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## The rise of the added worker effect

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# Non-technical summary

### Research Question

The added worker effect (AWE), the increase in the probability that a married woman joins the labor force (LF) when her husband becomes unemployed, has increased in the US over the last decades. We try to understand the forces behind this development.

### Contribution

We first document the increase in the AWE by using data from the Current Population Survey (CPS) while controling for many demographic factors. Then, we develop a theoretical model with labor market frictions and with households which have two members. Households face unemployment risks but their members adjust their labor supplies to insure against unemployment. We provide analytical solutions to the model. And we use a quantitative version of the model to explain the increase in the AWE by changes in the economic environment and labor force participation costs of married women.

### Results

We show that the increase in the AWE can be explained by i) the narrowing of the gender pay gap, ii) changes in the frictions in the labor market and iii) changes in the labor force participation costs of married women.

# Nichttechnische Zusammenfassung


## Fragestellung

Der Added Worker Effect (AWE), der Anstieg in der Wahrscheinlichkeit, dass eine verheiratete Frau erwerbstätig wird, wenn ihr Mann arbeitslos wird, hat in den letzten Jahrzehnten in den USA zugenommen. Wir beleuchten die Frage, wie sich diese Entwicklung erklären lässt.

## Beitrag

Als erstes dokumentieren wir den Anstieg des AWE mit Daten des Current Population Surveys (CPS). Der CPS ist ein amerikanischer Haushaltsdatensatz, der v.a. Angaben zum Arbeitsmarktstatus der Haushaltsmitglieder enthält. Als zweites entwickeln wir ein theoretisches Modell mit Friktionen auf dem Arbeitsmarkt und Haushalten mit zwei Haushaltsmitgliedern. Für die Haushalte besteht zwar die Gefahr einer Arbeitslosigkeit, aber ihre Mitglieder passen ihr Arbeitskräfteangebot an, um sich gegen Arbeitslosigkeit abzusichern. Wir lösen das Modell analytisch. Danach nutzen wir eine quantitative Version des Modells, um den Anstieg des AWE durch Änderungen im ökonomischen Umfeld und niedrigeren Kosten der Arbeitsmarktbeteiligung verheirateter Frauen zu erklären.

## Ergebnisse

Wir zeigen, dass der Anstieg des AWE durch 1. den Fall der Lohnlücke zwischen Männern und Frauen, 2. geringeren Suchfriktionen am Arbeitsmarkt, und 3. niedrigeren Kosten der Arbeitsmarktbeteiligung verheirateter Frauen vollständig erklärt werden kann.

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# The Rise of the Added Worker Effect*

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**Abstract**

We document that the added worker effect (AWE) has increased over the last three decades. We develop a search model with two earner households and we illustrate that the increase in the AWE from the 1980s to the 2000s can be explained through i) the narrowing of the gender pay gap, ii) changes in the frictions in the labor market and iii) changes in the labor force participation costs of married women.

**Keywords:** Heterogeneous Agents; Family Self Insurance; Dual Earner; Unemployment; Labor Market Search.

**JEL classification:** E24, J12, J64

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# 1 Introduction

Figure 3 shows the added worker effect (AWE), the increase in the probability that a married woman joins the labor force (LF) when her husband becomes unemployed, estimated from the Current Population Survey (CPS).[1] The figure shows that the AWE has increased over the last decades.

We explain the rise of the AWE through the interplay of several factors: i) the gender pay gap has decreased over the last three decades; ii) search frictions for prime aged married men and women have also changed; iii) there has been a strong increase in the employment rate of married women. To the extent that this increase cannot be explained by i) and ii) it may reflect a drop in the labor market participation costs of married women.[2]

We present a simple model, where households consist of a male and female spouse. Men can be either employed or unemployed in any given period, their transitions between these two states are determined by the arrival rate of job offers ($p_{U,m}$) and by exogenous separation shocks ($s$). Married women may be employed ($E$), unemployed ($U$) or out of the labor force ($O$). As in Garibaldi and Wasmer (2005) (hereafter GW), their labor market status is determined by the frictions - they receive offers with probability $p_{U,f}$ when $U$ ($p_{O,f}$ when $O$) - and by the disutility of labor ($\omega$) which varies across households. Women who derive a moderate disutility from market activities are 'marginal workers': when their husbands are employed they remain in state $O$; however, when their husbands become unemployed they flow into the LF.

These assumptions allow us to characterize analytically the labor supply of women and the AWE in the model. In quantitative experiments we shift the frictions, the gender gap, and the mean of the distribution of $\omega$. We find that the joint impact of these forces can account for the entire increase in the AWE observed in Figure 3.

