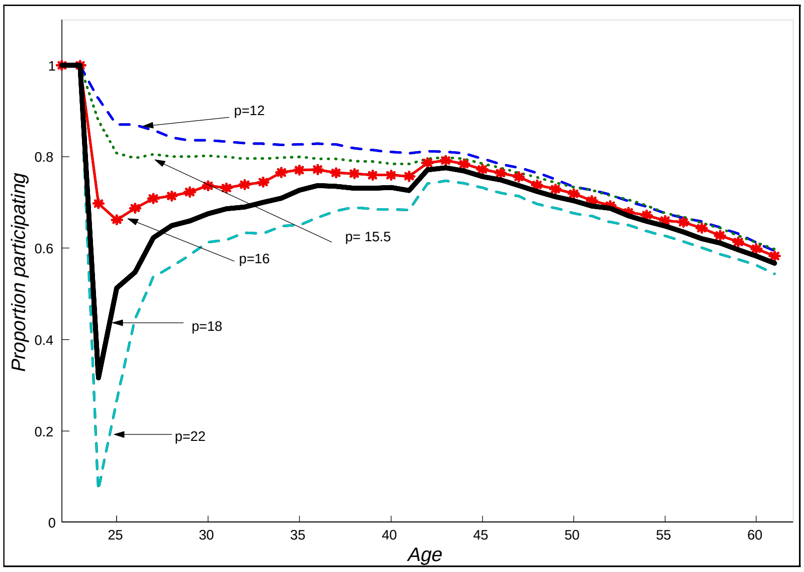


Figure 17: Participation Profiles varying child care costs (Unconstrained)

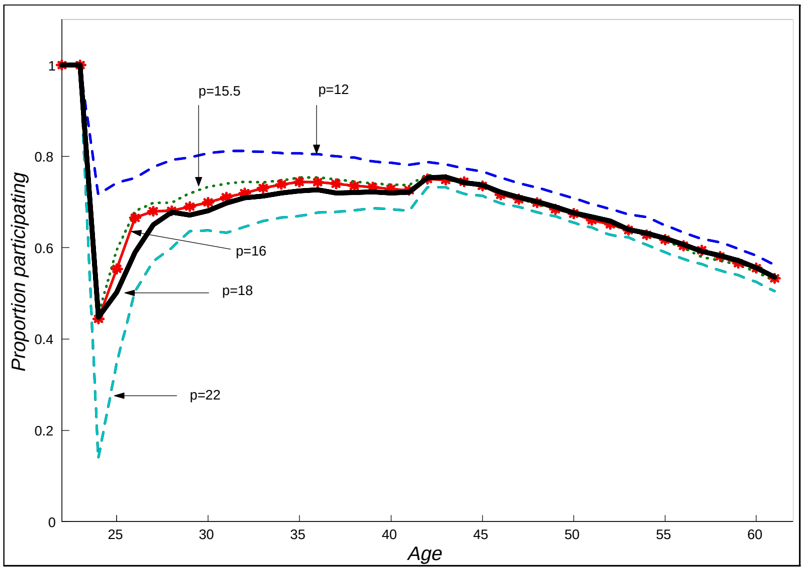


Figure 18: Participation Profiles varying child care costs (No Borrowing)

and 20, we show the life-cycle profiles for participation. An increase in the return to experience can have a large effect on participation, in particular inducing greater participation during early motherhood. This is particularly true when borrowing is unconstrained. The change in participation occurs because greater returns to experience induces individuals to borrow against future earnings to cover child costs when young. If borrowing is constrained, the increase in the return to experience has a much more muted effect on participation.

In the absence of returns to experience, individuals are more able to intertemporally substitute their labour supply, working when the wage is high or child costs low and exiting when they receive a bad wage shock or face high child-care costs. Hence, there is more exit for mothers with infants.

As with the reduction of child care costs, greater returns to experience are associated in our baseline with increases in the median duration of exits. When borrowing is restricted the effect on durations is less clear, but with this restriction we do not observe sufficient inceases in participation to match the data within the range we consider.

The important question here is how large are the increases in returns necessary to induce the observed changes in participation. When individuals are unconstrained, η_0 must increase to 0.08. This is a 24% increase in the marginal benefit of working at each age. This increase is slightly less than the increase of 38% estimated by Olivetti (2000).

We now try to disentangle the pure dynamic effect induced by an increase in the return to experience from the wealth effect. There are several ways we can change the return to experience and keep expected lifetime income constant. In Table 13, we focus on adjusting the initial wage for women, y_0, for each value of the return to experience to hold constant the net present value of life-cycle earnings for a women who participates in every period. The key point about this table is that increases in returns to experience lead

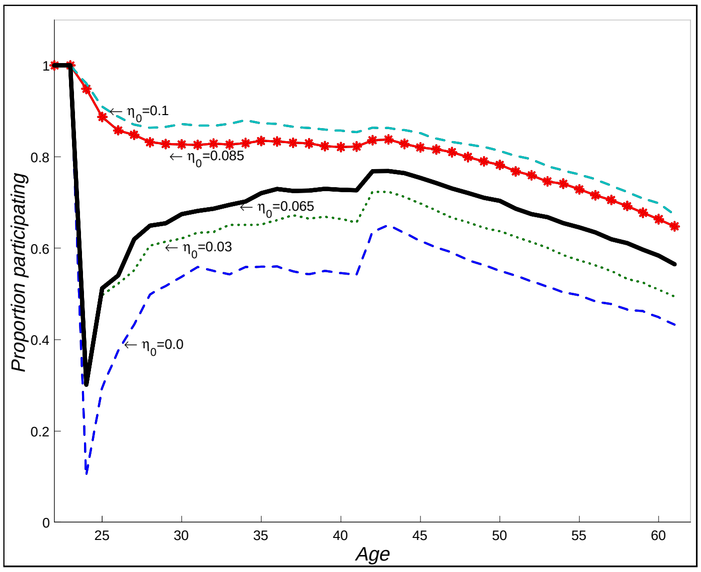
declines to the same value at the end of the working life-cycle in all cases.

