Women’s increased involvement in the economy has been the most significant change in labor markets during the past century. In this paper, I account for this period of structural change of the labor market in a macroeconomic model, and study how the increase in female labor force participation has affected the economy’s response to aggregate shocks. I explicitly model heterogeneity in gender and household composition as well as the historical decrease of the gender wage gap. The model captures the salient features of historical data, including a strong increase in employment among married women, low crowding-out of married men, and relatively stable employment over time for single women. I then study how the changing labor force composition affects the economy’s aggregate employment dynamics. The underlying trend in employment, driven by growth in female labor force participation, contributed to the perceived quick employment recovery after recessions before 1990, and the absence of growth thereafter consequently explains the more recent slower employment recoveries. In general, incorporating both one- and two-person households matters for employment dynamics, with single households reacting more strongly to shocks and employment responses by subgroups changing over time. Despite relatively large changes by subgroup, the aggregate effect is unchanged between the 1970s and the present time due to multiple counteracting forces.
1. Introduction

Figure 1 shows the dramatic change in female labor force participation among married women in the U.S. over the last five decades. At the beginning of the 1960s, the mode household in the economy was a household with two adults of which one, the husband, was the sole breadwinner. Today, this is no longer the case. In Claudia Goldin’s words, “women’s increased involvement in the economy was the most significant change in labor markets during the past century” (Goldin 2006).

In this paper I account for this period of structural change of the labor market in a macroeconomic model, and study how the increase in female labor force participation has affected the economy’s response to aggregate shocks. For this purpose I construct a heterogeneous agent model in which I explicitly include the gender and household composition dimensions (alongside heterogeneity in assets and productivity). Otherwise the model is a straightforward business cycle model, leaving the incorporation of monetary and labor-market frictions to future research.

The model is able to capture the salient features of historical data, including a strong increase in employment among married women, low crowding-out of married men, and relatively stable employment over time for single women. Model results show that the underlying trend in employment, driven by growth in female labor force participation, contributed to the perceived quick employment recovery after recessions before 1990, and the absence of growth thereafter consequently explains the more recent slower employment recoveries.
In general, incorporating both one- and two-person households matters for aggregate employment dynamics, with single households reacting more strongly to shocks. Furthermore, employment responses by subgroup have changed over time. For instance, among married women, the response to a shock has become more muted as women on average have moved further away from their work margin. Despite relatively large changes by subgroup over time, the aggregate effect is unchanged between the 1970s and the present time due to multiple counteracting forces.

On a more general level, my paper departs from the standard macroeconomic model assumption of a representative agent and introduces heterogeneity in the gender and household composition dimensions to be able to study how the increase in labor force participation among women has affected the economy’s employment dynamics. The answer to that question has implications for how we understand historical data, but also for what we can expect for the future, now when the labor force participation increase among married women has slowed down (or even stopped).

Why should we believe that the increased labor force participation among married women matters for the economy’s aggregate response? A first answer is purely mechanical: women now make up a larger share of the workforce. If labor supply elasticities differ depending on gender and marital status, the changing composition of the workforce should have an effect on the aggregate elasticity in the economy.

A second answer is that even within subgroups, the employment responses to fluctuations in wages might have changed over time. It seems likely that with increasing participation, women have on average moved further away from their reservation wage, and hence would respond less to price changes, while the opposite might be true for married men.

A third answer is that the strong underlying growth in labor supply among married women up until the end of the 1990s had an impact on total employment growth, both in normal times and after the economy was hit by a negative shock. From a mechanical viewpoint, the underlying trend growth in female labor supply sped up the employment recoveries after a recession up until the 1990s. However, whether the trend growth in female employment has changed the employment reaction to negative shocks in a fundamental way or whether it is just a question of a changing trend in employment growth depends on the effect the growth in employment among married women had on the other subgroups in the economy (Albanesi 2018; Fukui et al. 2018).

To evaluate these plausible mechanisms and give a quantitative answer, we need a structural model capturing both the individual household responses and general equilibrium effects. Traditionally, macro models analyzing aggregate shocks and labor supply have used a representative agent setting, i.e., a single household representing all households in the economy. Heterogeneous-agent models analyzing aggregate shocks and labor supply standardly assume a sole-breadwinner household (even though there are exceptions). The few recent papers looking at the trend of an increasing labor supply among women
and the effect on aggregate shocks use a representative household structure, and hence cannot speak to questions about intra-household interaction.

In this paper I use a heterogeneous-agent model of the Bewley/Huggett/Aiyagari type that explicitly incorporates heterogeneity in gender and household composition (alongside heterogeneity in assets and productivity). There are three types of households: single men, single women, and couples (consisting of one man and one woman), and they are all subject to idiosyncratic shocks in terms of productivity and unemployment. Each period, households choose how much to consume and to save, and if they want to supply labor on the market or not. Within couples none, one or both individuals can choose to work. The labor choice is only on the extensive margin. The reason for this is that the most important changes over time have happened on the extensive margin: I argue that it is more important to capture the decision to actually start working than a potential decision to increase hours from say 36 to 42 hours per week. Hours worked per worker by subgroup have been stable since the 1960s. Moreover, between two thirds and three quarters of the hours fluctuations over the business cycle happen on the extensive margin.

Using this framework, I model a closing of the wage gap between men and women as a result of a decreasing productivity wedge facing women. The increase in labor supply among married women is then an equilibrium outcome driven by the shrinking wage gap and other equilibrium variables such as wealth accumulation etc. I incorporate this closing of the productivity gap as an exogenous trend and do not take a stance on why it arises, but only note that it is consistent with a theory of female-biased technological change, a theory of discrimination and misallocation of female talent, or a combination of both. I model the closing of the productivity gap so that the observed wage gap in the model, taking into account any selection effect, is consistent with observed historical data.

A first test whether the model captures the correct labor supply patterns in the long run is if an increase in female employment is primarily driven by married women. In my model, this turns out to be the case. The closing of the wage gap can explain two thirds of the increase in married women’s labor supply, while the single women are hardly affected.

A second test is if the increase in labor supply among married women crowds out their husbands’ labor supply, something we have not seen in the data. In my model, married men decrease their labor supply by approximately five percentage points, which is in line with the data, and far from the increase in labor supply by married women. This result arises despite using a unitary household model with fixed bargaining weights (as opposed to, e.g., Knowles (2012) who uses endogenous bargaining) and no explicit modelling of home production (as opposed to, e.g., Jones et al. (2015)).

It turns out that explicitly incorporating both two-person and one-person households in a model with endogenous labor choice on the extensive margin matters for employment
responses. As in the data, single households’ hours fluctuate more than couple households’ hours. The effect arises since on average the mass of single households is closer to the working margin than is the mass of agents in couples. The economic reason is that the single household’s working and savings decisions only depend on the agent’s own productivity. When the individual chooses to work, he/she also accumulates assets for future unproductive periods. When the individual chooses not to work, he/she is also deaccumulating assets saved up from earlier working periods. Hence, the savings decision is tightly linked to the working decision for a single household. In the couple household, on the other hand, the savings decision is not only linked to one person’s current working decision, but to both individuals’ current productivities and continuation value.

I then use the model to analyze the employment response to a TFP shock at different points in time. I study the economy’s response to small “MIT shocks” (as proposed by Boppart et al. (2018)) and the resulting total response to a TFP shock is unchanged between the 1970s and the present time. This seeming null-result is the sum of multiple counteracting forces. Most importantly, among married women, the employment response from a TFP shock has become more muted over time, due to more and more women moving further away from the working margin. However, since women in absolute terms respond more strongly to aggregate shocks, their increasing share of the labor force drives up the aggregate response and the net result is close to zero.

A connected finding is that if the model economy is hit by a strong negative shock during a period with strong female labor force participation growth, it returns to its pre-recession level of employment after four years. However, if the shock happens later, when the labor force participation is no longer increasing, it takes longer for the employment figure to return to its pre-recession level. This pattern replicates what we have seen in the data: from the 1990s and onwards, it has taken longer after a recession for the employment figures to climb back to their pre-recession level. In other words, the underlying trend in employment, driven by the increase in female labor force participation, was driving up the employment figures historically after a recession. If we measure the employment deviation compared to the true underlying deterministic path, the response and speed of recovery have not changed over time.

1.1. Relation to previous literature

Standard macroeconomic models in the tradition of Kydland and Prescott (1982) analyzing the economy’s response to aggregate shocks are populated by an infinitely lived representative household, who derives utility from consumption and leisure and receives income from supplying labor and accumulating savings.

A first step to move away from the representative-agent framework came with the introduction of heterogeneous-agent models (Aiyagari 1994; Bewley 1986; Huggett 1993);
however, “the lion’s share of work on quantitative heterogeneous-agent models has focused on the bachelor household – one breadwinner per household” (Heathcote, Storesletten, and Violante (2009), page 339). Naturally, there were early exceptions, for example explicitly modelling intra-family insurance (Attanasio, Low, and Sánchez-Marcos 2005) or the family formation as an idiosyncratic risk (Cubeddu and Rios-Rull 2003). However, in the ten years since this quote was written, it has become more common to explicitly include the family and its members in dynamic macro models. Two notable examples are Heathcote, Storesletten, and Violante (2010), modelling each household as consisting of a husband and a wife when analyzing increasing wage inequality, and Guner, Kaygusuz, and Ventura (2011) incorporating both couples and singles in a life-cycle model when evaluating labor supply responses to tax reform.

Especially in the literature about female related issues (such as the increase in female labor force participation, discussed below) many life-cycle models explicitly incorporate the family structure. A more general point is made by Borella, De Nardi, and Yang (2018) who, using a life-cycle model, show that including gender and family formation can substantially improve a model’s fit to aggregate data in terms of savings and labor profiles over the life cycle.

The exercise in this paper takes as given the decrease in the gender productivity gap, and evaluates its impact on the employment figures for both men and women, both in couple and single households. There is a large literature on the underlying causes of the increased labor force participation among women in the post-war U.S. The papers which, like the current one, focus on the importance of the closing of the gender wage gap put forward different explanations for why this has happened. Jones, Manuelli, and McGrattan (2015) avoid taking a strong stance, but note that their approach is consistent both with the view that the wage gap is a consequence of discrimination (either directly in wages or through the presence of a glass ceiling) and with the view that the change in the gender wage gap arises from sex-specific productivity changes. More specifically, Galor and Weil (1996) and Ngai and Petrongolo (2017) stress the rise of the service sector, in which they say that women have a comparative advantage. Olivetti (2006) investigates a sex-specific increase in the return to experience, while Attanasio, Low, and Sánchez-Marcos (2008) find that the closing of the wage gap must be combined with a reduction in the cost of child-care to generate the changes we have seen.