# 2 Model

Time is discrete and the horizon is infinite. $\beta$ denotes the discount factor. Let $(w_m, w_f)$ denote the wages and assume all individuals supply a unit of labor when they work. Households pool resources, and consume total income ($I$) every period. The utility of consumption is $u(I)$. Let $S$ be the joint labor market status of the household members. We have:

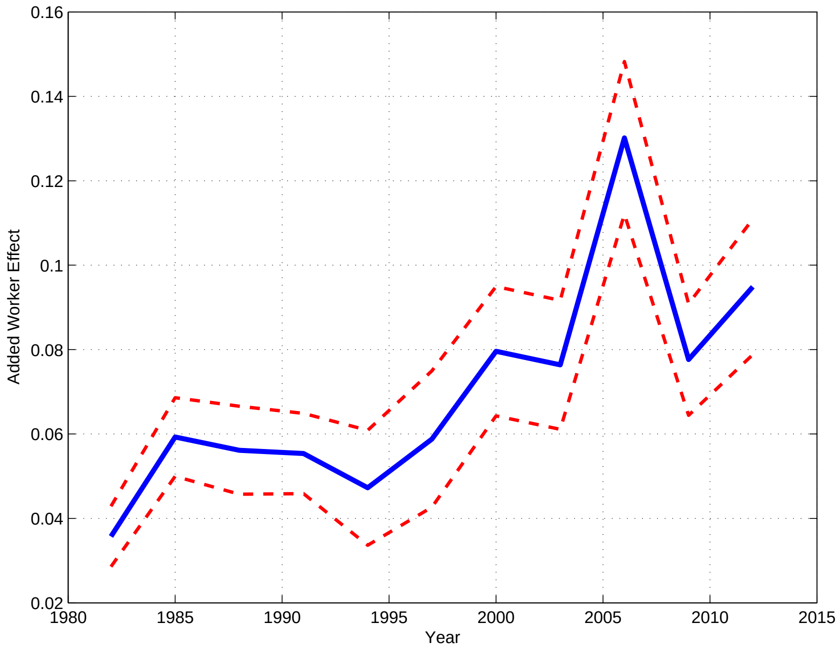
$$S \quad \in \quad \{EE,\ EU,\ EO,\ UE,\ UU,\ UO\}$$

where the first (second) element denotes the husband's (wife's) state. We assume that $I_S$ takes the following values: $I_S \in \{w_m + w_f, w_m, w_m, b + w_f, b, b\}$. $b$ denotes the level of

[1] Many authors have presented static estimates of the AWE, using various household surveys (e.g. Lundberg (1985), Stephens (2002) and Mankart and Oikonomou (2015) (hereafter MO) among many others). The fact that the AWE is significant echoes that financial markets are incomplete and labor markets are fraught with frictions. If these conditions were not met, the AWE would be equal to zero.

[2] This can be justified by lower fertility (Bloom, Canning, Fink, and Finlay, 2009), higher productivity in the production of home goods (Greenwood, Seshadri, and Yorukoglu, 2005), changes in cultural norms (Fernández, 2013) and so on.

Figure 1: The Added Worker Effect: from the 1980s to the 2000s




Note: The graph shows the increase in the probability that the wife enters the labor force when her husband becomes unemployed (relative to when he remains employed). The sample covers households where both spouses are 25-55 years old. The data are monthly observations from the CPS. The coefficients plotted in the figure are estimated from a linear probability model. The dependent variable is a dummy variable which takes the value 1 when the wife joins the LF. The coefficients correspond to dummy variables defined as follows: they take a value of 1 if the husband becomes unemployed between month $t$ and $t+1$ and these months fall within a predetermined 3 year interval. The value of the dummy is zero otherwise. The regressions include demographic variables (age, education, children). Details on the data and the estimation can be found in the online appendix.

consumption of the household when the husband is unemployed. It is meant to capture the income earned from benefits but also income and transfers from other sources (any insurance arrangement, formal or informal, not modeled here). To simplify we assume that women do not earn any benefits during unemployment since our focus is on women who are $O$ and then (following an unemployment shock suffered by the husband) join the LF. The utility cost of working $\omega$ remains constant through time. Search effort costs $\kappa\omega$ are proportional to the disutility of labor with $\kappa \in (0, 1)$.