Table 12: Participation Statistics varying Returns to Experience

η_0	*Opp Cost*	*Part*	*Part Kid*	*Ratio B/A*	*Median Duration*
			Unconstrained		
0.0	0.16	0.54	0.26	3.40	4
0.03	0.20	0.63	0.44	2.01	4
0.065	**0.24**	**0.68**	**0.44**	**2.03**	**4**
0.075	0.26	0.70	0.51	1.92	7
0.080	0.27	0.74	0.68	1.48	12
0.083	0.27	0.80	0.81	1.16	20
0.085	0.28	0.81	0.90	1.13	T
0.10	0.30	0.84	0.92	1.10	24
			No Borrowing Allowed		
0.0	0.17	0.54	0.26	3.77	4
0.03	0.20	0.61	0.44	1.97	4
0.065	**0.24**	**0.68**	**0.51**	**1.99**	**6**
0.075	0.26	0.69	0.51	2.0	6
0.080	0.27	0.70	0.53	1.95	5
0.083	0.27	0.71	0.52	1.94	5
0.085	0.28	0.70	0.51	1.97	5
0.10	0.30	0.73	0.54	1.83	5

The column *Part* reports the average participation rates of women across all ages. The column *Part Kid* reports participation rates of mothers of children aged 3 or younger. The column *Ratio B/A* reports $\frac{\text{Participation Before Childbirth}}{\text{Participation After Childbirth}}$. Median duration is for all women who exit at childbirth. The value T indicates the median woman does not reenter.

Figure 19: Participation Profiles varying returns to experience (Unconstrained)



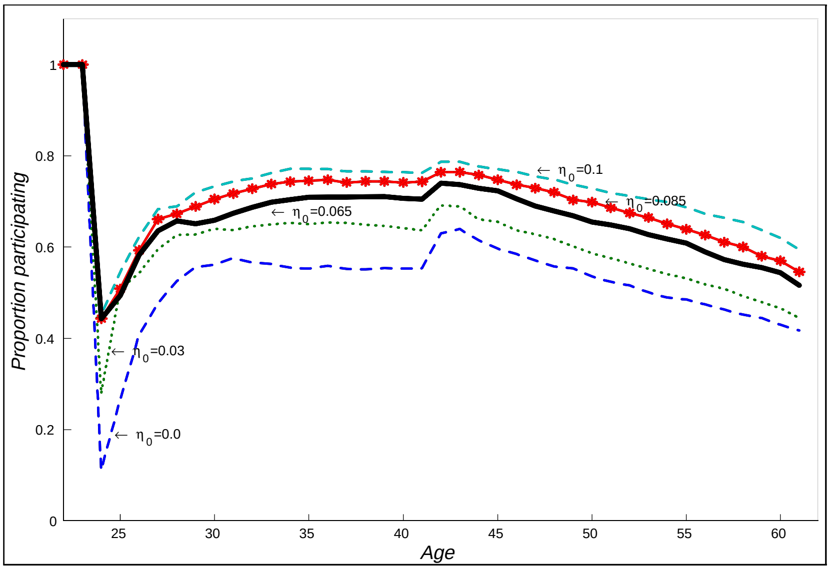


Figure 20: Participation Profiles varying returns to experience (No Borrowing)

to lower participation overall and lower participation by mothers of infants. This suggests that the increases in participation seen in Table 12 are due to the increase in lifetime earnings and corresponding fall in the proportion of lifetime earnings that would be spent on child care rather than to the changed return to accumulating human capital per se.[18]

Table 13: Returns to Experience, Wage Level Adjusted

η	$\ln y_0$	*Part*	*Partkid*	*Ratio bef/after*	*Median duration*
0.0	1.51	0.70	0.63	1.63	5
0.03	1.28	0.71	0.60	1.49	3
0.065	**1.00**	**0.68**	**0.44**	**2.03**	**4**
0.085	0.83	0.65	0.33	2.84	4
0.10	0.71	0.63	0.24	3.95	3

The wage schedule is shifted up or down by varying lny_0 to hold constant the net present value of earnings for a woman who participates in every year.

5.3 Depreciation

The evidence in table 14 suggests that depreciation rates have increased between cohort 2 and 3. Table 14 shows, however, that increases in depreciation have little effect on the participation statistics. Depreciation only impacts on participation when depreciation rates are very high. For values of depreciation between 0.0 and 0.06 we do not observe much difference in participation statistics. However, the result that depreciation has very little impact on participation is somewhat dependent on the ratio of the wage to child-care costs: if the ratio is higher and so child-care costs less important, then increases in depreciation can have a big impact. From

[18] We also consider adjusting the husband's initial wage in each of the returns to experience scenarios to hold constant the net present value of total family income for a household where the woman works full-time. When this adjustment is made, an increase in the return to experience for women implies lower relative earnings for men because lower male earnings are necessary to hold household lifetime earnings fixed. Female participation increases faster as returns to experience increase with this adjustment than in the scenario with no adjustment. This is primarily because the lower (relative) male wage means the marginal utility from the extra consumption associated with an extra hour of work is greater.

these considerations we conclude, therefore, that the impact of depreciation is only second-order and is relevant only when the decision about participation is marginal.

