Female Labor Supply and Jobless Recovery

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October 20, 2019

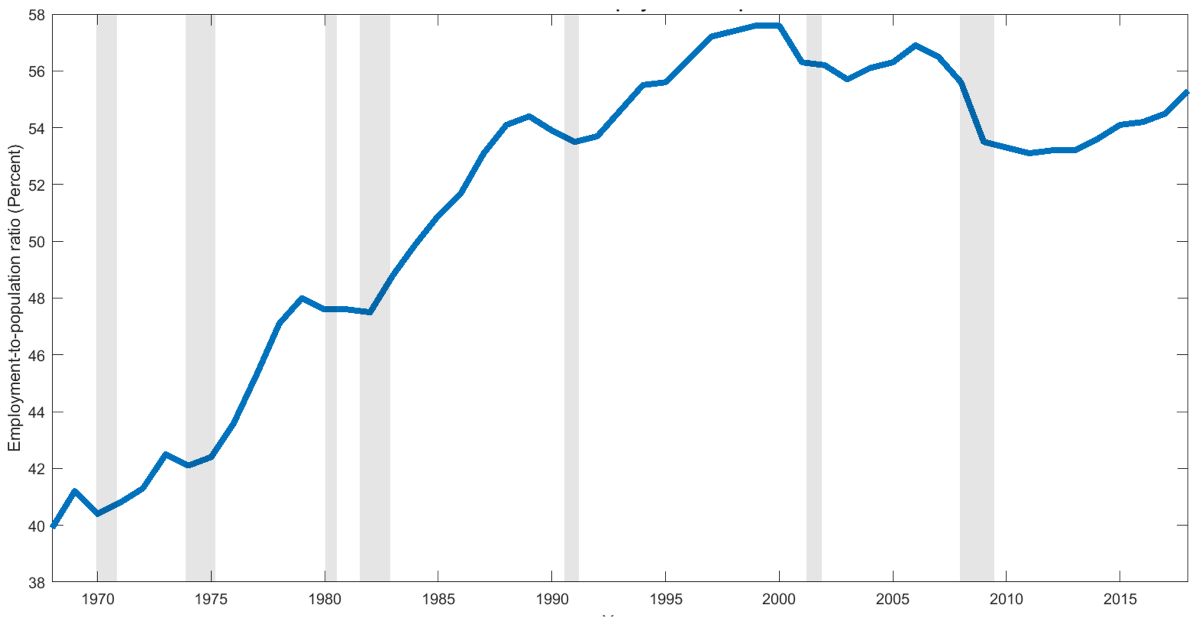
Abstract

*I would like to thank Julia K. Thomas, Aubhik Khan, Kyle Dempsey and Sanjay Chugh for their helpful comments which have significantly influenced this work. I am also grateful to Benjamin Lidofsky, Sayoudh Roy and Nupur Gupta for their help towards improving this paper.

1 Introduction

The demographic composition of the U.S. labor market has changed significantly over the past several decades, and one important aspect of this been a change in labor market participation among women. From the end of World War II until the late 1980s, female labor force participation rose steadily; since then, the trend has weakened and largely subsided. From around the same time as the leveling off in this series, starting in 1990, U.S. recessions have featured a jobless recovery phenomenon, wherein post-recession aggregate employment recovery is weak and lags the rebound in aggregate production. In this paper, I consider the connection between these two recent patterns, examining both empirically and through the lens of a general equilibrium macroeconomic model the extent to which the weakened secular trend in female labor supply may have contributed to jobless recoveries.

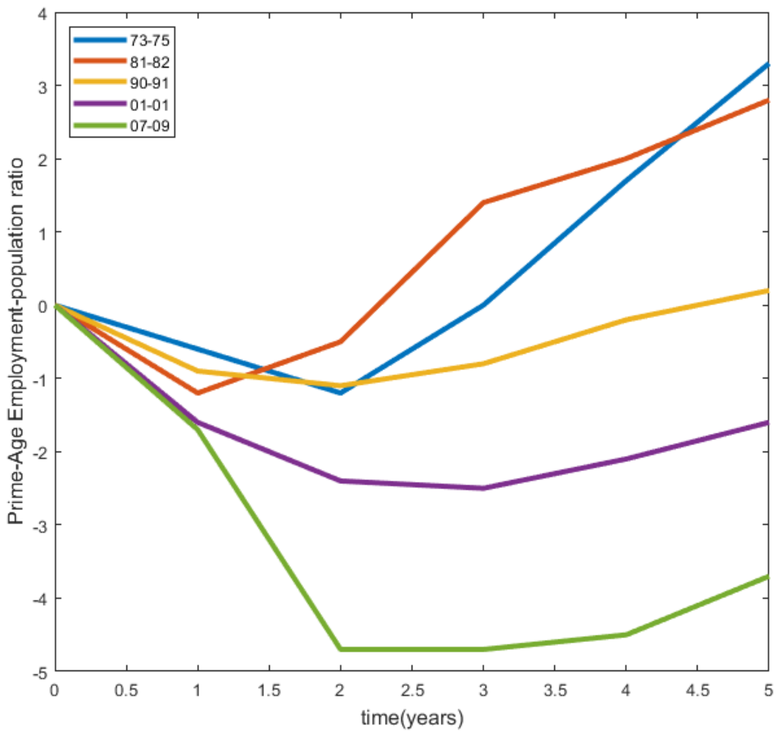
Figure 1: Secular trend in Female Employment-to-Population ratio



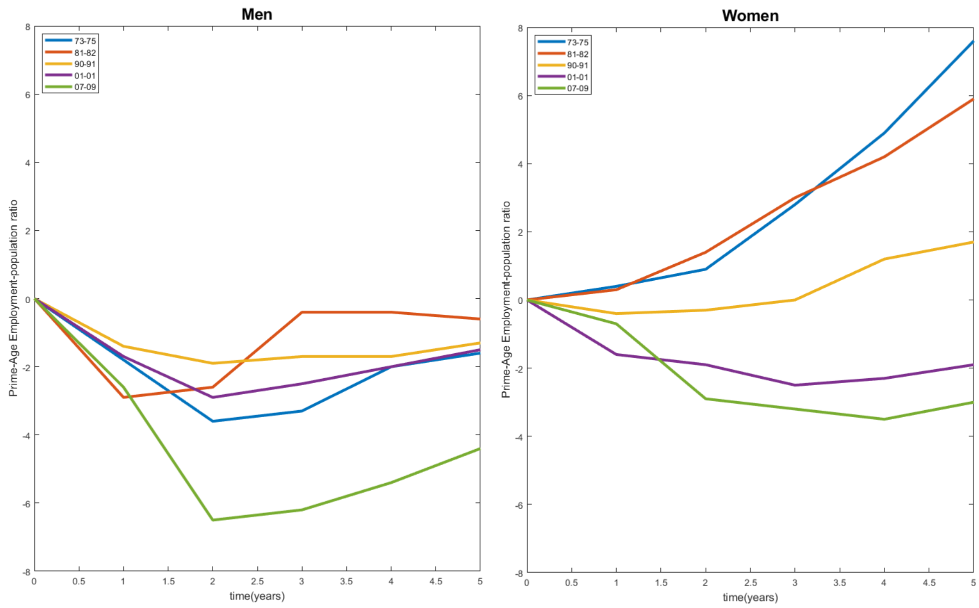
Notes: This series comes from the Current Population Survey (Household level) and has been retrieved from FRED, Federal Reserve Bank of St. Louis. This data is seasonally adjusted and aggregated at the annual level. The population comprises of all individuals above the age of 16.

Figure 1 graphs the evolution of the employment-to-population ratio for female workers in the U.S. There was a secular increase from 39.9% in 1968 to 54.4% in 1989; however, since then there has been a decline in the growth rate of the employment-to-population ratio. Figure 2 looks at recoveries in employment for the last 5 recessions. As is apparent

Figure 2: Slowing Recoveries for Prime-Age Workers



(a) All workers



(b) Male and Female workers

Notes: This figure graphs the employment-to-population of prime age workers (25-54) during the last 5 recessions and the subsequent recoveries. The x-axis measures time (in years) whereas the y-axis measures the employment to population ratio. I normalize each series to zero at the pre-recession peak. Each series is calculated by aggregating microdata from the March ASEC of the CPS.

from Panel (a), recoveries have slowed down for the recessions post 1990 as compared to the ones before. Next I decompose the series based on gender. Panel (b) shows that apart from the great recession of 2007-2009, recovery patterns have always been similar for men. However, for women, recoveries have significantly slowed down since the recession in 1990 and is qualitatively similar to the aggregate patterns observed.

Motivated by the observations above, I carry out an empirical investigation to establish whether the change in employment recovery patterns for women, and the absence of change for men, have been homogeneous across all subgroups of these two populations. In order to do that, I segregate the population based on age, marital status, gender, presence of children and education. I find that aggregate employment recoveries in the recessions prior to 1990 were predominantly driven by strong recoveries for young, married women with children. Each of these three characteristics appears important toward identifying the source of formerly robust, and now anemic, aggregate employment recoveries; for example, among young women with children, the changing recovery pattern noted above is more pronounced in the group who are married. Somewhat surprisingly, I find that education differences among women do not translate into significant differences in employment recovery patterns over the five recessions shown in Figure 2.

The findings from my empirical analysis inform the specification of a theoretical framework I next develop to gain insight into the possible links between the secular changes in female labor supply behavior and the advent of jobless recoveries. My model allows for persistent heterogeneity across households along the following five dimensions: age, marital status, gender, number of children and asset holdings. Each household faces marriage or divorce shocks conditional on their age and marital status, and each decides how much to save and how much labor each adult member will supply to the economy's firms. Conditional on having children, members also decide how much labor will be supplied at home to produce child care. My dynamic stochastic general equilibrium model is distinguished by an endogenously evolving distribution of households over asset holdings. That evolving distribution affects the lifetime utility ascribed to marriage for any single individual, which I will argue below is important to correctly evaluate the effectiveness of government policies designed to increase female labor market participation.

I run my model economy forward starting from an initial set of conditions reflecting the U.S. in 1968, and I examine its aggregate and subgroup employment changes at various points along the path from then until now, with particular attention to the interaction between female and male labor supply both at the household level and at the aggregate level. I next use my theoretical framework to decompose the relative contributions of several leading proposed causal factors underlying the labor supply changes described above. Jones, Manuelli and McGrattan (2015) and Heathcote, Storesletten and Violante (2017) argue that the narrowing of the gender wage gap was a major contributor to the dramatic increase in female labor force participation over years prior to 1990. Therefore, I allow for changes in the gender wage gap over time. We also know that there have been significant changes over the past five decades in marriage rates, divorce rates and the number of children that households have in the U.S. (Doepke and Tertilt, 2016). With this in mind, and given the evidence that family composition plays an important role in determining the labor supply of women[1], I also allow for time variation in these demographic rates.

This decomposition analysis allows me to identify the responsiveness of different sections of the population to each of these underlying factors. I find that narrowing of the gender wage gap is the largest contributor towards changes in labor supplied by married individuals, when comparing across steady states. However, when I examine the relative contribution of these underlying factors towards generating the secular trend in labor supply, I find that early on in the transition, it is actually the reduction in the number of young children for young, married women which is the most important factor. Since this is the period which showed a strong growth in female labor supply, I argue that one needs to consider the relationship between time spent towards child care and female labor supply while formulating policies aimed at improving aggregate employment.