A non-exhaustive list of other suggested reasons behind the increase in female labor force participation includes increased availability of household appliances (Greenwood, Seshadri, and Yorukoglu 2005), increased access to birth-control measures (Goldin and Katz 2002), improvement in maternal health (Albanesi and Olivetti 2016), evolving beliefs about payoffs from working among women (Fernández 2013), a higher divorce probability (Fernández and Wong 2014), and changes in culture and social norms (Fernández and Fogli 2009; Fernández, Fogli, and Olivetti 2004).

The implications of the increased labor force participation among women on the economic performance in general and the economy’s response to aggregate shock have
been studied in a few recent papers. Heathcote, Storesletten, and Violante (2017) study the impact of the rise in female labor supply on growth and income inequality, but do not include aggregate shocks. Fukui, Nakamura, and Steinsson (2018) focus on jobless recoveries and how much this phenomenon is a result of a slower (or even zero) increase in the labor force participation of women. Their model uses a representative couple formulation, in which the inclusion of home production makes the “crowding-out” effect small enough to match the empirical estimates. Albanesi (2018) estimates a DSGE model allowing for female-biased shocks using aggregate data, and finds that the dynamics of these shocks have changed in recent years, suggesting that the gender convergence has played an important role both to explain jobless recoveries and the Great Moderation. Both of the two latter papers look at aggregate hours for men versus women in a representative-couple sense, and do not distinguish between married and single individuals.

The combination of heterogeneous agents, aggregate shocks and explicitly modelled families with potentially more than one wage earner is scarce. One (rare) model that includes heterogeneous families, each family consisting of a husband and a wife, and analyzes aggregate shocks of the Krusell-Smith type (Krusell and Smith 1998) is Chang and Kim (2006). However, that paper does not consider the effects of an increase in employment among married women.

### 2. Structural change of the labor market

In this section, I describe the overall labor supply patterns over time and over the business cycle, by subgroup.

For calculations regarding employment and hours by subgroup over time, I use the CPS March Annual Social and Economic supplement (ASEC). This annual survey goes back to 1962 when approximately 30,000 households were surveyed. In the most recent years, more than 90,000 households have been included in the survey. I exclude all observations for individuals younger than 25 or older than 64, and all individuals who are employed in the armed forces.  

#### 2.1. Increased employment rate for married women

First, I describe the broad trends in labor supply across subgroups over time. Figure 2a shows employment by gender and civil status from 1962 up until now. The one observation that stands out is the strong increase in employment among married women: from 38% at the beginning of the 1960s up to 68% in the mid-1990. This can be thought of as a structural change of the labor market: from a structure with a majority of two-person

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1For all analyses, I weight the observations using ASECWT.
Figure 2: Work by subgroup (age 25-64). Source: CPS.

households with one bread-winner to a structure in which the most common type of household is a two-person household with two earners.

The most important changes over the last 60 years in terms of hours worked by different subgroups happened along the extensive margin, i.e., the number of persons participating in the labor force. Hours worked per worker have been remarkably stable, as Figure 2b illustrates. Married working men work more hours than single working men, and married working women work the least hours. However, the ordering and approximate levels have remained constant since the early 1960s.

Figure 3 shows the year-on-year fluctuations in average weekly hours and contribution by subgroup. One can immediately notice how married women are contributing to the increase in hours, especially during the early period, and how this increase is even counter-acting the fall in hours among the other groups in some years. In the next section, we will look more closely at this dynamic.

2.2. Jobless recoveries: nothing new for men

Figure 5 shows the employment-to-population figures after a recession, normalized to one in the year leading up to the recession.\(^2\) The thicker black line shows the employment-to-population ratio for the prime-aged working population (defined as age 25-64). As can be seen from the figures, after the recessions in 1970, 1974 and 1980, employment was back at or even above its pre-recession level four years later. After the 1990 recession, it was not yet back four years later, and even less so for the 2000 and 2007 recessions, giving rise to the idea of “jobless” recoveries.

\(^2\)I use the year with peak employment just before the recession hits as year zero, which could coincide with the beginning of the recession according to the NBER (the survey is conducted in March every year).
However, if we look at the four demographic subgroups separately, there are striking differences. As Figure 5 shows, neither the single nor the married men had returned to their pre-recession level four years later even before 1990. The one group driving up the employment figures in the 1970s and 1980s was married women.

Can we then draw the conclusion that the increased labor force participation among married women is what made the recoveries before 1990 “non-jobless”? At least from a purely mechanical perspective this seems to be the case, but as pointed out by Fukui, Nakamura, and Steinsson (2018), it depends on what we believe in terms of crowding-out. An increase in employment among married women has an income effect on households. In a standard macro model this would crowd out at least some of the work supplied by married men. Hence, in equilibrium the effect of an increase in employment among married women on aggregate employment is unclear. Using regional variation in the gender wage gap, Fukui et al. (2018) show that empirically, the crowding-out effect seems to be small.

2.2.1. International perspective

If we look at the rest of the world outside the U.S., the phenomenon of jobless recoveries in more recent years is not as prevalent. Graetz and Michaels (2017) look at evidence from a broader set of countries, and compile data from 17 countries for the years 1970 to 2011. Their conclusion is that recent recoveries have generally not involved any

Figure 3: Year-on-year change in average weekly hours per capita (age 25-64), contribution by subgroup. Source: CPS.
Figure 5: Employment figures after the economy is hit by a recession. Source: CPS.
**Figure 6:** Ratio of female to male labor force participation, normalized to the 2016 level (age 25-54). Source: OECD.

significantly slower recovery of employment. In this respect, the jobless U.S. recoveries seem to be the exception.

**Figure 6** shows the ratio of female to male labor force participation for the G7 countries, normalized to the 2016 level. As can be seen, the U.S. was the first country to reach its current level, while all other countries have been on an upward trajectory up until now.  

### 2.3. Hours volatility and responses to aggregate shocks

We now turn to how much hours worked by subgroup fluctuate over the business cycle. **Figure 7** shows two measures of volatility: total volatility and the volatility related to aggregate fluctuations by demographic subgroup, both measured over the years 1962 to 2015. Total volatility for a given demographic subgroup is the percentage standard deviation of the cyclical component of log average hours per capita within the group after removing the trend with an HP filter (using a smoothing parameter of 6.25, following Ravn and Uhlig (2002) for annual data).

I define the volatility related to aggregate fluctuations in the following way. I compute the cyclical component of the labor series for each demographic subgroup as the residual after applying an HP filter (using a smoothing parameter of 6.25). Then I regress this

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3For a broader set of countries, and for absolute levels of female labor force participation, see the appendix, section A.2.
cyclical component on the cyclical component of GDP (which is also the residual after applying an HP filter with a smoothing parameter of 6.25). Hence, the equation I estimate is:

$$\hat{x}_{c,t,i} = \beta \hat{Y}_{c,t} + \epsilon_t$$

(1)

with

$$\hat{x}_{c,t,i}$$ Cyclical component from HP filtering of yearly series of log($x_i$)

with $i \in \{\text{married men, married women, single men, single women}\}$

$$\hat{Y}_{c,t}$$ Cyclical component from HP filtering of yearly series of log GDP.

where $x_i$ are annual hours per capita for each demographic subgroup. The coefficient of interest, $\beta$, captures how responsive aggregate hours for this particular subgroup are to fluctuations in GDP. After estimating this equation, I create a series of predicted hours by subgroup, and then finally measure the percentage standard deviation of these series. Hence, one can think of the cyclical volatility as capturing the component of hours volatility that is related to aggregate economic fluctuations.

As Figure 7 shows, men have a higher volatility than women, and singles have a higher volatility than individuals in couples, confirming findings in, e.g., Doepke and Tertilt (2016). These two facts hold for both total volatility and volatility related to aggregate fluctuations. The first observation, that men have a higher volatility than women, seems

Figure 7: Volatility by demographic subgroup (age 25-64). Source: CPS, FRED.

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4This method follows Jaimovich and Siu (2009). Results are robust to including additional RHS variables such as lagged GDP.

5As a robustness check, I rerun the analysis using different filtering techniques and the conclusions remain unchanged, see section A.5.
at odds with the conventional wisdom that women have a higher labor supply elasticity than men. Therefore, I now look at sector representation. Figure 8 shows the relation between, on the one hand, how responsive a sector is to aggregate fluctuations and, on the other hand, sector choice by demographic subgroup. The x-axis in the graphs indicates sector responsiveness to aggregate fluctuations, measured as described above (running regression (1) with \( \hat{x}_{c,t,i} \) denoting a cyclical component of log hours in sector \( i \) at time \( t \)). The y-axis indicates the share of workers in that sector from a specific demographic subgroup. For instance, in the construction sector 28% of the employed are single men, compared to medical services where the corresponding figure is only 7%. The size of each bubble in the diagram indicates the fraction of the subgroup working in that particular sector (in other words: the sizes of the bubbles can be said to sum to one).

One thing that immediately stands out is that men are overrepresented in more volatile sectors while the opposite is true for women. Hence, one could argue that the fact that women in the aggregate are less volatile than men is driven more by labor demand than labor supply considerations (which is the primary focus of this paper).

A final observation related to aggregate fluctuations is that approximately two thirds of the fluctuations in total hours worked are due to changes in the extensive margin. Figure 9 shows the shares by subgroup, and for all subgroups the extensive margin is more important than the intensive margin in explaining the total change in hours related to aggregate economic fluctuations.

2.4. Summary of empirical observations

It is time to take stock of the empirical observations up to this point. First of all, since the 1960s, married women have increased their employment rate by roughly 30 percentage points: from 38% in 1962 to almost 70% at the beginning of the 1990s and thereafter. Second, we have not seen the same strong increase among single females. Third, the crowding-out within couples is small. These three observations should be captured by a model of increasing female labor supply.

In terms of volatility and responsiveness to aggregate shocks, there are two observations that should be highlighted. First of all, singles’ hours worked are more volatile than married individuals’ hours worked. This is true comparing married men to single men, and comparing married women to single women. For this cut, there are no apparent sector differences that explain the pattern.