Table 14: Participation Statistics varying Depreciation Rates

δ_P	*Part*	*Part Kid*	*Ratio B/A*	*Median Duration*
			Unconstrained	
0.0	0.71	0.45	2.01	3
0.01	0.69	0.44	2.04	4
0.02	**0.68**	**0.44**	**2.03**	**4**
0.06	0.64	0.45	1.97	5
0.15	0.58	0.40	2.30	18
			No Borrowing Allowed	
0.00	0.68	0.49	2.01	4
0.01	0.67	0.49	2.02	4
0.02	**0.68**	**0.51**	**1.99**	**6**
0.06	0.64	0.51	1.97	9
0.15	0.61	0.52	1.85	20

The column *Part* reports the average participation rates of women across all ages. The column *Part Kid* reports participation rates for mothers of children aged 3 or younger. The column *Ratio B/A* reports $\frac{\text{Participation Before Childbirth}}{\text{Participation After Childbirth}}$. Median duration is for all women who exit at childbirth.

In our model, the rate of depreciation of human capital is independent of the duration of the spell out of the market. There is some evidence, however, that this assumption is too restrictive in that human capital depreciation seems increasing in duration. Jacobson, LaLonde and Sullivan (1993), for instance, found that long-term displaced workers experience large and enduring earnings losses.[19] This pattern of depreciation could contribute to explain the

[19] Ljungqvist and Sargent (1998) argue that this, together with some features of

reduction in the median duration of exits of females.

5.4 Uncertainty

Changing the degree of uncertainty about husband earnings has an effect on individual behaviour through changing the precautionary motive to save and to participate. In table 15 and figure 21, we consider the effect of increasing the variance of the permanent shock to husband earnings. The precautionary effect means an increase in uncertainty leads to increased participation by mothers of young children. Increases in uncertainty lead to a flattening of the age - participation profile associated with young infants, and does not lead to large increases in the overall level of participation. However, the increase in uncertainty necessary to obtain this effect is implausibly large compared to standard estimates (e.g. Meghir and Pistaferri, 2004). Further, if we impose a borrowing constraint, the simulations do not generate this flattening of the age - participation profile for the range we consider.

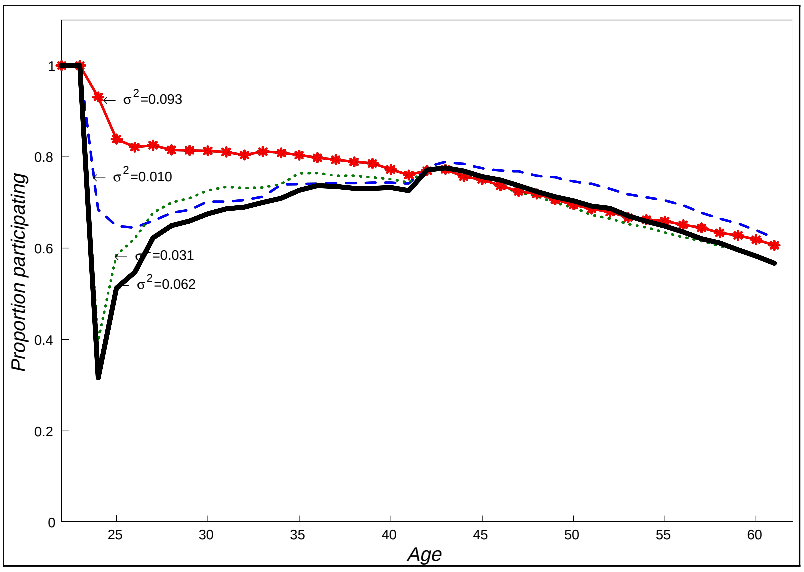


Figure 21: Participation Profiles varying husband earnings uncertainty (Unconstrained)

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the Welfare State, can contribute to explain the persistently high unemployment in some European countries.

Table 15: Participation Statistics varying Uncertainty

$\sigma^2_{\xi,m}$	*Part*	*Part Kid*	*Ratio B/A*	*Median Duration*
			Unconstrained	
0.010	0.73	0.66	1.54	18
0.031	**0.68**	**0.44**	**2.03**	**4**
0.062	0.70	0.53	1.71	4
0.093	0.76	0.86	1.19	T
			No Borrowing Allowed	
0.010	0.65	0.51	2.0	7
0.031	**0.68**	**0.51**	**1.99**	**6**
0.062	0.70	0.56	1.74	4
0.093	0.69	0.50	1.95	6

The column *Part* reports the average participation rates of women across all ages. The column *Part Kid* reports participation rates of mothers of children aged 3 or younger. The column *Ratio B/A* reports $\frac{\text{Participation Before Childbirth}}{\text{Participation After Childbirth}}$. Median duration is for all women who exit at childbirth. A value of T indicates the median women does not reenter.

5.5 Maternity Age

In our baseline, we set the age of mothers at childbirth at 24. As discussed in section 2, age of mothers at childbirth has increased markedly in recent cohorts and so in Table 16 and in Figure 22 we consider how changes in the age of mothers at childbirth affects participation.