Next, I examine the labor supply response of this model economy during recessions, which I generate using negative aggregate productivity shocks. I compare the results in

[1]See for example: Bloom et al(2009); Papps (2006)

the presence and absence of an upward trend in female labor supply. I find that recovery in aggregate employment is significantly slower in the absence of an upward trend, which confirms the hypothesis that the leveling off of the secular trend contributes towards the emergence of jobless recoveries which has been observed post recent recessions.

Finally, I use my theoretical framework to compare the effectiveness of alternative fiscal policies which are aimed at young, married women with children towards mitigating jobless recoveries. Specifically, I study the effects of countercyclical child care subsidy and countercyclical child care tax credit on different sections of the population. In this experiment, I allow households to choose between producing child care at home and buying it at the market at a subsidized rate. This subsidy is funded by taxes on wage and rental income as well as government spending.

To correctly assess the impact of any policy, it is important to have a general equilibrium framework, where the response of one section of the population will have implications for the rest of the population. When female labor supply increases in response to a policy, household income increases which increases consumption demand and savings. As a result, aggregate demand increases which in turn increases demand for aggregate labor. In my framework, since women switch from home-produced child care to market work, the offsetting effect that it has on the male labor supply within married households is not strong enough, as a result of which aggregate labor supply increases. In equilibrium, this results in an increase in aggregate labor. Further, increase in female labor supply may increase demand for market-provided child care. This can influence the price of child care which can in turn offset the effectiveness of a child care policy. Finally, the endogenous evolution of asset distribution for households allows me to examine policy effectiveness through future marriages in the following way. Suppose, a child care policy is implemented which aims to increase labor supplied by single mother households . This will affect the asset distribution over all single female households. This may affect the labor supply choices of single male households since their lifetime utility from future marriages improve. This may accentuate or offset the effectiveness of a child care policy towards increasing aggregate labor supply.

My paper is related to two broad strands of the literature: one, which investigates jobless recoveries and the other which examines secular changes in female labor supply. There have been several explanations that have been proposed to explain jobless recoveries. These include theories of generous unemployment insurance extensions (Mitman and Rabinovich, 2014), structural change (Jaimovich and Siu, 2012), wage rigidities (Shimer, 2012), access to credit (Herkenhoff, 2017). This paper provides an alternative explanation. Further this paper is also related to the large literature that discusses several competing theories towards explaining the secular trend in female employment. Some of the explanations that have been offered include narrowing of the gender gap (Jones, Manuelli and McGrattan, 2015; Heathcote, Storesletten and Violante, 2017) improvements in household technology (Greenwood, Sheshadri and Yorokoglu, 2005), medical progress which favor female health (Albanesi and Olivetti, 2016; Goldin and Katz, 2002), cultural changes (Fernandez, Fogli and Olivetti, 2004), rise of the service sector (Ngai and Petrongolo, 2017). I use my framework to understand the relative importance of several competing factors. I further highlight that only steady state comparisons may provide incomplete information regarding the importance of these factors; it is important to explicitly study their relative contribution along the transition.

This paper is motivated by the works of Albanesi (2019) and Fukui, Nakamura and Steinsson (2019). Both these papers discuss the changes in female labor market outcomes and their role in jobless recoveries. In my paper, I also take into account the heterogeneous labor supply responses to aggregate conditions by subgroups of the population, which as I show differ by age, marital status and presence of children. I argue that it is important for the quantitative results because the underlying factors that lead to this change will have a differential effect on each of these subgroups. Olsson (2019) discusses heterogeneity in labor supply responses of households which differ by marital status, and highlights its relevance in studying the changes in employment recoveries. However, my paper is the first that emphasizes the importance of accounting for children when studying the effect of a secular change in female labor supply on jobless recoveries. Further, based on my findings, I discuss the effectiveness of cyclical policies involving child care which are aimed at improving aggregate labor supply.

The paper is organized as follows. Section 2 examines the data and provides empirical evidence towards highlighting the dimensions of household heterogeneity that matter for jobless recovery. Section 3 describes the theoretical framework, the specification of which is informed by the findings in Section 2. Section 4 discusses the model solution and justifies the parameter choices made. Section 5 explains the key results. Section 6 discusses policy experiments and Section 7 concludes.

2 Empirical Evidence

2.1 Data Description and Sample Selection

In this paper, I use the Annual Social and Economic Supplement (ASEC) of the Current Population Survey (CPS) as available through the Integrated Public Use Microdata Series[2]. The CPS is administered jointly by the U.S. Census Bureau and the U.S. Bureau of Labor Statistics at both the household as well as individual level and is considered to be the primary source of official labor force statistics for the U.S. government.

For my analysis, I consider individual-level observations pertaining to the working-age population (that is, aged 16-65). I drop those who reside in institutionalized quarters such as prisons and psychiatric wards, or are in the armed forces. I then proceed to calculate the employment-to-population ratios for subgroups of the population which vary by gender, age, marital status, presence of children and education. The goal is to identify how these subgroups' recoveries from recessions changed over the past 50 years. In particular the recessions considered are 1973-1975, 1981-1982, 1990-1991, 2001-2001 and 2007-2009 (as defined by the NBER). I count individuals as employed if they either reported to have worked for pay or for profit, or worked for at least fifteen hours in a family business or farm in the preceding week. Those who reported to be temporarily absent from work due to illness, vacation, bad weather or a labor dispute are also considered to

[2]Sarah Flood, Miriam King, Renae Rodgers, Steven Ruggles and J. Robert Warren. Integrated Public Use Microdata Series, Current Population Survey: Version 6.0 [dataset]. Minneapolis, MN: IPUMS, 2018. https://doi.org/10.18128/D030.V6.0

be employed.

2.2 Decomposition Analysis

In this section, I discuss the patterns observed from my empirical analysis when the population is divided by age, presence of children, marital status and education.

2.2.1 Age

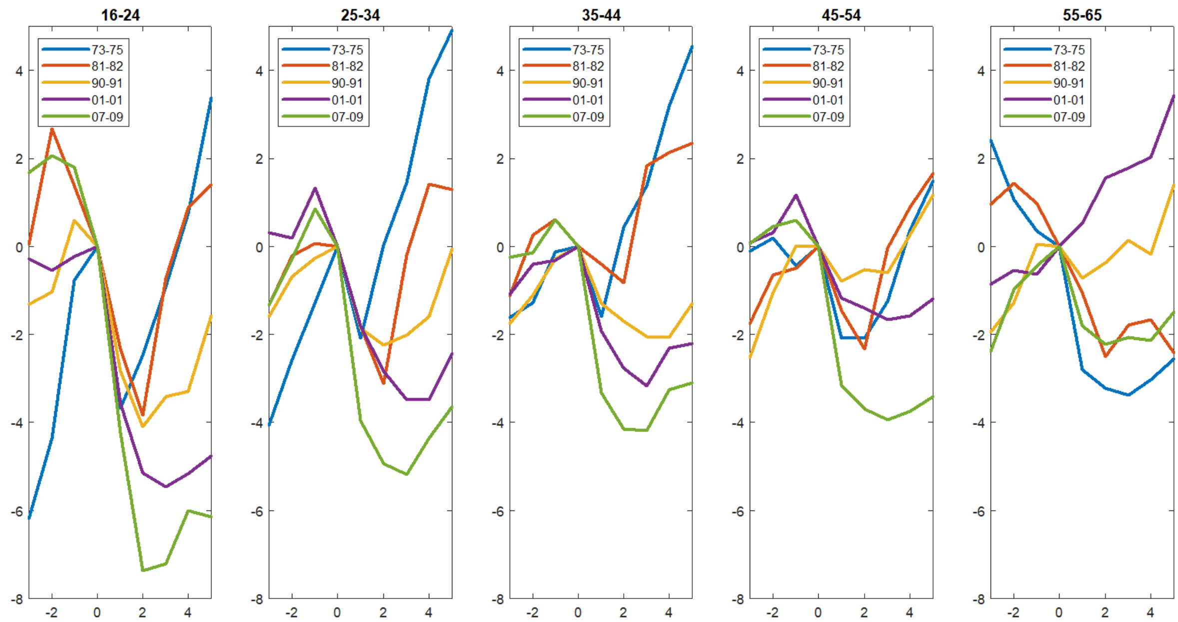
To analyze changes in employment recovery patterns for different age groups, I divide the population into 5 age bins: 16-24, 25-34, 35-44, 45-54, 55-65. Panel (a) in Figure 3 displays deviations in the average employment-to-population ratio from the pre-recession business cycle peak for each of these subgroups. I find that the recovery patterns did not change much for the older cohorts. In contrast, for those aged less than 44, the recoveries were significantly faster in the recessions before 1990. Panel (b) reports the results of the analysis when I further subdivide the population in each age group by gender. I find that the aggregate patterns are driven by the younger female cohorts, whereas the younger male cohorts have always displayed slow recoveries. Further, recovery patterns look similar for both genders among older cohorts and have not changed significantly across the recessions.

In order to test whether age is a proxy for time of marriage, I conduct the same analysis but restrict the population to include only married individuals. The results shown in Figure 4 are very similar to those in Figure 3 suggests that the differences across age groups are independent of martial status.

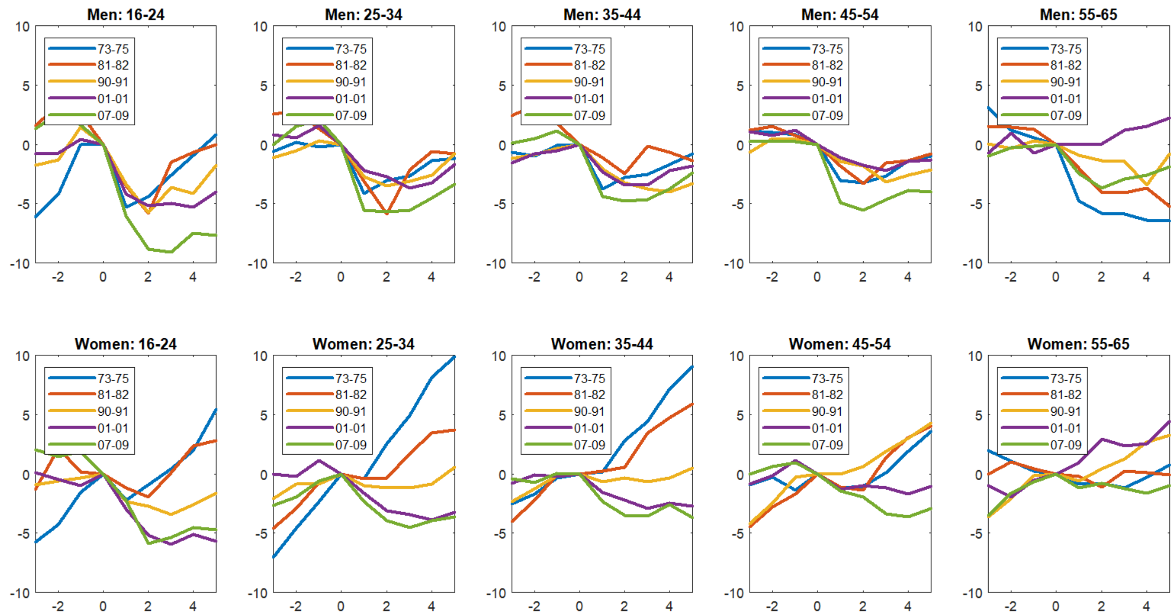
2.2.2 Children

Since the recovery patterns have primarily changed for younger women, I proceed to test whether the presence of young children helps to explain the jobless recoveries that we see since the 1990s. The CPS reports the number of young children aged less than 5 which live in the same household as the parent. Figure 5 shows results of the married population now divided by the presence of young children. I find that households with children had