The next observation is that on an aggregate level, men’s hours are more volatile than those of women. This is true both within couples, in which married men’s hours are more volatile than those of married women, and comparing single men to single women. However, the higher aggregate volatility among men is highly correlated with sector. Men are more likely to work in sectors that are highly business-cycle sensitive. In this paper I ignore any sectoral differences in volatility.
Figure 8: Sector responsiveness to aggregate fluctuations (x-axis) relative to the fraction of workers being of the particular demographic subgroup (y-axis). Size of marker indicates share of subgroup working in the sector. Population aged 25-64. Source: CPS.
A last observation from the data is that the extensive margin is of first-order importance. Between two thirds and three quarters of the fluctuations in hours are due to extensive-margin fluctuations, and this is true for all subgroups. Moreover, the main changes over time have happened on the extensive margin. Hours worked per worker have not changed nearly as much. Therefore, in the choice between intensive and extensive margin, I choose to include the extensive margin in the model.

3. Model

In this section, I lay out the benchmark steady-state model. The model is an infinite horizon general equilibrium model of the Bewley (1986)/Huggett (1993)/Aiyagari (1994) type. Time is discrete and every time period is assumed to be one year.

Individuals derive utility from consumption and disutility from supplying labor, which is endogenously chosen. There is only an extensive labor margin choice. Individuals face two types of idiosyncratic risks: shocks to productivity and unemployment risk. There is no possibility to insure against these risks. Households can only save in a riskless bond, and they face an exogenous borrowing constraint.

There are three types of ex-ante heterogeneous households: single males, single females, and couple households (consisting of one male and one female). I start with the problem facing a single man or woman, which is identical save for some gender-specific parameters.
3.1. The single household problem

Working-age households have a constant probability of entering a retirement phase \( \pi_r \in [0, 1] \) and retired households have a constant probability \( \pi_w \in [0, 1] \) of being reborn as a working-age household. With gender denoted by \( i \in \{m, f\} \), working-age single households solve the following recursive problem:

\[
V_i^w(a, \omega_i, u_i) = \max_{c, \ell, a'} \left\{ u(c, \ell) + \beta_i \left[ (1 - \pi_r)EV_i^r(a', \omega_i', u_i') + \pi_r V_i^r(a') \right] \right\} \tag{2}
\]

subject to

\[
c + a' \leq (1 - u_i)(1 - \tau_i)w_i \omega_i \ell + u_i \phi_i (1 - \tau_i)w_i \omega_i - T + a(1 + r) \tag{3}
\]

\[
\ell \in \{0, 1\} \tag{4}
\]

\[
a' \geq a \tag{5}
\]

Unemployment is denoted by \( u_i \in \{0, 1\} \). The budget constraint, (3), says that consumption \( c \) plus savings for the next period \( a' \) cannot exceed labor income if employed \( (w(1 - \tau_i)w_i \omega_i \ell) \) (which is positive if the household chooses to work) or unemployment benefits if unemployed \( (\phi_i w(1 - \tau_i)w_i) \), minus the lump-sum tax, plus gross capital income.

The \( \tau_i \) (which later in the calibration will be set to zero for men and to a positive value for women) enters as a wedge between the agent’s underlying productivity and the perceived market productivity.\(^6\)

As can be seen from the constraint (4), labor is restricted to be zero or one, in other words, the model only includes the extensive margin labor choice.\(^7\)

The instantaneous utility function \( u(c, \ell) \) has a constant relative risk aversion (CRRA) and is separable in consumption and participation in the labor market:

\[
u(c, \ell) = \frac{c^{1-\sigma} - 1}{1-\sigma} - \psi_i \ell.
\]

After working-age single households stochastically enter retirement, they solve the following problem:

\[
V_i^r(a) = \max_{c, a'} \left\{ u(c, 0) + \beta_i \left[ (1 - \pi_w)EV_i^r(a') + \pi_w EV_i^w(a', \omega_i', u_i') \right] \right\} \tag{6}
\]

\(^6\)Another way of modelling the wage gap is to assume it is a wedge, or tax, between the marginal product and the wage the individual receives (as in, e.g., Hsieh et al. (2013) or Jones et al. (2015)). However, in a GE model, the question arises what to do with the tax revenue.

\(^7\)It would be conceptually straightforward to include a choice on the intensive margin as well. For example, the labor choice could be restricted to \( h \in \{0, [h, 1]\} \) where \( h \) represents a lower bound on hours possible to supply to the market, or one could introduce a fixed hours cost of working, as done in, e.g., Chang et al. (2018), use a part-time penalty, as in, e.g., French (2005), or a combination of fixed cost and non-linear earnings, as in Erosa et al. (2016). However, in terms of computational burden it would be non-trivial. Since most of the changes in the relative numbers of hours worked between groups happened along the extensive margin and between two thirds and three quarters of the business fluctuations are on the extensive margin, I choose to focus only on that margin in this model.
where \( \kappa \) denotes retirement benefits. When a retired household is reborn as a working-age household, its productivity and unemployment state (\( \omega'_i \) and \( u'_i \)) are drawn from the ergodic distribution. Hence, there is no intergenerational transfer in terms of productivity.

### 3.2. The couple household problem

The couple household consists of a husband and a wife, who derive utility from consumption and disutility from supplying labor.

When modelling households that consist of more than one person, one has to assume what type of decision process the household uses. Intra-household decision processes can be categorized into three broad classes: the unitary model, non-cooperative processes or cooperative processes. The unitary model, by far the most commonly used, especially in macro models, assumes the existence of a common household utility function. One important implication of the unitary assumption is that decisions only depend on prices and total household income, and are independent of the distribution of income; in other words, they display income pooling, and decisions do not depend on who brought in the money. However, many micro studies have questioned the plausibility of the unitary model in favor of non-cooperative or cooperative models (see, e.g., Chiappori et al. (2002)).

Non-cooperative models assume that no binding agreements between members exist and that the optimal decision need not be Pareto efficient. Both individuals optimize their own utility (which can include caring/altruism towards the other partner). Typically, the actions constitute a Nash equilibrium. One rare example of a macro model using a non-cooperative decision process is Aiyagari et al. (2000). In this study, the household problem is static in nature, which greatly simplifies the analysis; there is no borrowing or lending on a capital market.

Cooperative models assume that negotiations taking place within households result in a Pareto efficient outcome, in the usual sense that no other feasible choice would have been preferred by all household members. There are few macro models using a cooperative decision process, one of them being Knowles (2012) (who also rules out savings).

In this paper, couple households are modelled as unitary households, despite the potential shortcomings of that assumption. The main reason is that a unitary household assumption is a natural starting point for an analysis of the effect of including both singles and couples in a model, due to its simplicity. Secondly, since savings and intertemporal decisions are essential for the questions at hand, deviations from the unitary assumption would substantially complicate the model.
Working households have a constant probability of retiring \( \pi_r \in [0, 1] \) and retired households have a constant probability \( \pi_w \in [0, 1] \) of becoming a working-age household again. Hence, I am assuming that both individuals in the couple enter the retirement phase at the same time.

With the state vector \( x_c \) given by \( x_c = (a, \omega_m, \omega_f, u_m, u_f) \), working-age couple households solve the following recursive problem:

\[
V^c_{\omega}(x_c) = \max_{c, \ell_m, \ell_f, a'} \left\{ u(c, \ell_m, \ell_f) + \beta_c \left[ (1 - \pi_r)EV^c_{\omega}(x'_c) + \pi_r V^r_{\omega}(a') \right] \right\}
\]

\[
s.t. \quad c + a' = w(1 - \tau_m)(1 - u_m) + \omega_f(1 - u_f) + \bar{w}(1 - \tau_m)\omega_mu_m + (1 - \tau_f)\omega_fu_f - 2T + a(1 + r)
\]

\[
\ell_i \in \{0, 1\} \quad \forall i \in \{m, f\}
\]

\[
a' \geq a
\]

Hence, the couple household’s problem is analogous to that of the single household except that a couple household consists of two persons, each with a labor supply decision. Similar to the retired single-person problem, the retired couple households solve the following problem:

\[
V^r_{\omega}(a) = \max_{c, a'} \left\{ u(c, 0, 0) + \beta_c \left[ (1 - \pi_w)V^r_{\omega}(a') + \pi_w EV^c_{\omega}(x'_c) \right] \right\}
\]

\[
s.t. \quad c + a' = (1 - \tau_m)\kappa + (1 - \tau_f)\kappa + a(1 + r)
\]

\[
a' \geq a
\]

As for single households, when a retired household is reborn as a working-age household, the productivity and unemployment states in the next period for the husband and the wife (\( \omega'_m, \omega'_f, u'_m, u'_f \)) are drawn from the ergodic distribution.

The instantaneous utility function is given by:

\[
u(c, \ell_m, \ell_f) = \zeta_1 \left( \frac{c}{\zeta_2} \right)^{1-\sigma} - 1 - \psi_m\ell_m - \psi_f\ell_f
\]

\( \zeta_1 \) and \( \zeta_2 \) together parametrize how the couple derives utility from consumption compared to the single household. In the simplest case, the two individuals in the couple household could split their money equally, buy their own consumption good on the market just as a single individual, and the household utility would be the sum of the two individuals’ utilities. This would mean \( \zeta_1 = \zeta_2 = 2 \). However, if there are economies of scale in the household and some goods are common (think about, e.g., broadband access or heating), we have \( \zeta_2 < 2 \). If the couple household has a different relative valuation of consumption vs. disutility of labor compared to singles (due to, e.g., a higher probability of having children who need to consume as well) it would show up in a different \( \zeta_1 \).
3.3. Technology

The production side of the model is completely standard. Competitive firms employ labor and capital hired from households to produce a homogeneous final good, which is used for both consumption and investment. The aggregate production function is assumed to be Cobb-Douglas:

\[ F(K, N) = zK^a N^{1-a}. \]  \hfill (17)

In the steady-state version of the model we have \( z = 1 \) at all times. Capital is assumed to depreciate at rate \( \delta \).

3.4. Government

The government pays out unemployment and retirement benefits every period and finances itself via lump-sum taxes. It runs a balanced budget in every period.