Table 16: Participation Statistics varying Maternity Age

Age at Childbirth	*Part*	*Part Kid*	*Ratio B/A*	*Median Duration*
			Unconstrained	
23	0.66	0.38	2.15	4
24	**0.68**	**0.44**	**2.03**	**4**
28	0.72	0.59	1.60	11
31	0.72	0.56	1.57	11
36	0.72	0.56	1.52	14
No kids	0.81			
			No Borrowing Allowed	
23	0.66	0.45	2.20	2
24	**0.68**	**0.52**	**1.97**	**6**
28	0.70	0.58	1.67	12
31	0.71	0.59	1.52	12
36	0.72	0.57	1.47	13
No kids	0.80			

The column *Part* reports the average participation rates of women across all ages. The column *Part Kid* reports participation rates for mothers of children aged 3 or younger. The column *Ratio B/A* reports $\frac{\text{Participation Before Childbirth}}{\text{Participation After Childbirth}}$. Median duration is for all women who exit at childbirth.

Mothers who have children later, tend to participate more while their children are infants, but this effect is not monotonic in

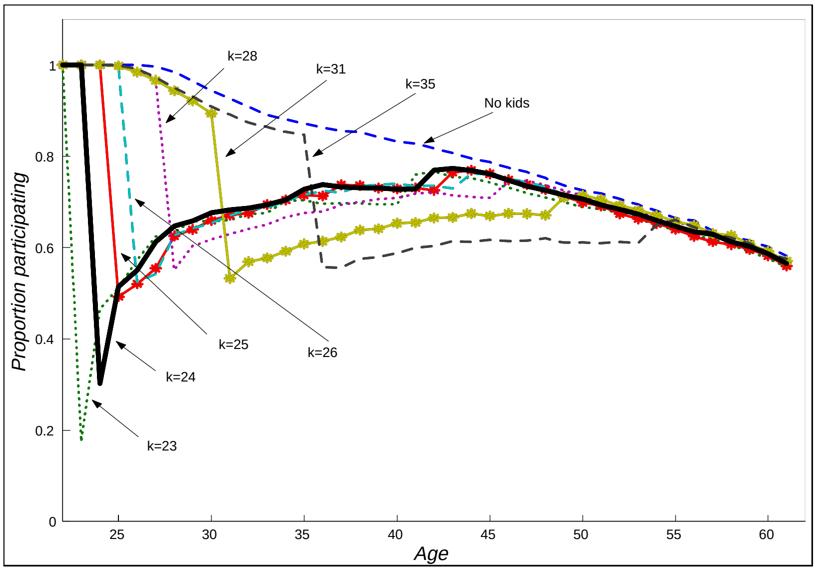

Figure 22: Participation Profiles varying maternity age (Unconstrained)

maternity age. Further, overall participation rates remain fairly constant as age at childbirth increases and the ratio of participation before to participation after motherhood decreases. This means that an exogenous change of the maternity age could explain the fewer exits observed in recent cohorts. This is itself partly due to the returns to experience in the model: once women have accumulated human capital, the incentive to leave the labor market are smaller because of the higher opportunity cost it has.[20]

However, median duration increases with age of childbirth. This is again due to a composition effect: as age of childbirth increases, the opportunity cost of exit increases. Women with the highest opportunity cost who previously exited for only a short period, no longer exit. For those that remain, their length of exit may be lower than previously but the composition effect means that median duration of exit increases.

[20]The delay of marriage due to the availability of the pill, argued by Goldin (2002), could imply an increase of women employment by itself, rather than via the mechanism of increasing education.

6 Implications and Conclusions

It is now time to take stock on the simulations performed in the previous section and discuss what can be learned from them in terms of explaining the differences in the behaviour of the Hillary Clinton and Oprah Winfrey cohorts that we discussed in Section 2. We simulate three main changes to important determinants of female labour supply. While we do not make an explicit attempt to match the size of these changes in actual data (partly because it is very hard to identify and measure these phenomena), our simulations serve the purpose of evaluating the relative merits of different possible explanations of the observed changes in female labour supply. In particular, having matched the behaviour of the Hillary Clinton cohort in our baseline simulations, we check how the life-cycle profile of female labour supply changes when we decrease the cost of child care relative to earnings, when we increase the returns to experience, and third, when we increase the depreciation rate of human capital when out of the labour market. In addition, we also simulate changes in husband earnings uncertainty and maternity age.

First, we observe that a relatively large decrease in child care costs would be needed to explain the increase in participation of mothers of young children from the observed 0.44 rate in the Clinton cohort to the observed 0.67 in the Winfrey cohort. We presented evidence showing that such changes in childcare costs have occured. However, in our baseline simulations, reducing child care costs increases median duration of non-participation for those who exit after childbirth. This is the opposite of what is observed in the data. If households face borrowing constraints, median durations do not increase as childcosts fall.

Second, while a sizeable increase in the returns to experience seems able to explain the increase in participation of mothers of young children,[21] we should stress some interpretation issues. The increase in participation seems to be more related to the wealth

[21] We need an increase of around 24% in the wage growth due to an extra year of participation.

effect implied by the increase in the return to experience than by the increased cost of being out of the labour force. As with child costs, the increase in participation leads to an increase in mean and median duration of exit for those who do move out of the labour market, and this, once again, is in contrast with what we observe. An increase in the return to experience changes both the opportunity cost of exit, but also the level of life-time earnings. Once we (counterfactually) control for the increase in life-time earnings, we do not observe the same reallocation of participation over the life-cycle. Indeed, the effect of increased returns to experience goes in the opposite direction, leading to a reduction in participation when children are very young. Further, in section 2 we cast some doubt on the size of the change in return to experience in the data. Finally, when we restrict the ability of households to borrow, changes in returns to experience do not have the impact on participation profiles we observe in the data.