Figure 3: Slowing recoveries for workers of different Ages



(a) All workers

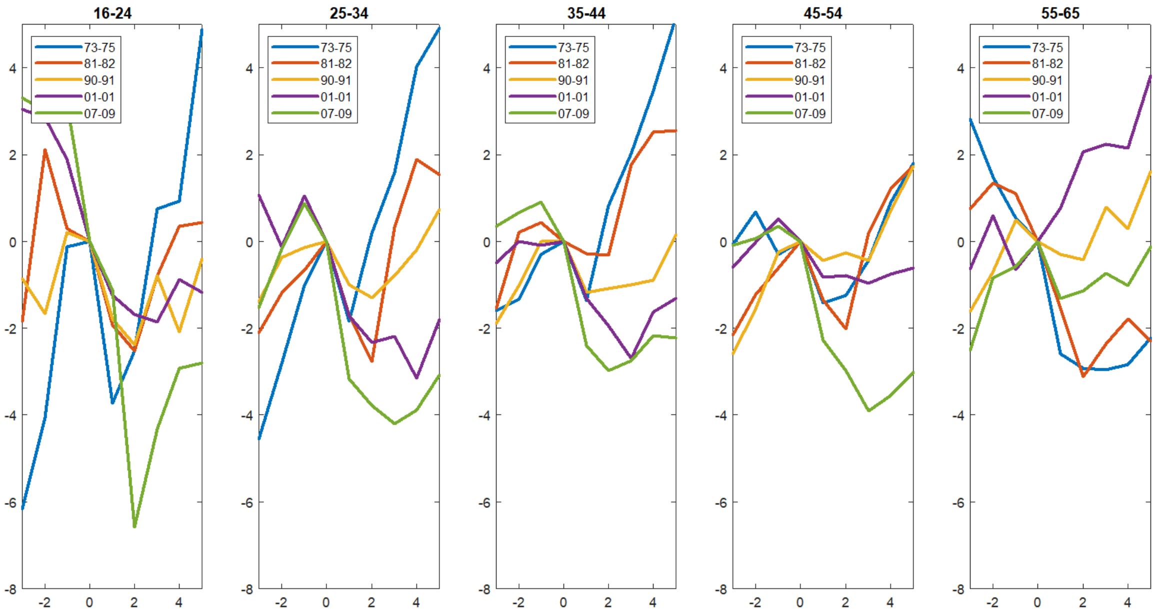


(b) Men and Women workers

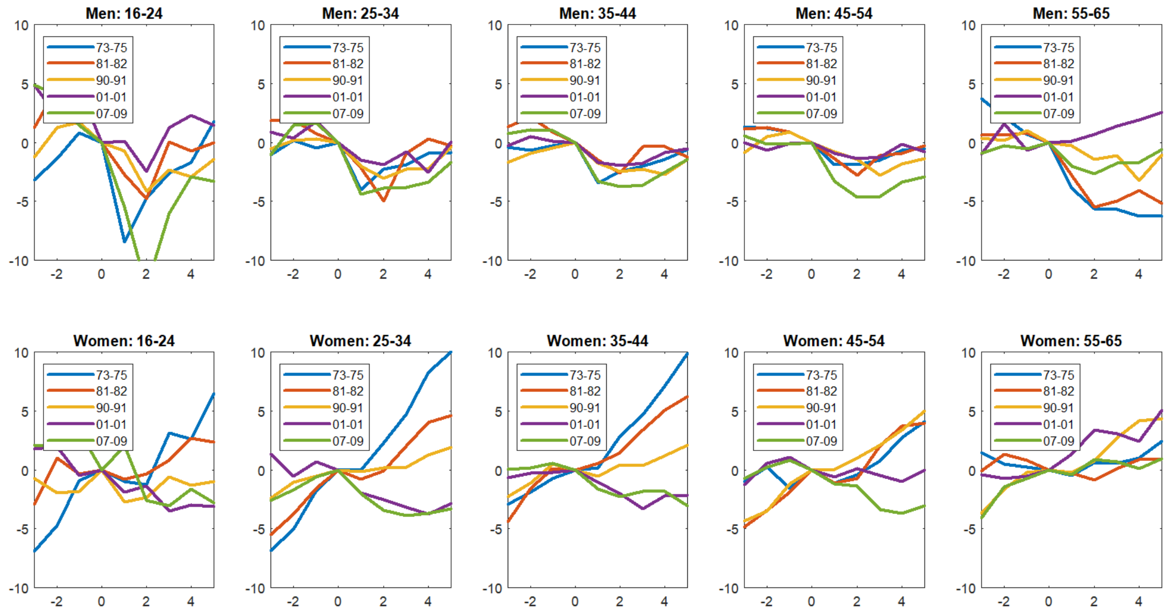
Notes: This figure graphs the employment-to-population of workers divided into 5 age categories (16-24, 25-34, 35-44, 45-54, 55-65) during the last 5 recessions and the subsequent recoveries. The x-axis measures time (in years) whereas the y-axis measures the employment to population ratio. I normalize each series to zero at the pre-recession peak. Each series is calculated by aggregating microdata from the March ASEC of the CPS.

slower recoveries from recessions after 1990. Again, when divided by gender, the slowdown in recoveries is driven by the female population, particularly those with children whereas

Figure 4: Recoveries for *married* workers of different Ages



(a) All workers

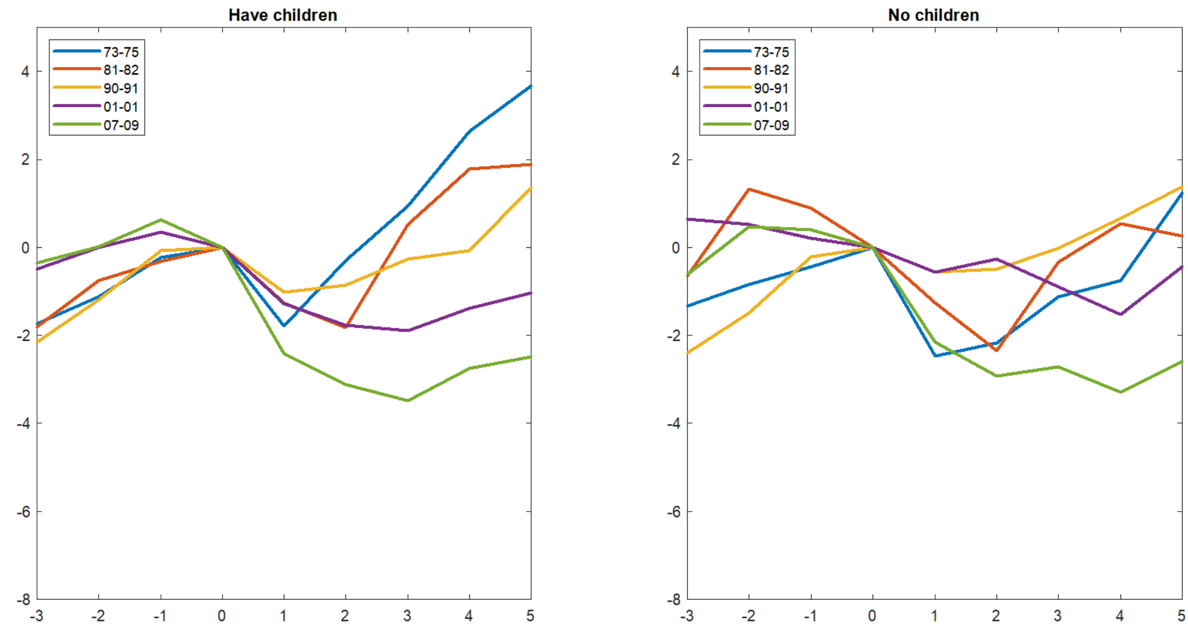


(b) Men and Women workers

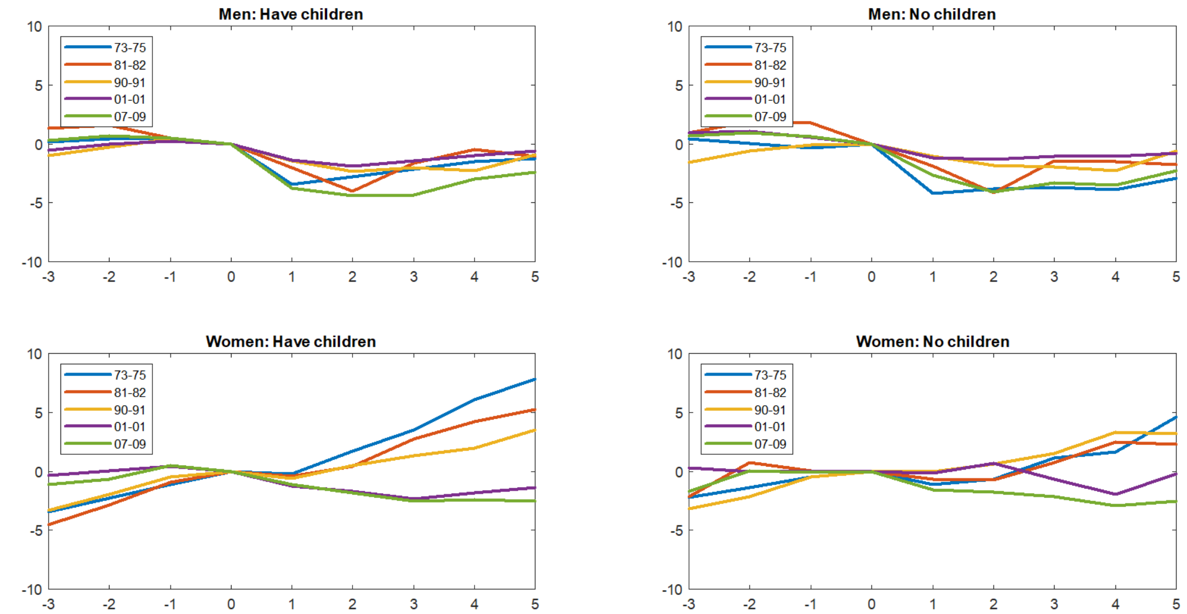
Notes: This figure graphs the employment-to-population of workers divided into 5 age categories (16-24, 25-34, 35-44, 45-54, 55-65) during the last 5 recessions and the subsequent recoveries. The x-axis measures time (in years) whereas the y-axis measures the employment to population ratio. I normalize each series to zero at the pre-recession peak. Each series is calculated by aggregating microdata from the March ASEC of the CPS.

the recovery patterns for men have always been similar.