3.5. Equilibrium definition

Now we can define a stationary equilibrium. Denote a household’s state vector by \((a, b)\) where assets \(a \in A\) and type \(b \in B\), with \(A\) and \(B\) given by:

\[ A = [\bar{a}, \bar{a}] \]
\[ B = \left\{ (c, (\omega_m, \omega_f), (u_m, u_f)), (m, \omega_m, u_m), (f, \omega_f, u_f) \right\} \]

using \(c\) to denote couple households, \(m\) single males, and \(f\) single females. Further, define \(C\), \(M\), and \(F\) as:

\[ C = \{A \times (x, \cdot) | (x, \cdot) \in B, x = c\} \]
\[ M = \{A \times (x, \cdot) | (x, \cdot) \in B, x = m\} \]
\[ F = \{A \times (x, \cdot) | (x, \cdot) \in B, x = f\} \]

and

\[ \mu_c = \int_C d\Gamma, \quad \mu_m = \int_M d\Gamma, \quad \mu_f = \int_F d\Gamma. \]

Let \(\hat{\omega}_i\) define the effective market productivity: \(\hat{\omega}_i = (1 - \tau_i)\omega_i\ \ \forall i \in \{m, f\}\).

A recursive competitive equilibrium is given by a set of prices \(\{r, w\}\), decision rules \(C(a, b), E_m(a, b), E_f(a, b)\) and \(A(a, b)\), and a stationary distribution \(\Gamma\) such that:

1. The decision rules solve the households’ problem for all \((a, b)\).
2. Firms optimize, i.e., factor prices are given by:

\[ r = F_1(K, L) - \delta \quad \text{and} \quad w = F_2(K, L) \]

3. The government budget balances:

\[
\left( \frac{\pi_w}{\pi_r + \pi_w} \right) T \left( \mu_c 2 + \mu_m + \mu_f \right) = \frac{w \varphi}{\varphi} \left( \int_{\mathcal{C}_{um}} \hat{\omega}_m \, d\Gamma + \int_{\mathcal{C}_{uf}} \hat{\omega}_f \, d\Gamma + \int_{\mathcal{M}_u} \hat{\omega}_m \, d\Gamma + \int_{\mathcal{F}_u} \hat{\omega}_f \, d\Gamma \right) \\
+ \left( \frac{\pi_r}{\pi_r + \pi_w} \right) \kappa \left( \mu_c \left( 2 - \tau_r^f - \tau_r^m \right) + \mu_m \left( 1 - \tau_r^m \right) + \mu_f \left( 1 - \tau_r^f \right) \right)
\]

where \( \mathcal{C}_{um} = \{ \mathcal{A} \times (x, \cdot, (u, \cdot)) | (x, \cdot, (u, \cdot)) \in \mathcal{B}, x = c \text{ and } u = 1 \} \) etc.

4. Capital and labor markets clear:

\[
K' = \int_{\mathcal{A} \times \mathcal{B}} A(a, b) \, d\Gamma \\
L = \int_{\mathcal{D}} \left( \hat{\omega}_m E_m(a, b) + \hat{\omega}_f E_f(a, b) \right) \, d\Gamma + \int_{\mathcal{M}} \hat{\omega}_m E_m(a, b) \, d\Gamma + \int_{\mathcal{F}} \hat{\omega}_f E_f(a, b) \, d\Gamma
\]

5. For all relevant Borel sets \( \mathcal{B} \)

\[
\Gamma(B, b) = \sum_{\mathcal{B}} \pi(b | \mathcal{B}) \int_{a : A(a, b) \in \mathcal{B}} \Gamma(da, b)
\]

Note that when I later move on to the deterministic transition path, I will not use the stationary equilibrium but a sequential equilibrium definition in which the equilibrium objects depend on time. To facilitate understanding, I nevertheless spell out the stationary version here, note that the sequential transition-path equilibrium is very similar to that in a steady state, and leave it to the appendix (section A.6).

4. Baseline calibration

In this section I describe how I calibrate the baseline steady-state version of the economy. Since I want to primarily address long-term trends, I calibrate the model to annual data.

Households face two types of idiosyncratic risks: earnings risk determined by the transition matrix \( \pi(\omega'|\omega) \) and unemployment risk determined by the transition matrix \( \pi(u'|u) \). I describe both components in turn. Thereafter I describe the calibration of the remaining parameters.
4.1. Idiosyncratic productivity risk and offered wages

Individuals face labor productivity risk. I assume that log labor productivity follows an AR(1) process specified as:

$$\log(\omega_i') = \rho_i \log(\omega_i) + \varepsilon_{\omega_i}, \ i \in \{m, f\}$$  \hspace{1cm} (18)

with persistence $\rho_i$ and innovation $\varepsilon_{\omega_i} \sim N(0, \sigma_{\omega_i}^2)$. I use values from Borella et al. (2018) who estimate the process separately for men and women using data from the PSID. As can be seen in Table 1, the males’ productivity process is more risky, with a slightly higher persistence and variance. For single households, I use the Rouwenhorst procedure\(^8\) to discretize the process into a 15-state Markov chain: $\omega_i \in \{\omega_1^i, ..., \omega_{15}^i\}$.

For couple households, the productivity process for the husband is assumed to follow the same process as for single men, and the productivity process for the wife is assumed to be the same as the one for single women. However, the innovations of the processes for the husband and wife are assumed to be correlated with $\text{Corr}(\varepsilon_m, \varepsilon_f) = \rho_t$. Since an individual has 15 productivity states, the couple has $15^2$ potential combinations of husband and wife productivities: $(\omega^m, \omega^f) \in \{\omega_1^m, ..., \omega_{15}^m\} \times \{\omega_1^f, ..., \omega_{15}^f\}$. To estimate the transition matrix for the couple productivities, I use a simulation procedure which is a generalization of the method used in De Nardi et al. (2018). Given the AR(1) formulation and the relevant parameters ($\rho_m, \rho_f, \sigma_{\omega_m}^2, \sigma_{\omega_f}^2, \rho_t$), I simulate a very long sequence ($>10^9$ periods) of husband and wife productivities given random draws of the correlated innovations. For every draw I bin the husband and wife productivity in the corresponding bin among the $15^2$ combinations. Then I calculate the observed transition probabilities for each state.\(^9\)

The observed gender wage gap in the model is made up of three distinct pieces, two exogenous and one endogenous. First, there is a small gender productivity gap due to the lower variance of the innovation term to log productivity. Second, there is an exogenous productivity gap, denoted by $\tau_f$ in the model. Third, there is a selection effect in the model, so that the observed wage gap does not equal the wage gap of offered wages.

---

\(^8\)I prefer the Rouwenhorst procedure to, e.g., the Tauchen method since the productivity processes are highly persistent; see Kopecky and Suen (2010) for a detailed description and evaluation of the method.

\(^9\)With $\rho_t = 0$, the joint transition matrix is simply given by the Kronecker product of the transition matrices for males and females, respectively. If one would want to accept that the discretized productivity states for couple individuals differ from those for single individuals, one could define $x^A = \log(\omega^m) + \log(\omega^f)$ and $x^B = \log(\omega^m) - \log(\omega^f)$. We would then have $x^A_{t+1} = \rho x^A_t + (\varepsilon^m_t + \varepsilon^f_t)$ and $x^B_{t+1} = \rho x^B_t + (\varepsilon^m_t - \varepsilon^f_t)$ where $\text{Cov}(\varepsilon^m_t + \varepsilon^f_t, \varepsilon^m_t - \varepsilon^f_t) = 0$. Using the Kronecker product for the joint transition matrix, we could then convert $x^A$ and $x^B$ back to $\log(\omega^m)$ and $\log(\omega^f)$. However, then the productivity states for a single individual and a married individual would differ in levels and therefore I prefer to use the simulation based approach.
<table>
<thead>
<tr>
<th>Parameter</th>
<th>Description</th>
<th>Value</th>
<th>Source</th>
</tr>
</thead>
<tbody>
<tr>
<td>$\rho_m$</td>
<td>Persistence males</td>
<td>0.973</td>
<td>Borella et al. (2018)</td>
</tr>
<tr>
<td>$\rho_f$</td>
<td>Persistence females</td>
<td>0.963</td>
<td>Borella et al. (2018)</td>
</tr>
<tr>
<td>$\sigma^2_{\varepsilon m}$</td>
<td>Conditional variance males</td>
<td>0.016</td>
<td>Borella et al. (2018)</td>
</tr>
<tr>
<td>$\sigma^2_{\varepsilon f}$</td>
<td>Conditional variance females</td>
<td>0.014</td>
<td>Borella et al. (2018)</td>
</tr>
<tr>
<td>$\rho_{\varepsilon}$</td>
<td>Couple correlation</td>
<td>0.36</td>
<td>Estimate from PSID</td>
</tr>
<tr>
<td>$\tau_f$</td>
<td>Female productivity wedge</td>
<td>20%</td>
<td>See text</td>
</tr>
<tr>
<td>$\tau_m$</td>
<td>Male productivity wedge</td>
<td>0%</td>
<td>Normalization</td>
</tr>
</tbody>
</table>

Table 1: Parameters for the productivity processes and wages.

Given the higher variance of men’s log productivity, the average offered wage to women is 5% lower than the average offered wage to men, before applying any productivity wedge. However, the selection effect is stronger for women: relatively more women with low wages choose not to work. Therefore, in the absence of a female productivity wedge, the observed wage gap between men and women would be much smaller than 5%. I choose $\tau_f$, the female productivity wedge, so that the observed median wage gap is 20% and observed mean wage gap is 21%.

In the same way, the observed correlation of working husband wages and working wife wages in the model differs from the chosen $\rho_{\varepsilon}$ due to the selection effect. It is more likely that a wife with a high productivity draw works than one with a low-productivity draw, and therefore the resulting observed correlation is higher. However, in practice, this difference is small, and I therefore ignore it.

4.2. Idiosyncratic unemployment risk

The unemployment risk is taken from Krueger et al. (2016). Since they use quarterly data and I have an annual model, I have to convert their transition probabilities, taking into account all possible routes from e.g. employed first quarter to employed first quarter one year later (e.g. being employed all four consecutive quarters, or losing one’s job in the first quarter, being unemployed in the second quarter, finding a job in the third quarter again, etc.). The resulting transition matrix is:

$$
\begin{bmatrix}
\pi_{uu} & \pi_{ue} \\
\pi_{eu} & \pi_{ee}
\end{bmatrix}
= \begin{bmatrix}
0.0538 & 0.9462 \\
0.0533 & 0.9467
\end{bmatrix}.
$$

(19)

The model in Krueger et al. (2016) is a model with aggregate uncertainty in which employment/unemployment transitions depend on the transition of an aggregate two-state TFP process. When adopting their employment/unemployment transitions I condition on an aggregate transition from a good to a good state.
There is no difference in the model between men and women in terms of separation rates or job-finding rates. In the U.S. there are no statistically significant differences between men and women in terms of search intensity, neither on the extensive nor the intensive margin, according to Krueger and Mueller (2012) who use data from the period 1991-2006.