Third, increases in depreciation rates can have a large effect on the opportunity cost of exit and we show evidence in section 2 that depreciation rates appear to have increased. However, somewhat surprisingly, these increases do not seem to have a significant effect on the participation decision. The impact of depreciation appears to be second-order. Only when the decision about participation is marginal do changes in depreciation have a large effect on participation.

From these three experiments, we conclude that reductions in the price of child-care (relative to earnings) can reproduce the observed changes in the participation statistics. Similarly, a large increase in returns to experience can induce the same changes, but changes in depreciation cannot. Behind these results the same determinants operate: for households making decisions in a life-cycle context where they are free to save or borrow the most important determinant of participation is the size of the fixed cost relative to the increase in lifetime earnings associated with participation. In this sense, both the reduced child-cost and the increased returns to experience have the same effect of reducing the ratio of the cost of participation to the increase in lifetime earnings associated with participation. Since the cost of reentry associated with higher depreciation can be spread over the remaining lifetime, the cost of non-participation is smaller in our model than if the impact was on consumption in the reentry period only.

When we restrict the ability of households to borrow, we remove part of their ability to exploit intertemporal incentives and this means that a particular change in a parameter has a smaller impact on the participation profile. This means that greater changes in the parameters are necessary to induce the observed changes in participation in cohort 3. In the case of returns to experience, we do not induce enough of an increase in participation to match the data within the (wide) parameter range considered.

We explored two further explanations of the change in participation which do not involve wealth effects in the same way. First, the observed increase in maternity age does increase participation and flatten the age-participation profile in the direction observed in the data. However, the magnitude of the simulated changes is much smaller than that observed in the data. Second, an increase in husband earnings uncertainty might explain an increase in participation of mothers of young children for precautionary reasons. In the simulations, we observe that increases in uncertainty do induce greater participation. There is a reallocation of participation towards the early stages of the life-cycle, leaving the average level of participation fairly constant. There is an increase in the duration of exit of those who still exit, since these are the women who receive very low wage shocks themselves. While this is conceptually interesting, it should be stressed that the increase in husband uncertainty necessary to flatten the age-participation profile is implausible.

We were unable, in any of our simulations with unconstrained borrowing and saving, to capture simultaneously the flattening of the age-participation profile and the decline in median duration of exits. Fewer women exit after childbirth, but those that do exit, in the simulations, spend longer out of the labour force. This is a composition effect: those that still exit may have reduced the duration of their exits, but the sample of those out of the labour force has changed. Perhaps surprisingly, in our simulations, this composition effect dominates the behavioural change that induces women to spend shorter time out of the labour force. Because of the prevalence of the composition effect, however, the simulations do not agree with the observed data. However, when we simulated individuals with borrowing constriants, median duration did not increase as we observed for unconstrained individuals. This suggests there is a stronger behavioural response reducing durations and this offsets the selection effect.

We discuss here two further possible explanations for the observed decline in median durations that deserve further investigation: first, we consider whether the *structure* of child-costs may have changed; second, we consider whether the depreciation rate may be non-constant.

Hotz and Miller (1988) estimate the time cost of child-care on data from the 1970s and we used their estimates in our calibration exercise. In the experiment in section 5, we varied the price of this child-care holding the time cost constant. To induce a reduction in median duration, we may change the shape of the G function in equation (4). In particular, it is possible to make the function more convex by increasing parameter ϕ in equation (3). This means that child-care costs initially fall more quickly with the age of the child, but then fall more slowly than in the baseline. Table 17 shows that this leads to an increase in female participation, particularly for mothers of small children and to a reduction in the median duration of exits, as in the data. In this case, we are making the intertemporal incentives to work more pronounced because of the change in child-costs with age of the child. Unfortunately, we have no evidence (one way or another) about changes in the shape of the G function.

Mincer and Olfek (1982) discuss the possibility that the depreciation rate may be non-constant. In particular, the rate of depreciation

Table 17: Varying Shape of Childcare Costs

ϕ	*Part*	*Part Kid*	*Ratio B/A*	Median Duration
0.89	**0.68**	**0.44**	**2.03**	**4**
0.78	0.78	0.81	1.23	3
0.76	0.79	0.81	1.22	2

The column *Part* reports the average participation rates of women across all ages. The column *Part Kid* reports participation rates of mothers is for mothers of children aged 3 or younger. The column *Ratio B/A* reports $\frac{\text{Participation Before Childbirth}}{\text{Participation After Childbirth}}$. Median duration is for all women who exit.

associated with a long spell of non-participation may be disproportionately large, whereas workers who return quickly face only small depreciation rates. While Mincer and Olfek (and in a different context Jacobson, LaLonde and Sullivan, 1993) find some evidence to support this suggestion, it is not clear that there has been any change in the way that the depreciation rate increases with length of exit, and it is not clear what the net impact would be on participation.

The results of this paper are very suggestive and open further lines of enquiry. Two important issues that we have ignored are the incentives to accumulate human capital and the possibility of working part time. Both these issues again, can be very important in the early part of the life cycle, where most of the action happens both in the data and in our simulations. It would therefore be worthwhile incorporating these issues in more realistic incarnations of the model. Finally, as we mentioned in the previous paragraph, it might be worth extending the model to consider depreciation rates that increase with the duration of the exit out of the labour market.

From an empirical point of view, it is important to gather additional evidence on the size of the changes in the various determinants of female labour supply, ranging from the cost of childcare, to the return to experience and depreciation. Unfortunately, as we discussed, it is difficult to disentangle the various effects especially for the determinants of wages. Selection issues and the difficulty of isolating cohort, time and age effects make the separate identification of depreciation and returns to experience particularly hard. Related to this difficulty are also the general equilibrium effects which cause changes in female labour supply to have important effects on wages.