Figure 5: Recoveries for *married* workers differing by presence of *children*



(a) All workers



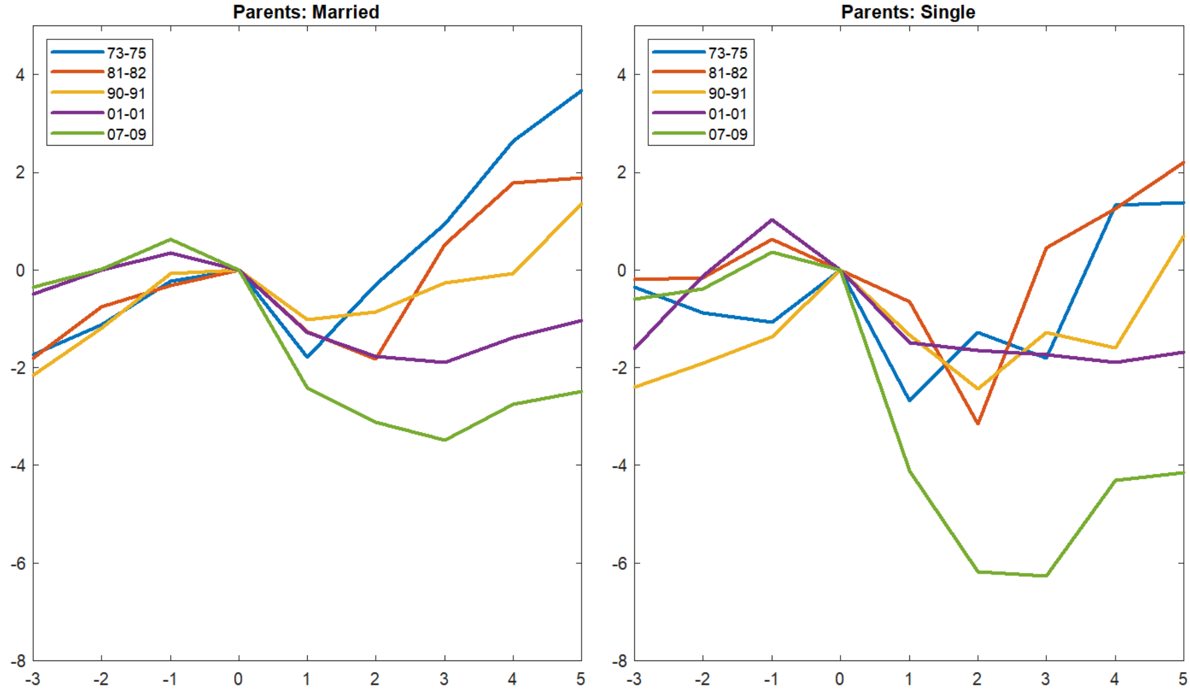
(b) Men and Women workers

Notes: This figure graphs the employment-to-population of married workers divided into 2 groups based on the presence of children during the last 5 recessions and the subsequent recoveries. The x-axis measures time (in years) whereas the y-axis measures the employment to population ratio. I normalize each series to zero at the pre-recession peak. Each series is calculated by aggregating microdata from the March ASEC of the CPS.

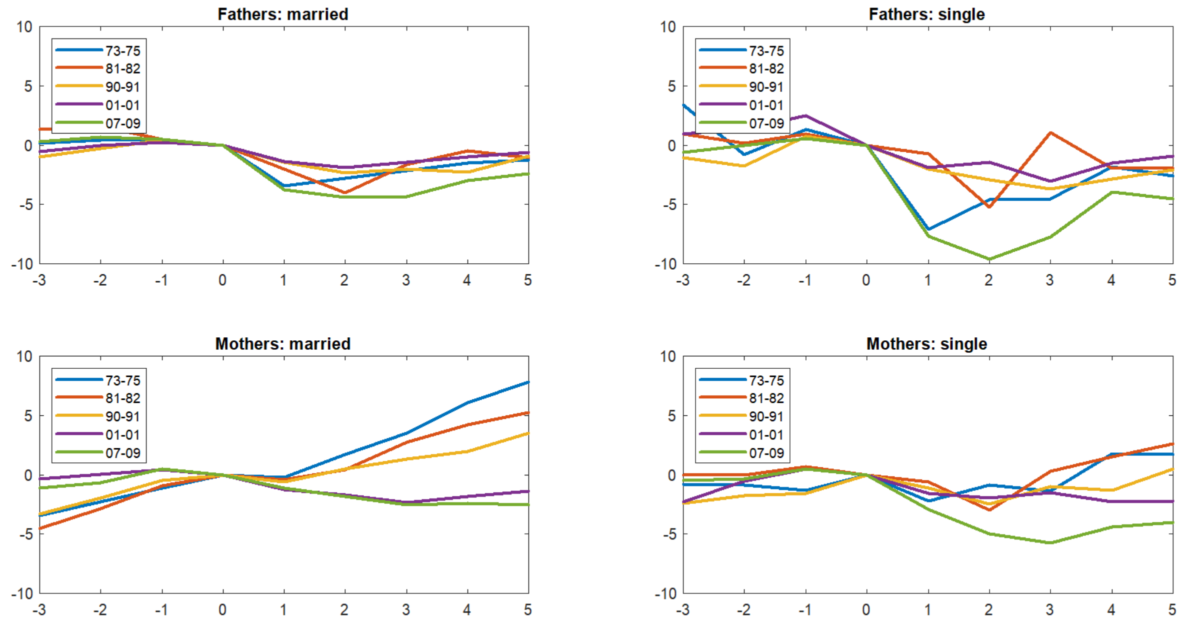
2.2.3 Interaction of Children and Marital status

The previous section tested whether the trends among married individuals vary by the presence of children. Here, I test whether the trends among individuals with children

Figure 6: Recoveries for workers with children differing by *marital status*



(a) All workers



(b) Men and Women workers

Notes: This figure graphs the employment-to-population of workers with children divided into 2 groups based on their marital status during the last 5 recessions and the subsequent recoveries. I assume that singles include all those who are divorced, widowed or never married. The x-axis measures time (in years) whereas the y-axis measures the employment to population ratio. I normalize each series to zero at the pre-recession peak. Each series is calculated by aggregating microdata from the March ASEC of the CPS.

vary by marital status. In this case, single households consist of all individuals who are divorced, separated, widowed or never married. Figure 6 displays the results. I find that although single households with children have also undergone changes in their recovery patterns over the last recessions, the changes are starker for those who are married. This indicates that marriage is also relevant for the jobless recoveries.

2.2.4 Education

I conduct my last decomposition based on education levels. In particular, I divide the population into 4 groups: less than a high school (HS) degree, just a HS degree, some college education and those with at least a college degree. Figure 7 shows the employment to population ratios for the different education groups. I find that although the changes have been starker for those with a HS degree and some college experience, recoveries in employment have become weaker over time for all these groups. Hence I conclude that education differences do not drive changes in the recovery patterns.

Thus, to summarize the findings from this section, the changing recovery pattern is more pronounced among young women with children, particularly those who are married. Educational differences do not translate into significant differences in recovery patterns over the five recessions.

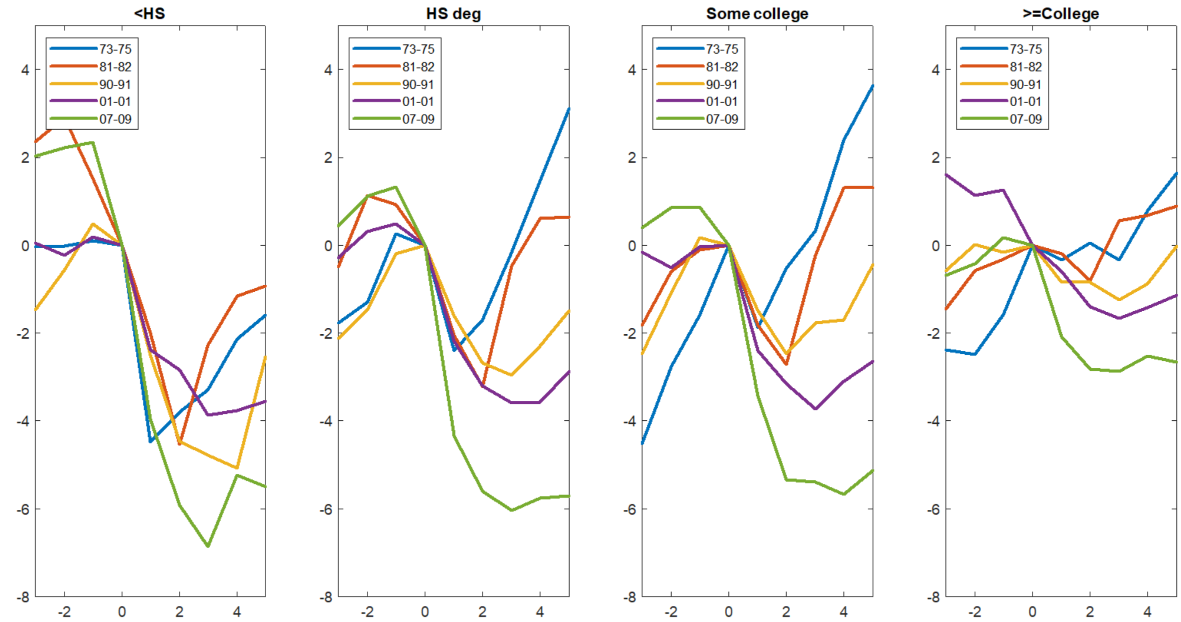
3 Model

3.1 Overview

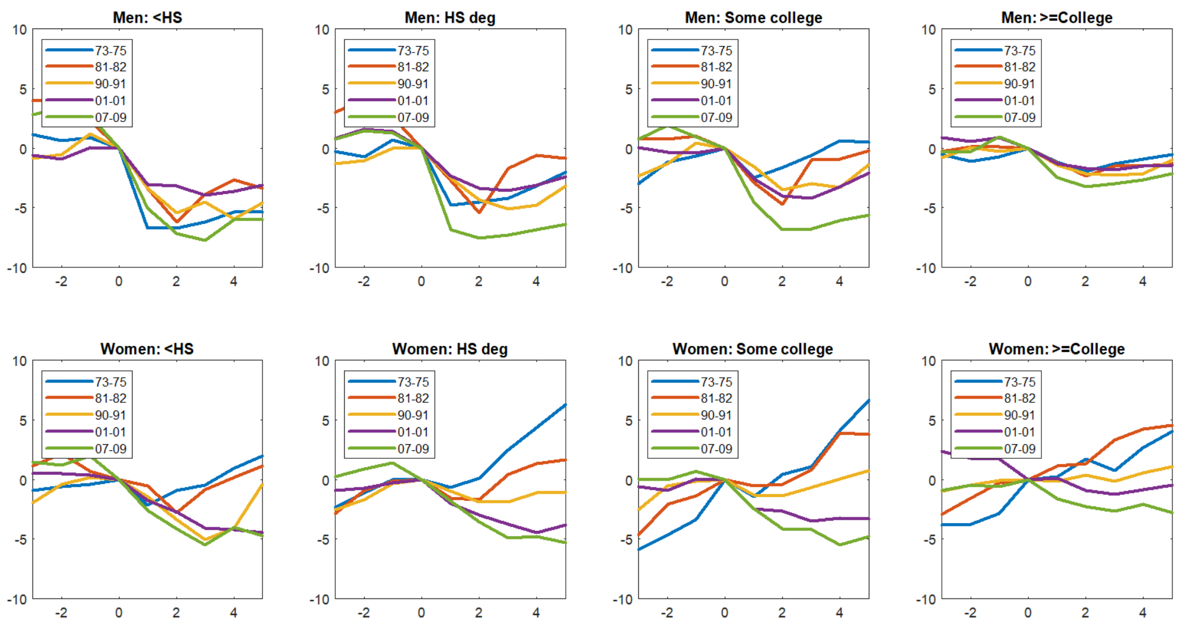
The economy is populated by agents who are heterogenous along the following dimensions: gender ($g = \{m, f\}$), age (j), marital status (single, s or partnered, p) and assets (k). The number of children that a household has depends on the age, gender and marital status of the household. I assume there are a unit measure of both men and of women.