However, there are clear gender differences between men and women in terms of unemployment level. Albanesi and Şahin (2018) document a gender unemployment gap: women have had a higher unemployment rate than men up until the 1980s, and thereafter the gap virtually disappeared, except in recessions, when it now is reversed (men have higher unemployment). However, looking at subgroups, single men are more unemployed than any other group, see Figure 10 (for the population aged 35-64, the pattern is the same, see section A.4). The second most unemployed group is single women. According to Albanesi and Şahin (2018), the convergence in unemployment rates between men and women is mainly driven by an increased labor force attachment among women. Hence, in the absence of a three-state model with frictions on the labor market, this convergence is therefore better captured by the labor supply choice than an exogenous unemployment shock.

To summarize, the equal unemployment probabilities used in this model constitute a reasonable starting point. Moreover, I assume that a husband’s and wife’s unemployment risks are uncorrelated.
4.3. Discount factors and savings targets

The utility function used in the model aggregates, which means that if the couple households had perfectly correlated productivity shocks, unemployment shocks and labor choices, they would behave as a twice as large single household (assuming \( \zeta_1 \), the consumption utility scale parameter, to be 2). Consequently, couple households would on average save twice as much as single households. However, shocks within households are not perfectly correlated, as discussed above and, importantly, the husband and wife do not perfectly correlate their labor supply. Hence, the couple has access to an intra-household insurance mechanism, which makes them less willing to save for precautionary reasons.

Of the three insurance mechanisms mentioned above – the productivity risk, the unemployment risk, and the labor supply mechanism – the lower joint productivity risk is the most important. If we assume that the husband’s and wife’s productivity processes were uncorrelated within the couple, the couple’s need for precautionary savings would decrease substantially. The reason is simply that the variance of their joint productivity would decrease by half compared to the perfectly correlated case.\(^{11}\) The opportunity to supply labor in an uncorrelated way is approximately one third as important in terms of how much less the couple wants to save, while the uncorrelated risk of unemployment affects the precautionary savings very little (with the calibration in this model, assuming a reasonably high replacement rate in case of unemployment).

In general equilibrium in an economy consisting of only couples, the interest rate would adjust to the couples’ lower demand for savings compared to single households. To induce enough savings the interest rate would go up, and the resulting savings per capita would be similar to the savings in a singles-only economy. However, in an economy populated by both singles and couples, the interest rate cannot adjust all the way.

Table 2 illustrates the effect. In the “singles economy” there are only single households, and the equilibrium interest rate is 1.54%.\(^{12}\) The “couples economy” consists of only

\(^{11}\)Assume that the individual perceives a productivity process with the following first two moments: 
\[ E[\omega_i] = \mu \text{ and } \text{Var}(\omega_i) = \sigma^2. \]
Then a couple with perfectly correlated productivity processes would have the following two first moments:
\[ E[\omega_i + \omega_j] = 2\mu \text{ and } \text{Var}(\omega_i + \omega_j) = 4\sigma^2. \]
However, if the productivity processes are uncorrelated, the first moment is unchanged, while the second moment is
\[ \text{Var}(\omega_i + \omega_j) = 2\sigma^2. \]

\(^{12}\)Compared to a canonical Aiyagari (1994) model like the one reported in the original paper with the calibration closest to mine (log utility, resulting interest rate 3.3%), the interest rate in my model is lower. One reason is the more risky productivity process, with a higher persistence (0.97 instead of 0.9) and a higher variance (0.45 instead of 0.4 unconditional). The other reason is the endogenous labor supply. Being able to choose leisure instead of labor in periods with relatively low productivity increases the demand for savings to be able to smooth consumption from good to bad states, and hence the equilibrium interest rate is lower.
couples, and the interest rate is more than one percentage point higher. If we compare the per-capita savings between those economies, the difference is not that big: singles save 5.9 per capita, while couples save 4.6 per capita, i.e., 77% of what the singles save in their singles-only economy.

However, if we mix those two types of households (assuming, for simplicity, an equal number of single and couple households), we get the third “singles and couples economy”. The equilibrium interest rate in this mixed economy is, as expected, in between the interest rates in the first two economies. The resulting effect on singles is, not surprisingly, that the higher interest rate makes them save more than in the singles-only economy, and work slightly less. The effect on couples is reversed: the lower interest rate makes them want to save less and work slightly more. What might be more surprising is the magnitude of the effects. In per-capita terms, the couples now save only 28% of what the singles do in per-capita terms.

The example given above assumed uncorrelated productivity processes within the couple, while in the baseline calibration in the model, the correlation is assumed to be 0.36. This correlation is far from enough to overturn the result of lower savings per capita for couples than singles in the model. However, turning to the data, in reality couple households save approximately twice as much as single households (in other words, the per-capita savings level is similar). To capture this fact, I assign a permanently higher discount factor to couple households. It could be thought of as capturing underlying permanent differences in how households discount the future, but it could also be a reduced form of modelling some other underlying difference between those types of households.

4.3.1. The absence of divorce

The model used in this paper does not incorporate any divorce risk, something one might suspect would affect asset accumulation. However, it is not entirely clear how divorce should be modelled and what the implications for savings would be. First of all,

---

13To clearly illustrate the effect, the couples consist of two individuals who are in every aspect like the individuals in the singles economy, the productivity risk is uncorrelated within the couple, and $\zeta_1$, the consumption scale factor, is assumed to be 2. In other words: the only thing that differs between the “singles economy” and the “couples economy” is that the couples are optimizing in households consisting of two persons.

14This fact is not driven by age differences between single and couple households, and it is not driven by any specific type of asset class. See section A.3 for asset holdings by household type and age.

15The same increase in couple savings could also have been achieved by increasing their risk aversion, or by introducing a large negative shock that would be (close to) perfectly correlated within a couple. For the latter option, one thing that is easy to think of is retirement, i.e., a long period without income that is close to perfectly correlated within couples. However, a retirement phase with a reasonable replacement rate is not sufficient to drive up the couple household savings enough, as can be seen from the results. To drive up savings for couple households enough the retirement phase must be both counterfactually long and have counterfactually low benefits. Results from models with differences in risk aversion and with a retirement phase with zero benefits are available upon request.
Table 2: Comparison of three stylized economies. The first economy consists of only singles, the second of only couples, and the third of both singles and couples.

<table>
<thead>
<tr>
<th></th>
<th>Singles</th>
<th>Couples</th>
<th>Singles and couples</th>
</tr>
</thead>
<tbody>
<tr>
<td>Interest rate</td>
<td>1.54%</td>
<td>2.61%</td>
<td>2.16%</td>
</tr>
<tr>
<td>Assets singles</td>
<td>5.93</td>
<td>–</td>
<td>9.50</td>
</tr>
<tr>
<td>Labor singles</td>
<td>1.21</td>
<td>–</td>
<td>1.10</td>
</tr>
<tr>
<td>Assets couples</td>
<td>–</td>
<td>9.10</td>
<td>5.35</td>
</tr>
<tr>
<td>Labor couples</td>
<td>–</td>
<td>2.12</td>
<td>2.17</td>
</tr>
</tbody>
</table>

one might argue that divorce is an endogenous decision, probably correlated with e.g. unemployment and bad productivity draws. Or one could argue that it is endogenous, but driven by some other unobserved “shock”, so that from a modelling perspective it can be treated as random.

However, even if one models divorce as a stochastic shock, the implications for savings differ depending on modelling choices. Fernández and Wong (2014) argue that there are conflicting interests within the family. Assuming that the wife has a lower income in the state of divorce, the married woman would prefer to increase savings to transfer more assets to the divorced state, while the married man on the other hand would prefer to increase consumption in the married state as this is what allows him to smooth consumption. In a partial equilibrium life-cycle model, they show that the net effect is a decrease in savings, assuming an equal split of assets in the case of a divorce and constant Pareto weights.

Cubeddu and Ríos-Rull (2003) also model divorce as a stochastic shock. In a general equilibrium model with family type following a stochastic process (and no further idiosyncratic shocks), they show how the size of savings differs dramatically depending on the details governing the marital type process. The net effect of divorce depends on, e.g., relative decision weights, rules governing the splitting of assets after separation, time horizons and subsequent marriage patterns.

Voena (2015) stresses that the difference in savings depends on the precise legal framework of the divorce process. Using panel variation in U.S. laws, she shows how the introduction of unilateral divorce is associated with higher household savings compared to a regime with mutual divorce decisions.

To summarize, it is not entirely clear how the absence of divorce affects relative savings in the model, and there is even evidence suggesting that couple savings would go down if divorce was introduced.
4.4. Remaining parameters

Table 3 lists the remaining parameters used in the model. I use log utility for consumption so that the preferences are of the “balanced growth” type. Hence, income and substitution effects cancel and labor supply would be constant with balanced growth in the model, which allows me to abstract from it.\textsuperscript{16}

The disutility of work for men and women, $\psi_m$ and $\psi_f$ respectively, together with the consumption scale for couple households ($\zeta_1$) are jointly chosen so that labor supply for the four demographic subgroups is approximately matched. As can be seen, the disutility of females is assumed to be 7.6% higher than the disutility of men in order to hit the correct employment rates by subgroup. This higher disutility of work for females can be seen as a reduced form of modelling various plausible mechanisms distorting the work-leisure choice for women compared to men: discrimination in the workplace, unevenly distributed household chores, or social norms, just to name a few.

Note that $\zeta_2$, the second parameter guiding the consumption scale for couple households, is indeterminate when we have $\sigma = 1$, i.e., log utility from consumption.

I assume an equal number of single female households and single male households ($\mu_m = \mu_f$) and that the total number of households sums up to one ($\mu_c = 1 - \mu_m - \mu_f$).

The retirement benefits for men are assumed to be 30% of the male median income (which is normalized to 1), since the standard replacement rate is around 40%, and in the period 1960 up until now, approximately three quarters of old-age households received social security income.\textsuperscript{17} Women are assumed to get $\tau_f$ less, and in line with the data, I set $\tau_f = 23\%$.

The probability for a working-age household to retire is chosen so that the expected work life is 40 years. The probability for a retired household to be reborn as a working-age household again is chosen so that the retirement phase is 15 years in expectation.