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7 Appendix

7.1 Solution Method.

Households have a finite horizon and so the model is solved numerically by backward recursion from the terminal period. At each age we solve the value function and optimal policy rule, given the current state variables and the solution to the value function in the next period. This approach is standard. The complication in our model arises from the combination of a discrete choice (to participate or not) and a continuous choice (over saving). This combination means that the value function will not necessarily be concave. We briefly describe in this appendix how we deal with this potential non-concavity.

In addition to age, there are four state variables in this problem: the asset stock, the permanent component of earnings of the husband, ν_t^m, the permanent component of earnings of the wife, ν_t,and the experience level of the wife. We discretise both earnings variables and the experience level, leaving the asset stock as the only continuous state variable. Since both permanent components of earnings are non-stationary, we are able to approximate this by a stationary, discrete process only because of the finite horizon of the process. We select the nodes to match the paths of the mean shock and the unconditional variance over the life-cycle. In particular, the unconditional variance of the permanent component must increase linearly with age, with the slope given by the conditional variance of the permanent shock.

Value functions are increasing in assets A_t but they are not necessarily concave, even if we condition on labour market status in t. The non-concavity arises because of changes in labor market status in future periods: the slope of the value function is given by the marginal utility of consumption, but this is not monotonic in the asset stock because consumption can decline as assets increase and expected labour market status in future periods changes. By contrast, in Danforth (1979) employment is an abosrbing state and so the conditional value function will be concave. Under certainty, the number of kinks in the conditional value function is given by the number of periods of life remaining. If there is enough uncertainty, then changes in work status in the future will be smoothed out leaving the expected value function concave: whether or not an individual will work in $t+1$ at a given A_t depends on the realisation of shocks in $t+1$. Using uncertainty to avoid non-concavities is analogous to the use of lotteries elsewhere in the literature.

The choice of participation status in t is determined by the maximum of the conditional value functions in t. In our solution, we impose and check restrictions on this participation choice. In particular, we use the restriction that the participation decision switches only once as assets increase, conditional on permanent earnings and experience. When this restriction holds, it allows us to interpolate behaviour across the asset grid without losing our ability to determine participation status. We therefore define a reservation asset stock, R_t to separate the value function and the choice of consumption made when participating from the value function and choice of consumption made when not participating.

Solving for the reservation asset stock serves two purposes: one, it makes it easier in the solution to allow for the fixed cost in the budget constraint (rather than having an unconditional policy function with a discontinuity); two, it provides an additional check on our numerical solution: the reservation asset stock should be increasing in the wage rate. A sufficient condition for this to be unique is that the conditional value functions be concave. This is not true in general, as discussed above, but uniqueness can be achieved by having enough uncertainty to make the conditional expected value function concave. Even when the conditional value functions are not concave, however, we can have a unique reservation asset stock, particularly if individuals are impatient enough: impatience means that individuals prefer periods of non-participation to be earlier in the life-cycle and so avoids the indifference about the timing of leisure which generates the non-uniqueness.

In solving the maximisation problem at a given point in the state space, we use a simple golden search method. We solve the model and do the calibration assuming this process is appropriate and assuming there is a unique reseration asset stock for each point in the state space. We then check that the results in our baseline case are unaffected when we use a global optimising routine, simulated annealing, and we do not assume a unique reservation asset stock. It is worth stressing that there are parameter values for which the techniques we used do not work. In particular, the assumption of a unique reservation asset stock fails as the variance of shocks gets sufficiently low and if households have discount rates very close to the interest rate.

7.2 Labour supply and wages by education

In this appendix, we look at employment rates and wages by education to reinforce the findings in section 2. We divide married women into two groups, those with more than high school education and those who are at most high school graduates. Figures 23 and 24 show employment and full-time employment rates for women with low education. Figures 25 and 26 show the rates for women with high education. We observe that the increase of women's employment and full time employment rates is important for both educational groups and in both cases the most significant change is the flattening of the age - participation profile between ages 25 and 35.

Figures 28 and 27 reports median hourly wages for the two education groups we have considered above.

To complement the evidence on exits, durations and depreciation in section 2, we present results on each statistic within education groups. In Tables 18 and 19, we report the fraction of those working who exit at each age and the corresponding durations for the high and low educated. Fewer women exit at each age in cohort 3 than in cohort 2 for both education groups, and median durations of exit are shorter.