The model period is one year long. Agents live for J periods and discount the future at the rate of β. In every period, both single and partnered households decide how much to save, how much to work in the market and how much to work at home. Households

Figure 7: Recoveries for workers differing by *education level*



(a) All workers



(b) Men and Women workers

Notes: This figure graphs the employment-to-population of workers which are divided into 4 categories based on their education levels (<HS, with HS degree, some college, $\geq$ college degree) during the last 5 recessions and the subsequent recoveries. I assume that singles include all those who are divorced, widowed or never married. The x-axis measures time (in years) whereas the y-axis measures the employment to population ratio. I normalize each series to zero at the pre-recession peak. Each series is calculated by aggregating microdata from the March ASEC of the CPS.

face gender-specific market wages $w_t(g)$ and rental rate r_t. There is a home production technology that uses the time spent at home as an input and produces a good that gives utility to households. This can be interpreted as home-produced child care that cannot be outsourced. Partnered households face age-specific divorce shocks, whereas single households face age-specific marriage shocks.

There is a representative firm which employs labor and uses capital for production. Wages and rental rates are determined in equilibrium. Female wages are subject to an exogenous discrimination tax which gives rise to a gender wage gap.

3.2 Single Households

At each time period, t, single households of gender g, with assets k and age j have a time endowment of 1 and face gender specific market wages $w_t(g)$ and rental rate r_t. Agents choose own consumption c, savings k', labor to be supplied to the market n and labor to be supplied at home, n^h. Expenditures are subject to their budget constraint, which is the sum of their labor income, $w_t(g)n$, and asset income, $(1 + r_t)k$. Agents are not allowed to borrow ($k' \geq 0$).

A home production technology converts the time spent at home to produce child care c^h. Agents derive utility from own consumption, child care production and own leisure, which is equal to $1-n-n^h$. Utility from child care production is subject to an equivalence scale $\chi^h_{s,t}$ which depends on the number of children at home. I assume that $\chi^h_{s,t}$ varies with age and gender.

At the beginning of the next period, singles face an exogenous age-specific probability of marriage, which is denoted by $p_{t+1}(j + 1)$. Conditional on receiving a marriage shock, the probability of getting matched to a single of the opposite gender, $\tilde{g}$, with next period assets equal to $\tilde{k}'$ is given by $\theta_{t+1}(\tilde{g}, \tilde{k}', j + 1)$ which is determined in equilibrium and is described by equation (12) later. For simplicity, I assume that agents get matched to other agents of the same age only. Agents maximize their lifetime utility as a single, $V_{s,t}$, which is defined below:

$$
\begin{aligned}
V_{s,t}(g,k,j) =& max_{\Omega_{s,t}} U(c, \frac{c^h}{\chi^h_{s,t}(g,j)}, 1-n-n^h) \\
&+ \mathbb{1}_{j<J}\beta\Big\{p_{t+1}(j+1)\int_{\tilde{k}'}\theta_{t+1}(\tilde{g},\tilde{k}',j+1)\hat{V}_{p,t+1}(g,k'+\tilde{k}',j+1)d\tilde{k}' \\
&+ \{1-p_{t+1}(j+1)\}V_{s,t+1}(g,k',j+1)\Big\} \qquad (1)
\end{aligned}
$$

subject to:

$$
\begin{aligned}
c + k' &\le w_t(g)n + (1+r_t)k \qquad (2) \\
c^h &\le A^h_t(n^h)^{\psi} \qquad (3) \\
c \ge 0; k' \ge 0; n, n^h &\in [0,1]; n+n^h \in [0,1] \qquad (4) \\
\Omega_{s,t} &= \{c, n, n^h, k'\}; k' = h_{s,t}(g,k,j)
\end{aligned}
$$

where $\hat{V}_{p,t+1}(g,k'+\tilde{k}',j+1)$ refers to the lifetime utility of the agent if married to an individual with next period assets equal to $\tilde{k}'$ and is defined by equation $(9-10)$ later.

Here equation (3) describes the technology of home production. I assume decreasing returns to scale ($\psi < 1$). A^h_t is the parameter that governs technological progress in home production.

The optimal policy rules for the problem described by equations $(1-4)$ are given by $\Omega^*_{s,t} = \{c^*_{s,t}(g,k,j), n^*_{s,t}(g,k,j), {n^h}^*_{s,t}(g,k,j), h^*_{s,t}(g,k,j)\}$

3.3 Partnered Households

At each time period, t, partnered households with household assets k and age j consist of 1 male and 1 female who are of working-age. Each individual has a time endowment of 1 unit. Agents choose joint household consumption c, which is subject to an equivalence scale parameter given by χ, savings k', labor to be supplied to the market by each individual n_m, n_f and labor to be supplied at home by the female, n^h_f. Expenditures are subject to their budget constraint, which is the sum of their labor income, $w_{m,t}n_m + w_{f,t}n_f$, and asset income, $(1+r_t)k$. Agents are not allowed to borrow ($k' \ge 0$).

A home production technology converts the time spent at home by the female to produce child care c^h. I assume that married men do not devote time at home towards child care production. This is an extreme assumption. However there is evidence that married women relative to married men spend a significantly larger fraction of their time towards home production (Ramey, 2009).

Each individual derives utility from joint consumption, child care production and own leisure, which is equal to $1-n_m$ for men and $1-n_f-n_f^h$ for females. Child care production is subject to an equivalence scale $\chi^h_{p,t}$, which depends on the number of children at home. I assume that $\chi^h_{p,t}$ varies with the age of the household.

At the beginning of the next period, partnered households face exogenous age-specific probabilities of divorce, which is denoted by $d_{t+1}(j+1)$. In the event of divorce, I assume that their is an equal division of household assets between the individuals. The household maximizes the sum of individual lifetime utilities weighted by fixed shares, ζ_m and $\zeta_f = 1-\zeta_m$, represented by $V_{p,t}$ as described below:

$$\begin{aligned} V_{p,t}(k,j) =& max_{\Omega_{p,t}} \zeta_m U\Big(\frac{c}{\chi}, \frac{c^h}{\chi^h_{p,t}(j)}, 1-n_m\Big) + \zeta_f U\Big(\frac{c}{\chi}, \frac{c^h}{\chi^h_{p,t}(j)}, 1-n_f-n_f^h\Big) \\ & + \mathbb{1}_{j<J}\beta\Big\{d_{t+1}(j+1)\{\zeta_m V_{s,t+1}(m, \frac{k'}{2}, j+1) + \zeta_f V_{s,t+1}(f, \frac{k'}{2}, j+1)\} \\ & + \{1-d_{t+1}(j+1)\}V_{p,t+1}(k', j+1)\Big\} \end{aligned} \tag{5}$$

subject to:

$$c + k' \leq w_t(m)n_m + w_t(f)n_f + (1+r_t)k \tag{6}$$

$$c^h \leq A^h_t(n^h_f)^\psi \tag{7}$$

$$c_{p,t} \geq 0; k' \geq 0; n_m, n_f, n^h_f \in [0,1]; n_f + n^h_f \in [0,1] \tag{8}$$

$$\Omega_{p,t} = \{c, n_m, n_f, n^h_f, k'\}; k' = h_{p,t}(k,j)$$

The optimal policy rules for the problem described by equations $(5 - \textbf{??})$ is given by $\Omega^*_{p,t} = \{c^*_{p,t}(k,j), n^*_{p,m,t}(k,j), n^*_{p,f,t}(k,j), {n^h}^*_{p,f,t}(k,j), h^*_{p,t}(k,j)\}$.

The lifetime utility of a female and a male in a marriage is described below respectively:

$$\hat{V}_{p,t}(f,k,j) = U\Big(\frac{c^*_{p,t}}{\chi}, \frac{c^{h*}_{p,t}}{\chi^h_{p,t}}, 1 - n^*_{p,f,t} - {n^h}^*_{p,f,t}\Big) + \mathbb{1}_{j<J}\beta\Big\{d_{t+1}(j+1)V_{s,t+1}\Big(f, \frac{k'^*}{2}, j+1\Big)$$
$$+ \{1 - d_{t+1}(j+1)\}\hat{V}_{p,t}(f, k'^*, j+1)\Big\} \quad (9)$$
$$\hat{V}_{p,t}(m,k,j) = U\Big(\frac{c^*_{p,t}}{\chi}, \frac{c^{h*}_{p,t}}{\chi^h_{p,t}}, 1 - n^*_{p,m,t}\Big) + \mathbb{1}_{j<J}\beta\Big\{d_{t+1}(j+1)V_{s,t+1}(m, \frac{k'^*}{2}, j+1)$$
$$+ \{1 - d_{t+1}(j+1)\}\hat{V}_{p,t}\Big(m, k'^*, j+1\Big)\Big\} \quad (10)$$

3.4 Firms

There is a representative firm in the economy which at every period t, rents capital K_t, at the rental rate r_t, and hires labor N_t at the wage rate, w_t to produce output Y_t according to the technology $Y_t = A_t K_t^{\alpha} N_t^{1-\alpha}$. Here A_t is the total factor productivity and α is the capital share of output. I assume male and female labor, $N_{m,t}$ and $N_{f,t}$ respectively, to be perfect substitutes, such that $N_t = N_{m,t} + N_{f,t}$. I assume that the female wages are subject to a discrimination tax, $\Delta_t \in (0,1)$, such that $w_f = \Delta_t w_{m,t} = \Delta_t w_t$. Thus the gender wage gap, which is defined as the ratio of female wage to male wage is represented by Δ_t. For completeness I assume that government spending, $G_t = \Delta_t w_t N_{f,t}$

Given w_t and r_t, the firm chooses its optimal factor demand to maximize its total profits. The firm's problem is given by:

$$max_{K_t,N_t} A_t K_t^{\alpha} N_t^{1-\alpha} - w_t N_t - (r_t + \delta)K_t. \quad (11)$$

where δ is the depreciation rate.