\textsuperscript{16}Boppart and Krusell (2016) have shown that a utility function where the income effect slightly dominates the substitution effect is more in line with cross-country evidence over a long time horizon. Allowing for such preferences would be an interesting but non-trivial extension.

\textsuperscript{17}In 1962, 69% of the aged units (a married couple living together or a nonmarried person) received social security, in 2015 the corresponding figure was 84% (Fast Facts and Figures about Social Security, 2017). However, taking into account this change over time doesn’t change any results; hence, I use the approximate average.
<table>
<thead>
<tr>
<th>Parameter</th>
<th>Description</th>
<th>Value</th>
<th>Source</th>
</tr>
</thead>
<tbody>
<tr>
<td>Preference parameters</td>
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<td></td>
<td></td>
</tr>
<tr>
<td>$\beta_m, \beta_f$</td>
<td>Discount factor singles</td>
<td>0.949</td>
<td>Standard value</td>
</tr>
<tr>
<td>$\beta_c$</td>
<td>Discount factor couples</td>
<td>0.96</td>
<td>See section 4.3</td>
</tr>
<tr>
<td>$\sigma$</td>
<td>Relative risk aversion</td>
<td>1.0</td>
<td>Standard value</td>
</tr>
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<td>$\psi_m$</td>
<td>Disutility of work men</td>
<td>1.406</td>
<td>See text</td>
</tr>
<tr>
<td>$\psi_f$</td>
<td>Disutility of work women</td>
<td>1.513</td>
<td>See text</td>
</tr>
<tr>
<td>$\zeta_1$</td>
<td>Consumption scale for couple hh</td>
<td>3.286</td>
<td>See text</td>
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<tr>
<td>$\zeta_2$</td>
<td>Consumption scale for couple hh</td>
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<td>Production technology parameters</td>
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<tr>
<td>$\alpha$</td>
<td>Capital share</td>
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<td>Standard value</td>
</tr>
<tr>
<td>$\delta$</td>
<td>Depreciation rate</td>
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<td>Standard value</td>
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<tr>
<td>Social security</td>
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<td></td>
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<tr>
<td>$\varphi$</td>
<td>Replacement rate unemployment</td>
<td>50%</td>
<td>Krueger et al. (2016)</td>
</tr>
<tr>
<td>$\kappa$</td>
<td>Replacement rate retirement</td>
<td>0.3</td>
<td>See text</td>
</tr>
<tr>
<td>$\tau_f^r$</td>
<td>Retirement “tax” on women</td>
<td>23%</td>
<td>SSA Fact Sheet</td>
</tr>
<tr>
<td>$\tau_m^r$</td>
<td>Retirement “tax” on men</td>
<td>0%</td>
<td>Normalization</td>
</tr>
<tr>
<td>Other parameters</td>
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<td></td>
<td></td>
</tr>
<tr>
<td>$a$</td>
<td>Borrowing constraint</td>
<td>0</td>
<td>Standard value</td>
</tr>
<tr>
<td>$\mu_m, \mu_f$</td>
<td>Share of hh single males (females)</td>
<td>22%</td>
<td>CPS</td>
</tr>
<tr>
<td>$\pi_r$</td>
<td>Prob. working age hh $\rightarrow$ retired</td>
<td>1/40</td>
<td>Krueger et al. (2016)</td>
</tr>
<tr>
<td>$\pi_{w}$</td>
<td>Prob. retired hh $\rightarrow$ working age</td>
<td>1/15</td>
<td>Krueger et al. (2016)</td>
</tr>
</tbody>
</table>

Table 3: Calibrated parameters
5. Steady-state results

I now turn to the steady-state results of the model. The upper half of Table 4 shows employment, consumption and asset holdings in the data. The employment figures refer to CPS data from 2017 for the age group 25-64. Consumption and asset data refer to the PSID wave 2008 for the whole population.\textsuperscript{18}

The second half of Table 4 shows the model results. Employment refers to the employment-to-population ratio for the working-age population in the model, to make the figures comparable. As can be seen, the employment figures line up in the right order: married men work the most, thereafter single men and single women, while married women work the least.

Consumption and asset holdings are for all households (both working-age and retired). As can be seen, couples consume more than single men both in the data and in the model. However, in the model, single women consume less than single men, which is not what we see in the data. One reason could be that that model does not include any social benefits and transfers of any kind (besides unemployment benefits), which is an income type that is more important for single women than for other groups.\textsuperscript{19}

The asset levels by group are roughly in line with the data: couples have slightly more than twice as much assets as single men, which is due to the higher permanent discount factor for couples.

There is a selection effect in terms of observed wages compared to offered wages, especially among married women. A married woman with a high wage is more likely to work than a woman with a low wage and therefore the observed average wage among working married women is higher than their average offered wage. The selection effect in the model is 10\% for married women, but non-existent for single women.

A selection effect is also present among men, albeit not as pronounced. The effect is stronger for married men, since they can, at times of low productivity, choose to stay at home if their wife has a relatively high productivity, while this insurance mechanism does not exist for singles. The result is that married men have a 6\% higher observed wage than single men, which might explain a (small) part of the marriage

\textsuperscript{18}Since 1999, when the PSID was redesigned, the consumption data cover over 70\% of all consumption items available in other data sources, such as the Consumer Expenditure Survey (CEX). The PSID consumption data cover, besides food, many other non-durable and services consumption categories, including health expenditures, utilities, gasoline, car maintenance, transportation, education, and child care. For a detailed description of the consumption data in the PSID, see Blundell et al. (2016). I also follow their method of imputing rent expenditures for homeowners using the self-reported house value. Asset data refer to cash, bonds, stocks, real estate, business property, cars and vehicles, and pension funds, deducting mortgages and other debts.

\textsuperscript{19}See Low et al. (2018) for an overview of the development of welfare programs over time, in particular how the PRWORA reform replaced AFDC with TANF, and the impact on women’s labor supply in a life-cycle model setting.
Couples | Single men | Single women
---|---|---
**Data**
Employment | 85.7%, 67.6% | 72.7% | 70.6%
Consumption | 1.7 | 1.0 | 1.0
Assets | 2.3 | 1.0 | 0.7

**Model**
Employment | 86.7%, 67.7% | 75.4% | 73.5%
Consumption | 1.9 | 1.0 | 0.7
Assets | 2.2 | 1.0 | 0.6

Table 4: Data moments and model results. Consumption and asset holdings are normalized to single men values.

premium for men (typically thought of in the 10-40% range; see Korenman and Neumark (1991)).

### 5.1. Comparing steady-state models

Some initial insights can be gained from comparing steady-states with different calibrations. Table 5 describes four models that differ in terms of female productivity gap ($\tau_f$) and female disutility of labor ($\psi_f$). Model 1 refers to the baseline model, calibrated so that labor force participation by subgroup and the observed female wage gap are what we observe in the data today, as described in section 4. Model 2 refers to the baseline model, but calibrated so that the observed female wage gap is what we observed at the beginning of the 1960s.

Model 3 is an alternative specification in which $\psi_f$, the disutility of labor for females, is adjusted up 20% but the productivity gap is the same as in the baseline model. Model 4, finally, is a model in which I change both $\tau_f$ and $\psi_f$.

Figure 11 shows the resulting employment rates. There are a couple of insights to be had. First of all, in model 2 a higher productivity wedge, $\tau_f$, makes the married women work substantially less. What might at a first glance be more surprising is the small (and even positive) effect on single women’s employment rate. However, for single women, a change in the productivity wedge is similar to a change in the overall wage level, and such a change has a small impact on labor supply with balanced growth preferences. The income effect and the substitution effect cancel, and therefore the net effect on single women is small (and in this case even positive). Hence, the model delivers a theory of

---

20 A related observation is that the selection effect is stronger in this model: for married women the average wage among working individuals is 16% higher than the offered wage.
why married and single women display different responses to changes in wages in the long run.

A second observation is that the increase in married men’s employment is not nearly as large as the decrease in married women’s employment. There is no “crowding-out” within the couple, in line with what we see in the data.

A third observation is the negligible effect on single men, which is not surprising. The only way this higher productivity wedge affects single men is via the general equilibrium channel with changes in the interest rate, wage and lump-sum tax.

In model 3, an increase in women’s disutility of labor by 20% leads to decreasing employment figures for both married women and single women, while again single men are, of course, unaffected. Married men adjust their employment slightly upwards to compensate for their wives’ lower labor supply.

In model 4, finally, both the productivity gap and the disutility of labor are increased compared to the benchmark. In this model, both single women and married women work less, while again married men work slightly more to compensate for their wives’ lower earnings, and single men are hardly affected. Model 4 is an example of a parametrization of the model for which the employment rates by subgroup in 1962 are hit very closely.

### 6. Transition from low to higher female labor force participation

In this section I describe the economy during a deterministic transition. The variable that changes over time is $\tau_f$, the female productivity wedge. Hence, I choose to only include the effects directly driven by the shrinking female productivity wedge. Clearly, the approach does not rule out the possibility that other changes (such as, for example, access to contraception, changes in divorce laws, cheaper child-care, and/or changes in social norms) have played an important part. However, the decreasing wage gap is

<table>
<thead>
<tr>
<th>Model 1</th>
<th>Model 2</th>
<th>Model 3</th>
<th>Model 4</th>
</tr>
</thead>
<tbody>
<tr>
<td>$\tau_f$</td>
<td>20%</td>
<td>45%</td>
<td>20%</td>
</tr>
<tr>
<td>$\psi_f$</td>
<td>1.513</td>
<td>1.513</td>
<td>1.816</td>
</tr>
<tr>
<td>Observed wage gap (mean)</td>
<td>21%</td>
<td>43%</td>
<td>19%</td>
</tr>
<tr>
<td>Observed wage gap (median)</td>
<td>20%</td>
<td>45%</td>
<td>20%</td>
</tr>
</tbody>
</table>

Table 5: Comparison of four models with different calibrations of the female disutility of labor ($\psi_f$) and the productivity wedge ($\tau_f$) and the resulting observed wage gap.
Figure 11: Steady-state comparison. Employment rates by subgroup from four steady-state models with different calibrations as described in Table 5.

more easily observed in aggregate data, and I deem it an important first step to focus on its effect in isolation.