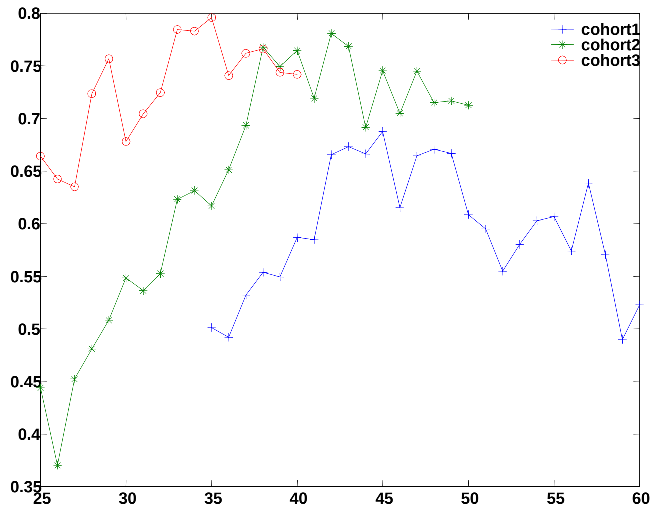

Figure 23: Employment Rate, Low Education

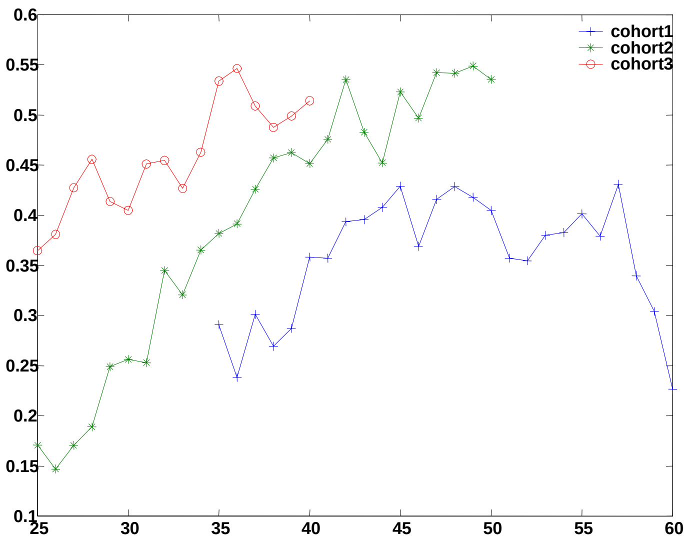

Figure 24: Full-Time Employment Rate, Low Education

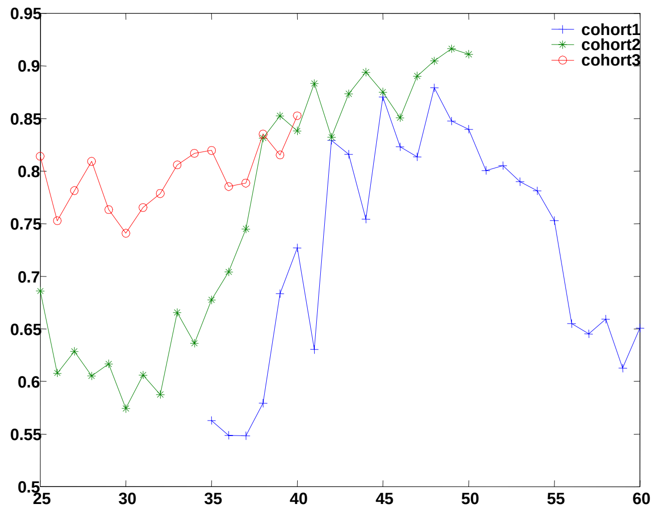

Figure 25: Employment Rate, High Education

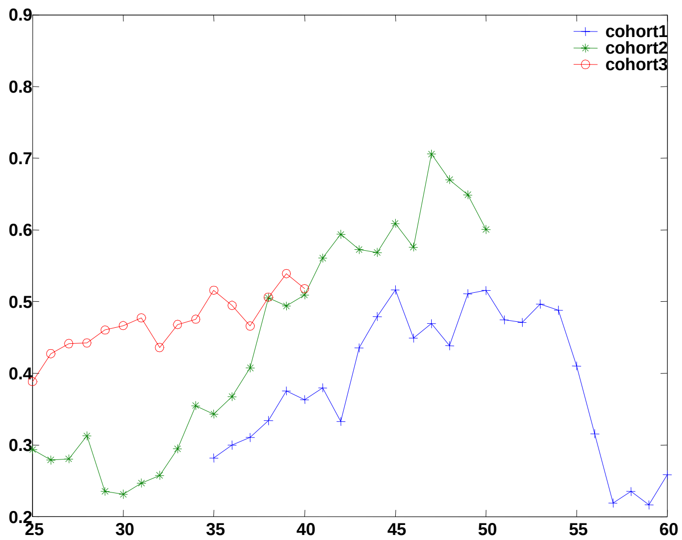

Figure 26: Full-Time Employment Rate, High Education

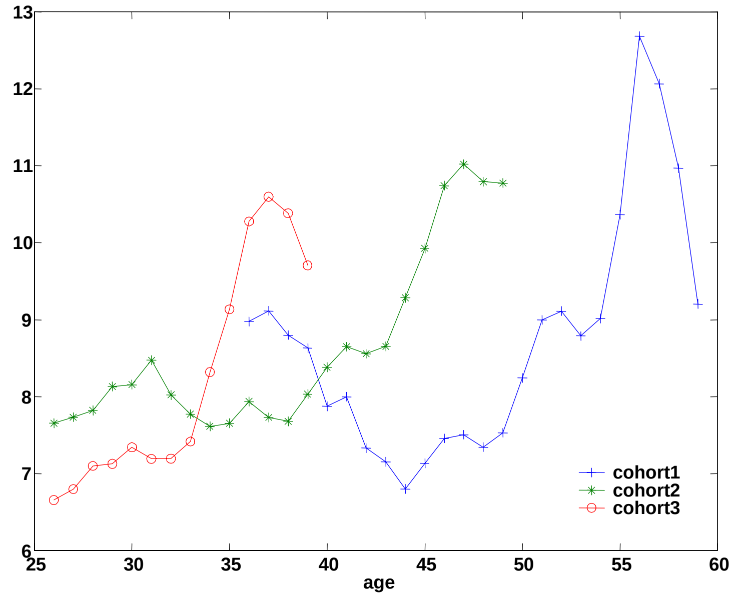

Figure 27: Median Hourly Wage, High Education

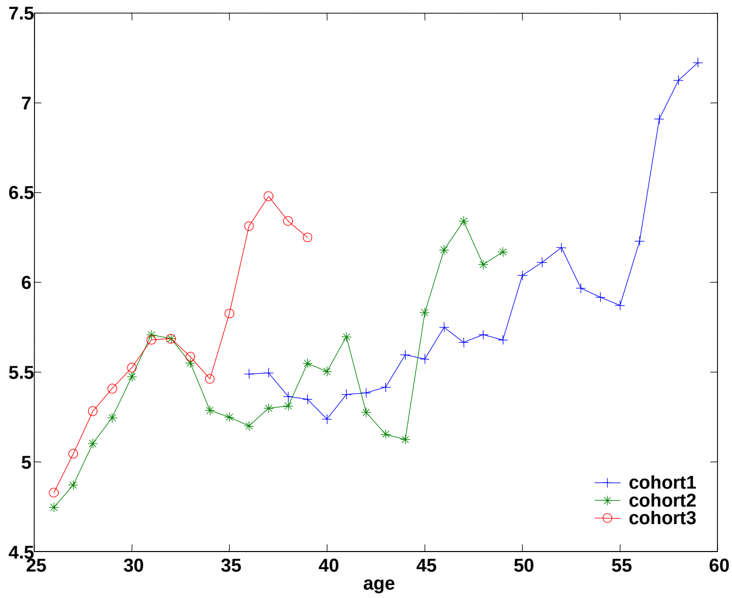

Figure 28: Median Hourly Wage, Low Education

Table 18: Exits and Durations for the Low educated

Age	*Cohort 2*				*Cohort 3*			
	Fraction of workers that exit	*Duration*			*Fraction of workers that exit*	*Duration*		
		All	*Reentering*			*All*	*Reentering*	
		Median	*Mean*	*Median*		*Median*	*Mean*	*Median*
26	0.32	3	3.0	2	0.18	1	2.6	1
27	0.18	3	3.2	2	0.16	2	1.9	1
28	0.15	3	4.5	2	0.07	1	1.0	1
29	0.15	6	3.8	1	0.06	5	2.5	1
30	0.18	10	3.3	2	0.19	33	1.6	2
31	0.17	7	3.2	2	0.12	2	1.9	2
32	0.15	2	1.6	2	0.12	31	3.8	4
All		3	3.2	2		2	2 .2	1

Table 19: Exits and Durations for the High Educated

Age	*Cohort 2*				*Cohort 3*			
	Fract	*Duration*			*Fract*	*Duration*		
		All	*Reentering*			*All*	*Reentering*	
		Median	*Mean*	*Median*		*Median*	*Mean*	*Median*
26	0. 22	3	2.8	2	0.15	2	2.3	1
27	0.14	4	2.8	2	0.09	1	1.8	1
28	0.14	7	5.0	7	0.07	5	4.9	3
29	0.16	3	1.0	2	0.12	2	1.8	1
30	0.20	3	3.4	3	0.10	2	1.7	2
31	0.11	4	3.5	2	0.08	1	3.1	1
32	0.16	5	3.5	4	0.08	4	1.5	1