3.5 Distribution of households

Let the distribution of single households of gender g, age j and assets k be given by $\mu_{s,t}(g,k,j)$. Let the distribution of partnered households of age j and assets k be given by $\mu_{p,t}(k,j)$. The probability of getting matched to a single of the opposite gender, $\tilde{g}$, with next period assets equal to $\tilde{k}'$, given by $\theta_{t+1}(\tilde{g}, \tilde{k}', j+1)$, is defined as:

$$\theta_{t+1}(\tilde{g}, \tilde{k}', j+1) = \frac{\mu_{s,t+1}(\tilde{g}, \tilde{k}', j+1)}{\int_{k'} \mu_{s,t+1}(\tilde{g}, k', j+1) dk'} \tag{12}$$

Aggregate distributions evolve according to the following rule:

$$\begin{aligned}
\mu_{s,t+1}(g, k, j+1) = \{1 - p_{t+1}(j+1)\} & \int_{\{\hat{k} | k = h_{s,t}(g, \hat{k}, j)\}} \mu_{s,t}(g, \hat{k}, j) d\hat{k} \\
& + d_{t+1}(j+1) \int_{\{\hat{k} | k = \frac{\hat{k}}{2}\}} \mu_{p,t}(\hat{k}, j) d\hat{k}
\end{aligned} \tag{13}$$

$$\begin{aligned}
\mu_{p,t+1}(k, j+1) = \{1 - d_{t+1}(j+1)\} & \int_{\{\hat{k} | k = h_{p,t}(\hat{k}, j)\}} \mu_{p,t}(\hat{k}, j) d\hat{k} \\
& + \frac{1}{2} p_{t+1}(j+1) \sum_{g} \int_{\tilde{k}} \int_{\{\hat{k} | k = h_{s,t}(g, \hat{k}, j) + h_{s,t}(\tilde{g}, \tilde{k}, j)\}} \mu_{s,t}(g, \hat{k}, j) \theta_{t+1}(\tilde{g}, \tilde{k}, j+1) d\hat{k}.d\tilde{k}
\end{aligned} \tag{14}$$

3.6 Equilibrium

A competitive equilibrium is a set of sequences,

$$\{c_{s,t}, n_{s,t}, n^h_{s,t}, h_{s,t}, V_{s,t}, c_{p,t}, n_{p,m,t}, n_{p,f,t}, n^h_{p,f,t}, h_{p,t}, V_{p,t}, \hat{V}_{p,t}, \mu_{s,t}, \mu_{p,t}, \theta_t, w_t, r_t\}_{t=1}^{\infty}$$

for given $\mu_{s,0}, \mu_{p,0}$, that solve the households' and firm's problems and clear markets for labor, assets and output such that the following conditions are satisfied:

1. $V_{s,t}$ solves the problem for single households which is defined by equations (1)-(4) and $(c_{s,t}, n_{s,t}, n^h_{s,t}, h_{s,t})$ are the associated policy rules.

2. $V_{p,t}$ solves the problem for partnered households which is defined by equations (5)-(8) and $(c_{p,t}, n_{p,m,t}, n_{p,f,t}, n^h_{p,f,t}, h_{p,t})$ are the associated policy rules.

3. $\hat{V}_{p,t}$ is calculated using equations (9)-(10).

4. $\mu_{s,t}$ and $\mu_{p,t}$ describe the aggregate distribution over single and partnered households respectively and are calculated using equations (13-14). Subsequently θ_t is calculated using 12.

5. w_t and r_t are determined competitively and the labor market and asset market clears.

$$w_t = (1-\alpha)A_t K_t^{\alpha} N_t^{-\alpha}. \tag{15}$$

$$r_t = \alpha A_t K_t^{\alpha-1} N_t^{1-\alpha} - \delta \tag{16}$$

$$N_t = N_{m,t} + N_{f,t} \tag{17}$$

$$N_{m,t} = \sum_j \int_k \{n_{s,t}(m,k,j)\mu_{s,t}(m,k,j) + n_{p,m,t}(k,j)\mu_{p,t}(k,j)\}dk \tag{18}$$

$$N_{f,t} = \sum_j \int_k \{n_{s,t}(f,k,j)\mu_{s,t}(f,k,j) + n_{p,f,t}(k,j)\mu_{p,t}(k,j)\}dk \tag{19}$$

$$K_t = \sum_j \int_k \{\sum_g k\mu_{s,t}(g,k,j) + k\mu_{p,t}(k,j)\}dk \tag{20}$$

Thus, incorporating the gender wage gap, $w_{m,t} = w_t$ and $w_{f,t} = \Delta_t w_{m,t}$.

6. Goods market clears by Walras Law.

4 Solution and Parameter Choices

Quantitative assessment of this framework to study the economy's business cycle responses requires the use of numerical methods to solve the model. The first step of the algorithm is to calibrate parameters so that the model's steady state matches the key moments from the data. For my benchmark model, I calibrate my parameters to match a steady state corresponding to 1968. I choose 1968 as the starting year because it is the first year for which CPS March ASEC collected data on the number of young children for every individual starting 1968.

Next, I incorporate changes in factors identified by the literature as possible contributors to the secular trend in female labor supply: the narrowing of the gender wage gap, technological advancements in home production, decreases in marriage rates, increases in divorce rates and changes in the number of young children at home[3]. I assume that agents in the model have perfect foresight with respect to transitions in each of these

[3]See for example: Heathcote, Storesletten, Violante (2018), Goldin (2014), Jones, Manuelli, McGrattan (2015), Greenwood et al (2005)

factors over time. I study the responses of the economy along the transition path until they reach the final steady state, which in this framework corresponds to 2014. I use the endogenous grid method to solve for decision rules for each type of household at every time period. Further, to study business cycle dynamics, I use a perfect foresight environment, where A_t fluctuates which represents shocks to total factor productivity.

Since I consider workers aged 16-65, there are 50 age cohorts in the model economy. I assume that utility derived by an individual of gender g takes the following functional form: $U_g(c, c^h, 1-n) = \frac{c^{1-\sigma}}{1-\sigma} + \frac{(c^h)^{1-\sigma^h}}{1-\sigma^h} + \eta_g \frac{(1-n)^{1-\phi}}{1-\phi}$. Table 1 lists the parameter choices made in this framework. I assume that agents are risk averse and their coefficient of relative risk aversion with respect to market good, $\sigma = 1$ and with respect to home produced good, $\sigma^h = 1.5$, which are standard in the literature. I assume separability in consumption of the home-produced good and the market good because the former is interpreted as child care in my framework, which cannot be substituted by own consumption if agents have children. The equivalence scale parameter, χ, which is used to scale married households' consumption of the market good is chosen to be the OECD equivalence scale corresponding to couple households. The parameters that govern the home production function, ψ, A^h, χ^h will be disciplined further by using moments from the American Time Use Survey.

The preference parameter for leisure for males and females, η_m and η_f respectively and the Pareto weight associated with the male utility, ζ_m, in a married household are jointly calibrated to match the average labor supplied by married men, married women and single women in 1968. ϕ which governs the curvature in the utility function from leisure will be disciplined using a measure of Frisch elasticity of labor supply for households. The parameter choices for capital share of output, α, depreciation rate, δ, and discount factor β result in steady state values of $\frac{K}{Y} = 2.31$, $\frac{I}{Y} = 0.16$ and an annual interest rate, $r = 4.76\%$. The total factor productivity, A, is normalized to 1 in steady state.

I use the ratio of the median income of full-time year-round female to male workers, which is published by the United States Census Bureau from 1968-2014, as the gender wage gap for that time period. I use micro-data on the number of young children, aged less than 5, from the CPS March ASEC data and calculate the average number for a household of every age and marital status for every year between 1968-2014. The average calculated includes households which with no children[4]. I use data from the United States Census Bureau on household type to calculate the fraction of married households for every year between 1968-2014. To calculate the divorce rate for the entire time period of interest, I use a combination of two data sources. First, I use data reported by Doepke and Tertilt (2016), which is available for every year until 1990. Next, I use data reported by the National Center for Family and Marriage Research (NCFMR) for 2000 and for every year between 2008-2014. In both cases, the divorce rate is calculated as the number of divorces per 1000 married women aged above 15. I use interpolation to approximate the divorce rates between 1991-1999 and 2001-2007 by using the rates in 1990, 2000 and 2008. The marriage rate is calculated as the ratio of the number of marriages to the number of unmarried women aged 15 and above in a given year. Data on marriage rate is reported by the NCFMR for the years 1970, 1980, 1990, 2000, 2008-2014. Again I use interpolation to approximate the marriage rates for every year in between. I assume that the marriage rates in 1968-1969 were the same as in 1970. At this point, marriage rates and divorce rates used are not age-specific. The next step of my analysis would involve using a panel data structure to estimate age-specific marriage and divorce rates for individuals over the entire time period of interest.

5 Results

In this section, I describe the results obtained from this paper. This section is divided in the following way. Firstly, I compare the steady state results obtained from the model to their counterparts in the data and then study the relative contribution of each of the underlying causal factors influencing labor supply changes. Secondly, to understand the trend in labor supply, I compare its transition from the initial to the final steady state that is predicted by the theoretical framework and to that in the data and study the

[4]For married households, I use information reported by married women, since information on young children provided by married men is missing for 3 years in the data

Table 1: Parameter Choices

Parameter	Value
β	0.98
α	0.27
δ	0.069
A	1.0
σ	1
σ^h	1.5
χ	1.7
ϕ	4
η	[0.6195, 1.1340]
ζ_m	0.64975
A^h	0.5
ψ	0.2
χ^h	1.5

importance of each of the underlying factors along the trend. Finally, to understand the effect of the trend on jobless recoveries, I examine the response of the economy to an aggregate TFP shock (a) during an upward trend in female labor supply; (b) when the trend has leveled off.

5.1 Steady State

I compare the results for aggregate labor supply for married men, married women, single men and single women between the initial(1968) and final(2014) steady states. The changes that take place across the two steady states include narrowing of the gender wage gap, a decrease in marriage rates, an increase in divorce rates, a decrease in the fraction of married households and a change in the average number of children across households. In particular, there has been a significant decline in the average number of young children for young married households of ages less than 30, whereas there has been a slight increase for the older married households. Similar pattern emerges for single women households. For single men households however, the average number of young children has increased for individuals of almost all ages. These patterns have been illustrated in Appendix "something".

The results on aggregate labor supplied by married men, married women, single men and single women are illustrated in Table 2. The model does well in replicating qualitatively the changes in labor supplied by each group. As is seen in the data, I find that aggregate labor supplied by women, both married and single increases, with a larger increase by the former. Labor supplied by both married and single men decreases. Further, within married households, the increase in labor supplied by women (54.29%) is not completely offset by a decrease by men (6.4%), which is consistent with the results discussed by Fukui, Nakamura and Steinnson (2019) that not much crowding out takes place within the household.

In order to identify the relative contribution of a change in each of the factors, I conduct counterfactuals where I allow all but one of the factors to change from 1968 to 2014. The results suggest that for partnered men and women, the biggest contributor has been a narrowing of the gender wage gap, which makes it more favorable for women to increase their labor supply and men to decrease their labor supply. For single men, the increase in average number of young children at home across all age cohorts is the primary contributor towards a decrease in the labor supplied in the market. For single women, the decrease in marriage rates is the largest contributor towards increasing labor supply.