The decrease in $\tau_f$ may be interpreted in several ways. One is that the decrease of $\tau_f$ is driven by a female-biased technical change (as suggested by, e.g., Galor and Weil (1996) or Ngai and Petrongolo (2017)). Another is that it could be due to a decrease in discrimination. The discrimination against women, leading to misallocation of talent and lost productivity, was probably worse in the 1960s than now, and one can easily come up with several examples. For instance, as told by Jones (2016), Sandra Day O’Connor, who later became the first female Supreme Court Justice, graduated third in her class from Stanford Law School in 1952. However, the only private sector job she could get upon graduation was as a legal secretary. It is easy to imagine that the same type of discrimination and misallocation of talent takes place also at lower levels, but that this discrimination has decreased over the years.

6.1. Modelling the transition

We now turn to the transition path. The transition is assumed to happen with perfect foresight: in 1960 people learn that $\tau_f$, the female productivity wedge, will go down over time. Hence, agents are surprised only once but thereafter enjoy perfect foresight
Figure 12: The decline of $\tau_f$, the female productivity wedge, over time as modelled for the transition path.

about the future.\textsuperscript{21}

The end of the transition, the final steady-state, is the baseline model calibrated as described in section 4, while model 2 is used as the transition’s starting point. In other words, the only difference between the start and the end of the transition is that in 1960 the female productivity wedge was larger. Otherwise the two economies are exactly the same. It is obviously a stretch to assume that the economy was in a steady state in 1960, and we will keep that in mind when interpreting the results later.

$\tau_f^{1960}$ is calibrated so that the observed median female wage gap is 45% and the observed average female wage gap is 43% in the initial steady-state. I model the shrinking productivity wedge as a smooth decline from 45% to 20% over a period of 50 years, as Figure 12 illustrates. However, in reality the wage gap has had an uneven trajectory, with a strong decrease historically up until the 1930s, then being almost stable around 40% between 1950 and the end of the 1970s, and thereafter continuing to decrease (see Goldin (1990) for an overview of the history of the gender wage gap and its underlying forces). Instead of trying to match the observed average wage gap year by year, I choose a crude straight line approximation to facilitate the interpretation of the results. In a model with discretized productivity states, the observed median wage gap is the same as the offered median wage gap (despite differences in the underlying AR(1) parameters), since even with 15 productivity states, 15% of the individuals are in the middle bin. Hence, the selection effect would have to be extremely strong to overturn this. To summarize, I use the linear approximation of the median gap as given by Proctor et al. (2016).

\textsuperscript{21}An alternative would be to model the agents as myopic: at each date they believe that the current wage structure will prevail forever, being repeatedly surprised every year, as e.g. Heathcote et al. (2010) do as a robustness check.
6.2. Transition results

The resulting employment paths for the different subgroups are shown in Figure 13. A first thing to note is that the increase in married women’s employment is 19.5 percentage points, roughly two thirds of the total change between the years 1960 and 2000.

Second, married men decrease their labor supply by about 5.5 percentage points, but not nearly as much as the increase among married women, which corresponds well to what we observe in the data.

Third, except for the immediate jump at the beginning of the transition (which we will discuss later), single women hardly change their labor supply due to the change in the female productivity wedge. Changes in the female productivity wedge are for them similar to changes in the overall level of wages, and these changes have a small impact on labor supply if preferences are of the balanced growth type. The income effect and the substitution effects roughly cancel and labor supply is approximately the same. This is also in line with what we observe in data.

Lastly, single men are only affected by general equilibrium effects. Their labor supply is therefore, not surprisingly, hardly affected, except for the strong jump in the first half of the 1960s.

Thus, changes in the female productivity wedge, leading to changes in the gender wage gap corresponding to what we have seen in the data, have a strong effect on married women, and explain roughly two thirds of the total change in employment we have seen for this group during the last 60 years. The effect on single women is
very small, on the other hand. Nevertheless, in the short run, single women react a
great deal more to a sudden wage change, because their intertemporal elasticity is
higher.

There are, of course, other things that have been going on at the same time in the
economy that affect the question at hand. One thing is a potential decrease of the female
disutility of work, $\psi_f$. It is easy to imagine that the disutility of work for females has
gone down since the 1960s, due to workplace related factors (e.g. less discrimination
and harassment in the workplace), factors more generally related to the cost of working
(e.g., child-care options and social norms), and couple-specific factors (e.g. more evenly
distributed household chores). Some combination of those factors explains the remaining
third of the labor supply increase for women that is not captured by the model in this
paper, and the fact that single women have increased their labor supply somewhat more
than predicted by this model. However, for the purpose of this paper, I choose to focus
on the closing of the wage gap and its effects, and note that this gives a lower bound
for the overall effects of the increase in the labor force participation among (married)
women.\footnote{The increase in single households is also a trend that could be taken into account when analyzing changing household composition and the effect on an economy’s response to aggregate shocks. In 1962, one fifth of all women between 25 and 64 were single. By 2017, the corresponding figure had increased to two fifths. However, it is not entirely clear how this increase should be captured in a model with infinitely lived households. One could imagine that there is an influx of new households to the closed economy, that all those new households are singles, and that the distribution of immigrating single households corresponds to the ergodic distribution of existing households in terms of assets and productivity. That would correspond to changing the weights $\mu_m$ and $\mu_f$ over time. None of the main insights changes, and the results from such an exercise are available upon request.}

6.3. Labor supply responses by subgroup

There is a strong immediate response by single women at the beginning of the tran-
sition. Compared to the steady-state labor supply, the single women’s labor supply
immediately drops at the beginning of the transition and climbs back later. When they
learn about their higher future wage, they prefer to intertemporally shift some of their
labor supply from today to tomorrow. This effect exists but is much smaller for married
women.

The difference in immediate response is a direct result of how the mass of individuals
in the model is distributed in relation to the working decision. Figure 14 is helpful
to understand the underlying mechanisms. It shows the policy functions for a single
woman (not hit by an unemployment shock) in a model with only five productivity
states. For a given productivity level, a woman will work if she has little wealth, and
choose not to work if she is rich. At the asset level for which the woman decides to stop
working, there is also a kink in the savings policy function, and that is where the savings
policy function crosses the 45 degree line. In other words, for asset levels below the
point where the woman stops working, she is saving up assets, and for the asset levels
Figure 14: Illustrative policy functions for a single women (not unemployed) in a model with five productivity states. The x-axis denotes beginning-of-period assets.

Figure 15: Distribution of mass for single women over productivity and assets (blue dots) and the working frontier (red line). North-west is working region, south-east is where the women do not work. Mass not drawn to scale, differences are exaggerated. The x-axis does not show the full state space, but covers where > 99% of the mass are.
Figure 16: Illustration of work and savings behavior in the asset/productivity space. Gray line indicates where the savings policy function crosses the 45% line, dots indicate the asset level where the person is rich enough to choose not to work.

above the point where the woman stops working, she is decumulating assets. Hence, with a persistent productivity process there will be bunching of individuals around this exact point. This is seen in Figure 15, which shows the resulting distribution of mass among single women. The thick red line indicates the “working frontier”. In the region north-west of the line, i.e., in the region where individuals have low assets and/or high productivity, the decision is to work. In the region south-east of the line, i.e., in the region with high assets and/or low productivity, the decision is to not work. As can be seen from the illustration, there is a clear excess mass along the “working frontier”. Individuals move randomly between productivity levels, hence the mass is still spread out, but with a persistence of the productivity process such the one used in this model, the bunching behavior can clearly be seen.

To be able to compare this behavior among single women to the behavior among married women, first consider Figure 16a, which shows the asset level for which the single woman is rich enough to stop working, conditioning on productivity level, indicated by dots. The grey line shows the points where the savings policy functions cross the 45 degree line. As can be seen, the two decisions coincide.

Now we can compare this to Figure 17a, which shows the same type of graph but for a married woman, assuming that her husband is in the lowest productivity state. As can be seen, for a married woman the working frontier does not coincide with the wealth level where the switch from accumulation/decumulation of assets happens in the same
(a) Married woman, conditioning on having a husband in the lowest productivity state.

(b) Married woman, conditioning on having a husband with productivity state 10 (out of 15).

**Figure 17:** Illustration of work and savings behavior in the asset/productivity space. Gray line indicates where the savings policy function crosses the 45% line, dots indicate the asset level where the person is rich enough to choose not to work.
Figure 17b shows the case of a married women when the husband has a relatively high productivity (state 10 out of 15). For the states in which the woman has low productivity, she does not work while the husband does. However, higher productivity, even though leading to no change in the working decision, leads to a lower asset threshold for accumulating vs decreasing assets. The reason is the change in continuation value: if the woman has a higher productivity, there is an increasing probability that she will get an even higher productivity in the future and in that future state start working. Therefore, the continuation value increases with higher productivity, and the couple can “eat from their savings”, despite the actual working decision being constant.

7. Aggregate shocks during the transition path

It is now time to turn to the question about the economy’s response to aggregate shocks during the transition path. I study the economy’s response to a single, small “MIT shock” and regard the impulse response path as a numerical derivative of the economy’s aggregate response. For the TFP shock I use standard parameters as in Boppart et al. (2018), translated into annual values, i.e., I assume a standard deviation of \( \sigma_z = 0.0260 \). After impact a shock decays geometrically at a rate of \( 1 - \rho_z \), with \( \rho_z = 0.815 \).\(^{23}\)

Conceptually, Figure 18 shows what happens in the model: during the deterministic transition path, the economy is shocked by an increase in TFP, and then transitions back to its underlying transition path.\(^{24}\) As can be seen from the figure, the employment figures show that single men and single women react more strongly than married women. Married men seem to be reacting the least. I will now analyze these responses more formally.

7.1. Jobless recoveries

If the economy is hit by a strong negative TFP shock, how does employment react, and how does the reaction depend on where the economy is in the transition path? To see if the model captures the historical facts of employment effects after a recession, we do the following experiment: The economy is shocked with a negative TFP shock of

\(^{23}\)Boppart et al. (2018) use a quarterly serial correlation of 0.95, hence the annual value 0.815. A quarterly standard deviation of 0.007 gives an annual value of \( \frac{0.007 \cdot 1}{1 - 0.95^4} = 0.0260 \).

\(^{24}\)For a discussion about the appropriateness of MIT shocks during a transition path, section B in the appendix gives a comparison between a model with “true” uncertainty and BKM shocks during a transition path in a representative agent setting. The conclusion is that the two models give the same results, and that the underlying transition matters in that particular example for the economy’s response to aggregate shocks.
Figure 18: Resulting employment figures by subgroup from shocking the economy with a very large positive TFP shock (three standard deviations) in year 1980.