All		4	3.6	2		2	2.3	1

Table 20: Wage Depreciation, Low Educated

	Cohort 2				*Cohort 3*			
Age	*W Bef*	*W Af*	*Median*	*# Obs*	*W Bef*	*W Af*	*Median*	*# Obs*
26	6.1	5.8	-0.06	26	4.7	5.4	-0.09	13
27	6.5	4.8	-0.08	16	4.3	3.4	0.12	19
28	7.5	5.6	0.03	8	7.3	6.4	0.27	3
29	5.3	4.7	0.09	7	8.0	6.8	0.24	4
30	4.4	4.6	-0.37	9	7.1	3.5	0.19	3
31	7.2	6.7	-0.18	5	4.1	1.6	0.16	5
32	5.2	6.0	-0.08	5	4.5	4.7	0.00	4
All	4.2	4.2	-0.04	74	4.6	4.4	0.09	52

Table 21: Wage Depreciation, high educated

	Cohort 2				*Cohort 3*			
Age	*W Bef*	*W Af*	*Median*	*Obs*	*W Bef*	*W Af*	*Median*	*Obs*
26	6.1	5.8	0.04	18	4.7	5.4	-0.12	10
27	6.5	4.8	0.25	8	4.3	3.4	0.28	11
28	7.5	5.6	0.05	8	7.3	6.4	0.19	6
29	5.3	4.7	0.05	9	8.0	6.8	0.06	11
30	4.4	4.6	0.00	9	7.1	3.5	0.36	9
31	7.2	6.7	0.03	4	4.1	1.6	-0.19	6
32	5.2	6.0	-0.05	7	4.5	4.7	-0.49	7
All	7.5	6.0	0.05	62	6.8	5.4	0.11	57

Table 22: **Number of observations at each age by Cohort**

Cohort 1		Cohort 2		Cohort 3	
Age	Obs	Age	Obs	Age	Obs
35	312	25	383	25	385
36	303	26	387	26	386
37	290	27	384	27	409
38	278	28	360	28	418
39	278	29	363	29	417
40	275	30	360	30	414
41	272	31	360	31	404
42	262	32	344	32	401
43	256	33	333	33	395
44	246	34	323	34	384
45	236	35	309	35	383
46	233	36	299	36	389
47	232	37	299	37	367
48	225	38	295	38	358
49	214	39	294	39	386
50	209	40	289	40	276
51	201	41	285		
52	191	42	284		
53	184	43	247		
54	175	44	268		
55	167	45	261		
56	167	46	255		
57	152	47	242		
58	149	48	223		
59	152	49	236		
60	105	50	170		