As the gender wage gap decreases, the opportunity cost of not supplying labor to the market increases for women. As a result, women switch from home production to market production thereby increasing their labor supply. For younger cohorts, a decrease in the number of young children at home further allows more home good to be produced by supplying less labor at home, which further results in an increase in the labor supplied to the market by women. For older cohorts, the slight increase in the number of children has an offsetting effect, however the reduction in the gender wage gap dominates. The income effect due to female wages results in a decrease in labor supplied by married men, however since women substitute home production for market production, the effect is not very strong, as a result of which the decrease in married men's labor supply is not large.

For single men, an increase in the average number of children makes it costly for them to supply labor in the market, as a result of which there is a decrease in the labor supplied in the market. For single women, decrease in marriage rates results in increasing the labor supplied by them the most. Married households pool their income and share consumption. However, over time, the probability of that event decreases; thus single women depend on their own income to fund consumption. An increase in household income, particularly attributed to by increased labor supply of married women, results in an increase in consumption demand and savings of households, which in turn increases the output produced by firms and increases the wages earned by both men and women.

Table 2: Contributions of leading causal factors to underlying Labor Supply Changes

	Data 1968	Model 1968	Data 2014	Model 2014	(1)	(2)	(3)	(4)
Δ	0.585	-	0.793	-	0.585	-	-	-
p	0.077	-	0.032	-	-	0.077	-	-
d	0.013	-	0.018	-	-	-	0.013	-
#children	'68 values	-	'14 values	-	-	-	-	'68 values
N		0.441		0.477	95.7%	1.79%	-2.43%	-1.75%
$N_{f,p}$	0.109	0.109	0.190	0.169	95.0%	-1.90%	0.55%	4.72%
$N_{m,p}$	0.333	0.333	0.288	0.312	87.4%	1.07%	-5.79%	2.29%
$N_{f,s}$	0.198	0.198	0.208	0.222	15.81%	47.2%	-13.11%	-0.68%
$N_{m,s}$	0.273	0.311	0.228	0.294	7.18%	28.7%	12.4%	63.2%

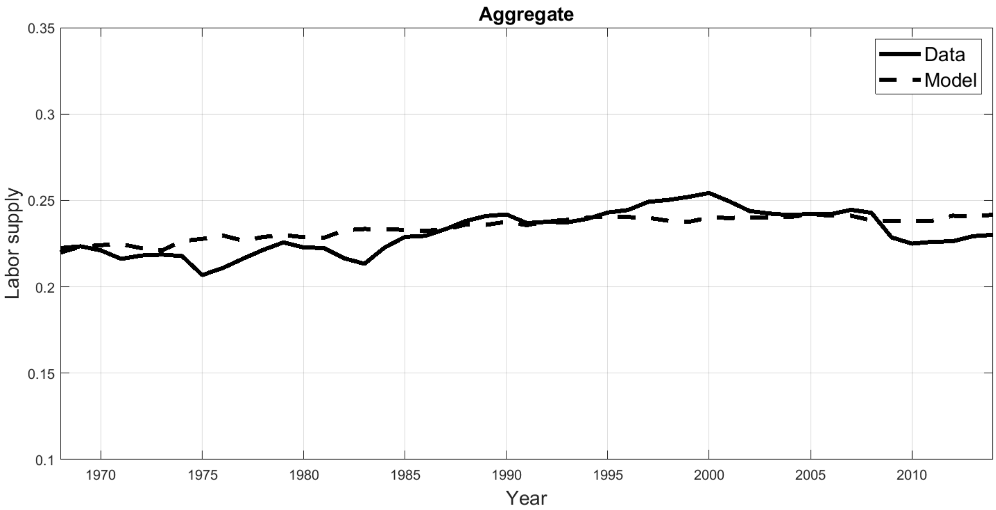
I use values on gender wage gap, marriage rates, divorce rates and the number of young children to solve my model directly from the data. The upper panel describes the values used. The first four columns in the lower panel compare the results obtained on labor supply to their counterparts in the data. Next, I conduct counterfactual exercises where I allow all but one factor to change between the two steady states. The lower panel in Columns (1),(2),(3) and (4) describe the percentage of the total change in labor supplied by each group explained by the gender wage gap, the marriage rate, the divorce rate and the number of young children at home respectively.

5.2 Understanding Secular trend in Labor Supply

I run my model economy forward starting from an initial set of conditions reflecting the U.S. in 1968, and I examine the labor supply changes in the aggregate as well as for each subgroup, at various points in time along the path. I assume that agents in the model have perfect foresight with respect to changes in the gender wage gap, marriage rates, divorce rates and the number of children for every year between 1968 and 2014. Figure

8 compares the implied path for aggregate labor supply that the model predicts to that seen in the data. My model does a reasonable job in predicting the trend in aggregate labor supply.

Figure 8: Secular trend in aggregate labor supply: model and data



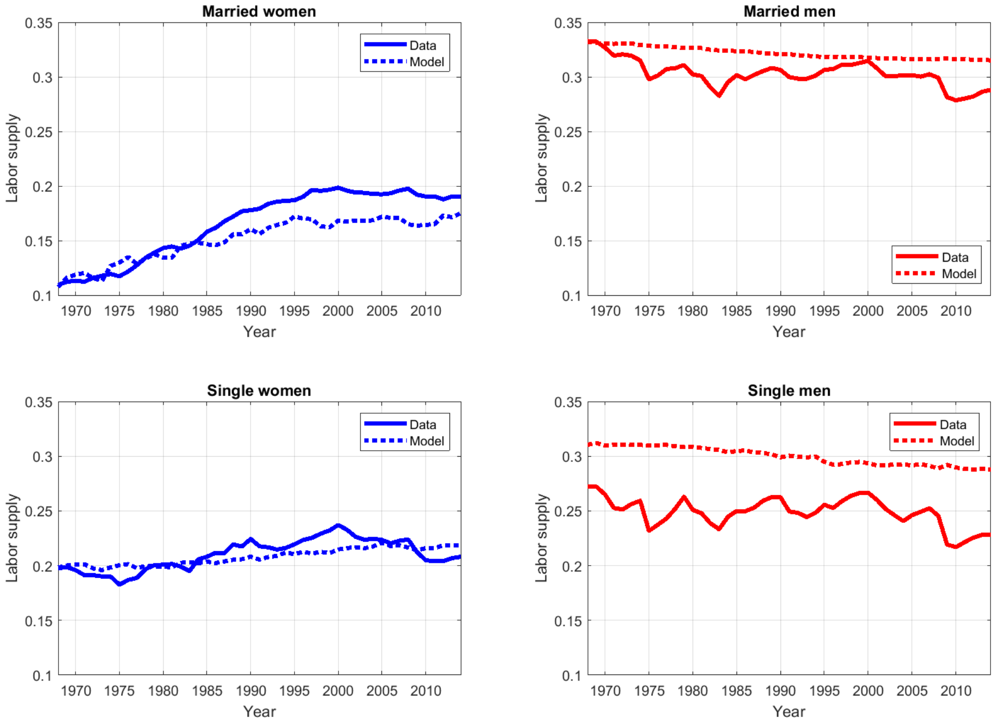
Notes: I use the measure of average number of hours worked by the population (includes all those who work 0 hours) from Doepke and Tertilt (2016) and divide it by 120 to get the data counterpart of aggregate labor supply.

Further, I test the path predicted by the model for subgroups of the population: married women, married men, single women, single women. The results are shown in Figure 9. My model implied trend for labor supply matches well with that seen in the data for married women, married men and single women. For single men, similar to the data, the model predicts a gradual decline in their labor supply. However, the levels are lower in the data. I hypothesize that this is because in the data, younger men who are acquiring education are more likely to be single. Since my model does not account for heterogeneity with respect to education levels, it fails to capture the levels correctly.

Next, to identify the importance of each of these underlying factors along the trend, I conduct counterfactual exercises, where I allow all but one of the factors to change over time. The results for married and single women are illustrated in Figures 10 and 11 respectively. The corresponding results for men are illustrated in Figures 13 and 14 in the Appendix.

For married women, the results indicate that from 1968 to early 1980s, the most

Figure 9: Secular trend in labor supply for married and single women and men

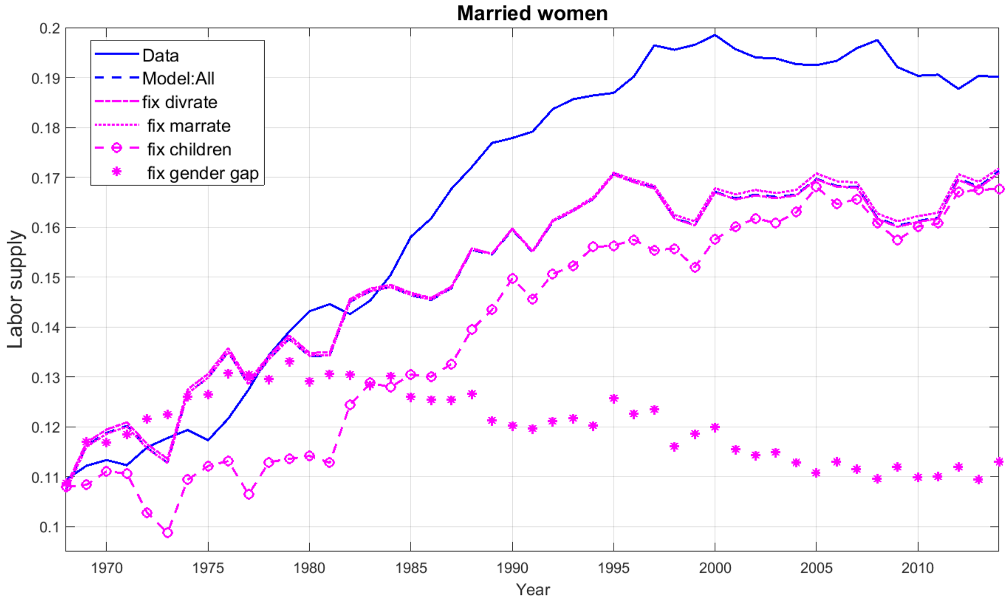


Notes: I use the measure of average number of hours worked by the population (includes all those who work 0 hours) from Doepke and Tertilt (2016) and divide it by 120 to get the data counterpart of aggregate labor supply. Here single households include all those who are never married, divorced, separated or widowed.

important factor that is associated with increasing labor supply is the reduction in the number of children for younger cohorts. Post that, the gender wage gap is the primary driving force. This decomposition highlights the association between female labor supply and children, particularly because the strong upward trend in married women's labor supply existed in the early part of the transition. I argue that this decomposition exercise is important along the trend because the role of children is not understood when comparing only across steady states. This result is also indicative of the fact that policies should be targeted towards reducing the cost associated with providing child care at home in order to increase female labor supply.