As can be seen from Figure 19a, when the economy is hit by a negative TFP shock, total employment falls. Single men are most affected immediately on impact. Four years later, the economy has returned to its initial total employment level (even slightly above). The subgroup driving this recovery is married women, and to some extent single women. After four years, neither single men nor married men have returned to their pre-recession employment level.

Figure 19b shows the same type of TFP shock, but in the year 2010, i.e., when the employment figure for married women has stabilized at its current level. Now, four years after the shock, the employment figures have still not returned to their pre-shock level. The main difference is that married women are no longer driving up the employment figures. Again, as in the data, single men are the group most severely hit by the negative shock in terms of employment.

Even though these results are not surprising, given the previous discussions about labor supply responses by subgroup (section 6.3) and the lack of crowding-out, both in steady-state and during the transition path, it is reassuring that the model captures the most salient features of the phenomenon sometimes referred to as jobless recoveries.
7.2. Impact of an aggregate shock

Figure 20 shows the TFP shock and the impulse response function for output at four different points in time during the transition path. As can be seen in the figure, the response does not change in any meaningful way between years. However, what on the aggregate might appear as no changes over time is the sum of multiple counteracting forces.

I now turn to the detailed employment results for different subgroups. The first line of Table 6 shows the immediate impact of an aggregate shock to employment by subgroup in the steady-state model (calibrated to “today”, i.e., the end of the transition as described above). The first observation is how the size of the employment effect in steady state differs between groups. If we first focus on married couples, we see that married men are least impacted (their employment rate goes up by 0.41% as a consequence of a TFP shock of one standard deviation), while married women react a lot stronger (1.43% impact). The substantially stronger response among married women than among their husbands is in line with labor supply elasticity estimates from a number of studies (see Blundell and MaCurdy (1999) for an early overview).

In line with data, singles, and in particular single men, exhibit the highest employment volatility. From a modelling perspective this is not surprising, given the discussion in section 6.3 about labor responses by subgroup. To reconcile the fact that married women and single women react more than married men, remember that we do not take into account any sector specificities in this model.

Turning to changes over time, Table 6 shows that married men as a group have increased their response over time. In 1970, the effect of an aggregate shock to their employment level was only half of what is estimated for steady-state “today”. However, absolute changes for married men are small as compared to the changes estimated for married women, whose response have decreased almost as dramatically in relative terms, and...
more in absolute terms. In 1970, their response was 32% stronger than today. This finding is in line with estimates by Blau and Kahn (2007) and Heim (2007), who both estimate a dramatically falling wage elasticity for women over the time period 1980 to 2000.

For single men the impact of an aggregate shock was stronger historically, and for single women the opposite is true.

To summarize, the fact that the impulse-response function of output is remarkably stable between years is the sum of counteracting forces. The effect on employment among married women has decreased over time, while the effect on married men has increased (albeit the absolute change is smaller). However, the relative share of married women in the workforce has increased, and since they have a higher response, this drives up the economy’s total responsiveness. The responsiveness of single men and single women has changed over time in opposite directions, and these changes are off-setting. The net effect is therefore close to zero.

The aggregate employment effect is a weighted sum of the effects by subgroup. Figure 21 compares the aggregate employment effect in 1970 to the aggregate employment effect in the end steady state, and decomposes the contribution from differences in employment shares and differences in response. The first bar is the actual employment response in 1970, and the contribution by subgroup. The second bar shows a counterfactual in which the fraction working by subgroup was held at the 1970 level, but the employment responses by subgroup are the end steady state responses. As can be seen, in such a counterfactual experiment married men contribute more to the aggregate response relative to the 1970s, while married women contribute less, as can directly be concluded from
Table 6: Immediate impact on employment from a TFP shock of 1 std.

<table>
<thead>
<tr>
<th></th>
<th>Married men</th>
<th>Married women</th>
<th>Single men</th>
<th>Single women</th>
<th>Total employment</th>
</tr>
</thead>
<tbody>
<tr>
<td>End steady-state</td>
<td>0.4%</td>
<td>1.4%</td>
<td>4.2%</td>
<td>3.4%</td>
<td>1.7%</td>
</tr>
<tr>
<td><strong>Response during the transition:</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1970s</td>
<td>0.2%</td>
<td>1.8%</td>
<td>4.6%</td>
<td>2.5%</td>
<td>1.7%</td>
</tr>
<tr>
<td>1990s</td>
<td>0.3%</td>
<td>1.6%</td>
<td>5.4%</td>
<td>2.8%</td>
<td>1.7%</td>
</tr>
<tr>
<td>2010s</td>
<td>0.4%</td>
<td>1.4%</td>
<td>4.2%</td>
<td>3.4%</td>
<td>1.7%</td>
</tr>
</tbody>
</table>

Table 6. The third bar in the figure shows a counterfactual measuring the importance of the changing composition in the workforce, assuming that the employment response by subgroup is kept at the 1970 level, while the employment fractions are the ones from the end-steady-state. As expected, the largest difference is for married women, which is the group who has increased its employment rate substantially.

Figure 21: Decomposing the difference in aggregate shock between 1970 and the end steady state. See text for further description.

8. Conclusions

Women’s increased involvement in the economy has been the most significant change in the labor markets during the past century. In this paper, I study how this increase has
affected the economy’s response to aggregate shocks. I explicitly model households as being single men, single women, or couple households. The model is able to capture the salient features of historical data in terms of employment by subgroup over time. Incorporating both one- and two-person households is also shown to matter for the employment dynamics in response to shocks, with single households reacting more strongly.

In this paper I have modelled the couple household as a unitary household, despite the potential shortcomings of that assumption. A richer model of the intra-household decision process would be an interesting extension, however, allowing for strategic interaction between individuals within a household is not trivial, especially when the problem is dynamic. The model in this paper in that sense serves as a useful benchmark to start thinking about a more careful modelling of the household that could include cooperative or non-cooperative processes with endogenous bargaining weights.

Except for household heterogeneity, which does not only include the standard dimensions of wealth and productivity but also gender and household composition, the proposed model is a straightforward model of the real business cycle type. Features that could be important for the analysis of aggregate employment dynamics that are not included are nominal price and wage stickiness and frictions on the labor market. Including these features, keeping the household heterogeneity, would enrich the framework. However, explicitly modelling the household is a necessary first step.
References


A. Appendix

A.1. More about sectors

Figure 22 shows the fraction of individuals in the labor force working in manufacturing sector, while Figure 23 shows the responsiveness of employment to fluctuations in GDP by sector and subgroup.

![Figure 22](image_url)

**Figure 22:** Fraction working in manufacturing (age 25-64). Source: CPS. Graph includes everyone with a defined sector, i.e., also unemployed with sector definition.

![Figure 23](image_url)

**Figure 23:** Responsiveness by sector and subgroup (age 25-64). Result from regressing cyclical component of hours by type in sector on GDP cyclical component. Source: CPS.
A.2. International comparison

Figure 24: Ratio of female to male labor force participation rate for all countries for which data is available from OECD. Figures are normalized to the 2016 ratio. Population aged 25-54. Source: OECD.

Figure 25: Labor force participation by gender, population aged 25-54. Source: OECD.
A.3. Asset holding couple and single households

Figure 26: Asset holdings by household type. Source: PSID 2008, referring to previous year. All values measured in 2008 USD. House value is value of first residence minus mortgages.

Figure 27: Asset holdings over the life cycle. Source: PSID 2008, referring to previous year. All values measured in 2008 USD. Robust standard errors.
A.4. Unemployment for more narrowly defined age group

As can be seen in Figure 28, which shows the unemployment rates by subgroup for individuals 35-65, the pattern is extremely similar to the pattern for the population 25-64. Hence, the high unemployment rate among single men is not purely driven by them being younger.

![Figure 28: Unemployment by subgroups, population 35-64. Source: CPS.](image)

A.5. Different filter options

As a robustness check, I rerun equation (1) using four different filtering techniques, Figure 29 shows the resulting coefficient of interest for the four different subgroups. As can be seen, all conclusions remain regardless of filter choice.

The four filters used are the following:
- **Hodrick-Prescott**: High-pass filter, using 6.25 as smoothing parameter.
- **Baxter-King**: Bandpass filter, filtering out stochastic cycles at periods smaller than 2 years and larger than 8 years.
- **Christiano-Fitzgerald**: Bandpass filter (based on the generally false assumption that data are generated by a random walk, but shown to still be nearly optimal), filtering out stochastic cycles at periods smaller than 2 years and larger than 8 years.
- **Butterworth**: Rational square-wave filter, filtering out stochastic cycles at periods larger than 8 years, and using order 2.
Figure 29: Resulting coefficient from regressing cyclical component of hours per capita on cyclical component of gdp from four different filters.

A.6. Sequential equilibrium definition

[To be added]
B. Aggregate shocks during a transition path in an RA model

A natural question to ask is if the MIT/BKM method reproduces the results from a model with true uncertainty, if the shocks take place during a transition (as is the case in this paper)? To investigate this I make a simple example in a representative agent setting with savings and endogenous labor. The utility function is supposed to be of the McCurdy type. I do the following three steps:

**Step 1:** True uncertainty model
- Set up RA model with $z$ (TFP) as a state variable, solve nonlinearly
- Solve for a transition path (letting $\theta$, the Frisch elasticity, go from 2 to 1 during 40 years, and thereafter remain)
- Simulate the model with a shock sequence for $z$

**Step 2:** BKM method
- Set up RA model w/o uncertainty (otherwise same as above)
- For each year during the transition: solve for IRFs from a shock
- Simulate the model with the same shock sequence as above

**Step 3:** Compare results

It turns out that the BKM/MIT method works very well and close to perfectly replicates the results from the model with “true” uncertainty. In this particular example, the IRFs vary along the transition. The effect on impact on labor supply is approximately 40% stronger if the shock hits exactly when the transition starts, than if it happens once the economy has reached its new steady state.
Figure 30: Compare results

Figure 31: Comparing IRFs over the transition
Figure 32: Difference if one uses final steady-state IRFs for the whole transition. Note scale on x-axis (otherwise one cannot see any difference). If the final steady-state IRFs are used for the transition path, the shock impact early during the transition path is underestimated.

Figure 33: Difference if one uses beginning-of-transition IRFs for the whole transition. If the beginning-of-transition IRFs are used for the whole time period, the impact of shocks are overestimated later.