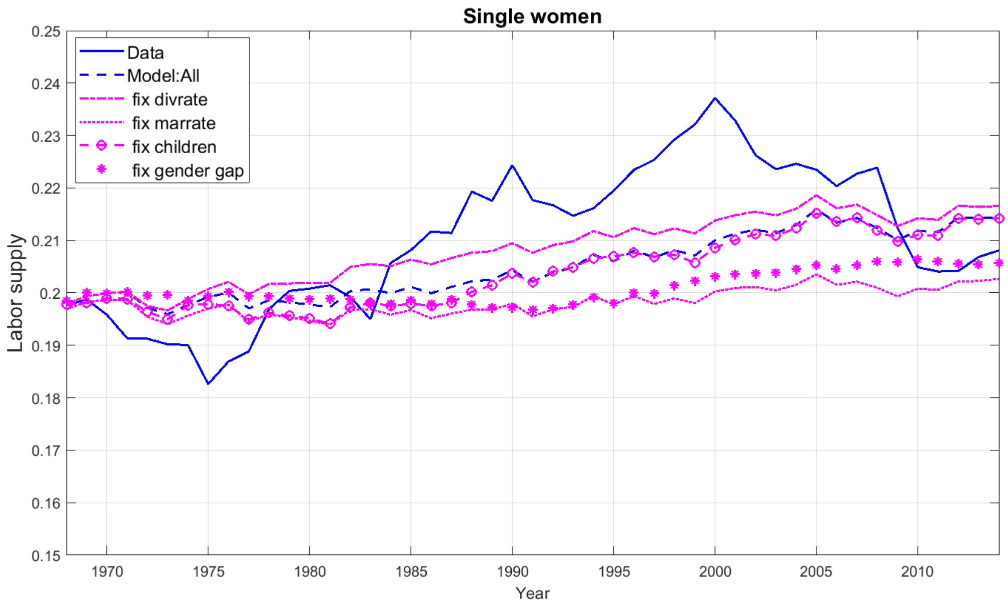
For single women, the decline in marriage rate is the primary contributor towards an increasing labor supply both across steady states as well as along the trend. The model further predicts that if the divorce rates had not changed, the labor supply increase would have been higher. As discussed earlier, marriage allows for income pooling which

Figure 10: Decomposition into factors underlying married women's trend in labor supply



I use the measure of average number of hours worked by the population (includes all those who work 0 hours) from Doepke and Tertilt (2016) and divide it by 120 to get the data counterpart of aggregate labor supply. For each of the counterfactual exercises, I fix only one of the underlying factors and study the trend in labor supply. The difference between this and the model implied path of labor supply when all factors are allowed to change, demonstrates the contribution of that factor.

Figure 11: Decomposition into factors underlying single women's trend in labor supply



I use the measure of average number of hours worked by the population (includes all those who work 0 hours) from Doepke and Tertilt (2016) and divide it by 120 to get the data counterpart of aggregate labor supply. Here single households include all those who are never married, divorced, separated or widowed. For each of the counterfactual exercises, I fix only one of the underlying factors and study the trend in labor supply. The difference between this and the model implied path of labor supply when all factors are allowed to change, demonstrates the contribution of that factor.

decreases the incentive towards supplying labor to the market for women, since wages for men are higher.

5.3 Understanding Jobless Recoveries

In this section I investigate the interaction between the secular trend in female labor supply and jobless recoveries. To do this, I compare the response of the economy to a 5% negative aggregate productivity shock when (a) there is an upward trend in aggregate female labor supply (Pre-1990) (b) when the trend has weakened (Post-1990). I assume that agents do not anticipate the arrival of the productivity shock; however, they can completely observe the future path of the shock after it hits the economy. Specifically, the underlying process for aggregate TFP is given by:

$$A_{t+1} = \rho A_t + (1 - \rho)A \tag{21}$$

where $\rho = 0.95$ is the persistence of the productivity process and A is its steady state value.

Figure 12: Cyclical response in Labor Supply: Aggregate, Females and Males

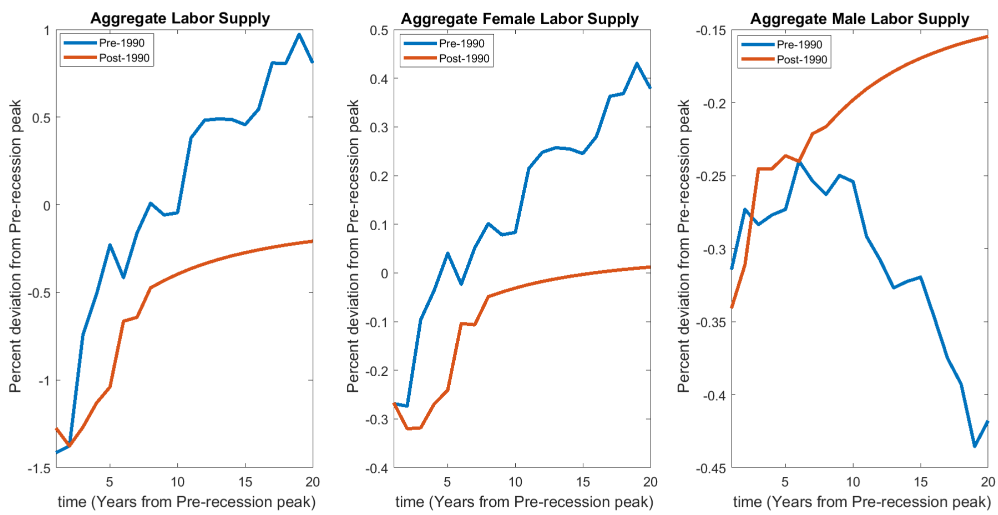


Figure 12 demonstrates the responses implied by the model for aggregate labor supply. As is evident in the first panel, aggregate labor supply recovers faster in a Pre-1990 recession as compared to a post-1990 one. The former has a half life of 4 years whereas for the latter it is 6 years. In the second and the third panel, the aggregate labor supply recoveries for females and males make it evident that it is the recovery in female labor supply that drives the strong recovery at the aggregate level for the pre-1990 recession. This confirms the hypothesis that leveling off the trend in female labor supply leads to jobless recoveries.

6 Policy Experiments

In this section, I discuss policy experiments which are aimed at mitigating jobless recoveries. I use my framework to discuss the effectiveness of each of these policies. I conduct a counterfactual exercise, wherein households with children have the additional option of buying child care: φ from the market at a price q. However, there is a required amount of total child care, $c_s^h(g,k,j)$ and $c_p^h(k,j)$ that needs to exist for every single and married household respectively. There is a firm that now produces child care using labor that it hires at the market wage rate using the following technology $Y^h = \gamma N^h$. Thus aggregate labor supply, $N = N^y + N^h$, where N^y is the labor demanded by the final goods firm.

In the following subsections, I study the labor supply choices during business cycles under alternative policies, which are funded using taxes on wage (τ_w) and rental income (τ_r) and Government spending G. Thus,

$$\text{Total Subsidy}_t = \tau_w \sum_g w_{g,t} N_{g,t} + \tau_r r_t K_t + \tau_d w_{f,t} N_{f,t} - G_t \tag{22}$$

I compare the recoveries in the post-1989 recessions (when the trend in female labor force participation has leveled off) in the presence and absence of these countercyclical government subsidies.

6.1 Per-unit Child Care Subsidy

Suppose the government provides a subsidy (τ_s) to households for every unit of child care that they purchase from the market. For single households, we can rewrite equations

(2)-(3) as:

$$c + (1 - \tau_{c,t})q_t\varphi + k' \leq (1 - \tau_w)w_t(g)n + (1 + (1 - \tau_r)r_t)k \tag{23}$$

$$c^h \leq A_t^h(n^h)^\psi + \varphi \tag{24}$$

For partnered households, we can rewrite equations (6)-(7) as:

$$c + (1 - \tau_{c,t})q_t\varphi + k' \leq (1 - \tau_w)w_t(m)n_m + (1 - \tau_w)w_t(f)n_f + (1 + (1 - \tau_r)r_t)k \tag{25}$$

$$c^h \leq A_t^h(n_f^h)^\psi + \varphi \tag{26}$$

6.2 Child Care Tax Credit

Suppose the government subsidizes child care in the form of a child care tax credit, T_c to all households with children, provided the parent who would have otherwise provided home-produced child care works in the market.

For single households, we can rewrite equations (2)-(3) as:

$$c + q_t\varphi + k' \leq (1 - \tau_w)w_t(g)n + (1 + (1 - \tau_r)r_t)k + \mathbb{1}_{n>0}T_{c,t} \tag{27}$$

$$c^h \leq A_t^h(n^h)^\psi + \varphi \tag{28}$$

For partnered households, we can rewrite equations (6)-(7) as:

$$\begin{aligned} c + q_t\varphi + k' \leq & (1 - \tau_w)w_t(m)n_m + (1 - \tau_w)w_t(f)n_f \\ & + (1 + (1 - \tau_r)r_t)k + \mathbb{1}_{n_f>0}T_{c,t} \end{aligned} \tag{29}$$

$$c^h \leq A_t^h(n_f^h)^\psi + \varphi \tag{30}$$

7 Conclusion

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[17] U.S. Bureau of Labor Statistics, Civilian Employment-Population Ratio [EMRATIO], retrieved from FRED, Federal Reserve Bank of St. Louis;

Figure 13: Decomposition into factors underlying married men's trend in labor supply

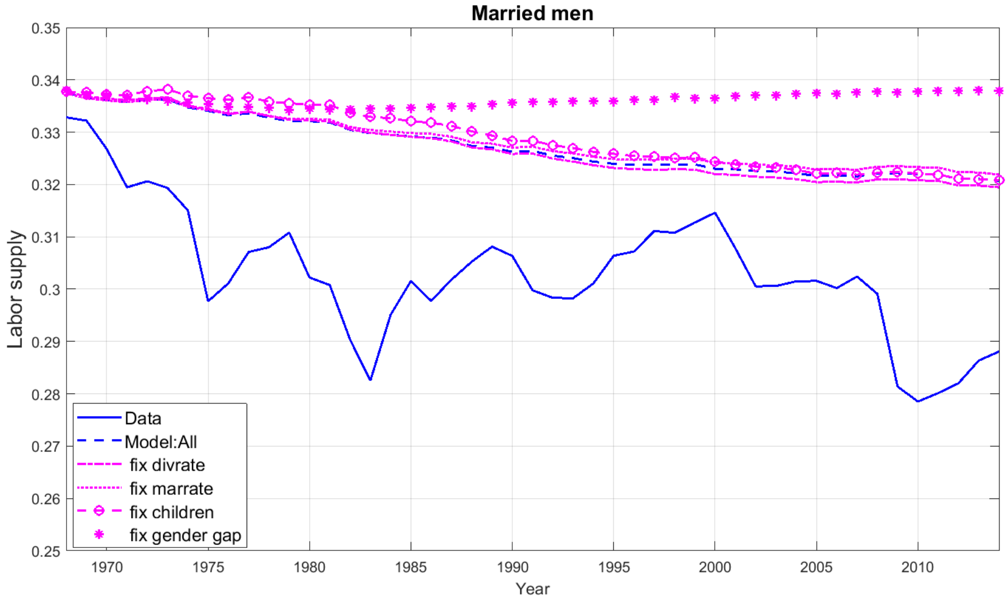

Figure 14: Decomposition into factors underlying single men's trend in labor supply