**Value functions** Let $W_S$[3] denote the lifetime utility of a couple in state $S$. We have that:

$$\begin{aligned}
W_{EE} &= u(w_m + w_f) - \omega + \beta[(1-s)^2 Q_{EE} + s(1-s)(Q_{EN} + Q_{UE}) + s^2 Q_{UN}] \quad (1)\\
W_{EU} &= u(w_m) - \omega\kappa + \beta[p_{U,f}((1-s)Q_{EE} + sQ_{UE}) + (1-p_{U,f})((1-s)Q_{EN} + sQ_{UN})] \quad (2)\\
W_{EO} &= u(w_m) + \beta[p_{O,f}((1-s)Q_{EE} + sQ_{UE}) + (1-p_{O,f})((1-s)Q_{EN} + sQ_{UN})] \quad (3)\\
W_{UE} &= u(b + w_f) - \omega + \beta[p_{U,m}(1-s)Q_{EE} + p_{U,m}sQ_{EN} + \\
&\quad (1-p_{U,m})(1-s)Q_{EN} + (1-p_{U,m})sQ_{UN}] \quad (4)\\
W_{UU} &= u(b) - \omega\kappa + \beta[p_{U,m}(p_{U,f}Q_{EE} + (1-p_{U,f})Q_{EU}) + (1-p_{U,m})(p_{U,f}Q_{UE} + (1-p_{U,f})Q_{UU})] \quad (5)\\
W_{UO} &= u(b) + \beta[p_{U,m}(p_{O,f}Q_{EE} + (1-p_{O,f})Q_{EN}) + (1-p_{U,m})(p_{O,f}Q_{UE} + (1-p_{O,f})Q_{UN})] \quad (6)
\end{aligned}$$

where $Q_{EE} = \max\{W_{EE}, W_{EU}, W_{EO}\}$, $Q_{EN} = \max\{W_{EU}, W_{EO}\}$, $Q_{UE} = \max\{W_{UE}, W_{UU}, W_{UO}\}$, and $Q_{UN} = \max\{W_{UU}, W_{UO}\}$ denote the envelopes of the value functions and $N$ denotes that the female spouse does not have a job offer at hand (she chooses between $U$ and $O$). In (1) the couple has both of its members employed. With probability $(1-s)^2$ their jobs are not destroyed next period, the wife can chose to remain in $E$, or flow to $U$ or to $O$. With probability $(1-s)s$ his job continues but her job is destroyed, in this case she chooses between $U$ and $O$. The remaining cases are defined analogously.[4]

**Policy Functions** Figure 2 shows the policy rules $S(\omega)$.[5] The figure is organized in 4 panels. The top one shows $S$ when both spouses have job offers. In 'Region 1' they both remain employed. When 'Region 2' is reached the optimal allocation is to set $N = O$ since the disutility $\omega$ of effort is too high. The second panel shows the case when the husband is $E$ and the wife is $N$. In 'Region 3' the wife is $U$ and in 'Region 4' she is $O$. The third panel assumes that the husband has lost his job. The wife is now $U$ in 'Region 5' and $O$ in 'Region 6'. Finally, the 4th panel shows the case where the wife has an offer and the husband is $U$. The wife is now $E$ in 'Region 7' and $O$ in 'Region 8'.

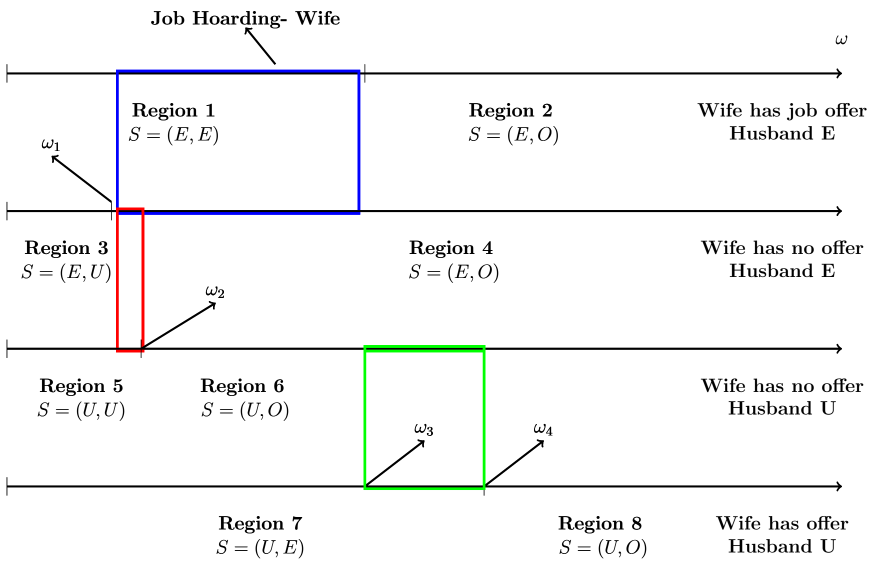
Consider the red and the green areas in the figure. These show ranges of $\omega$ which give an AWE. In the red rectangular, we have that $S = (E, O)$ (second panel) but when the husband becomes $U$ it is optimal to set $S = (U, U)$ (third panel). The AWE is a flow into unemployment which would not have occurred if the husband remained employed. In the green rectangular, the AWE is a flow directly to $E$. If the husband is $E$ and the wife receives an offer, she will not accept it (first panel). However, when the husband becomes

[3]For brevity $W_S(\omega) = W_S$ since $\omega$ is a fixed effect.

[4]The options $Q$ may appear meaningless (since $\omega$ is constant), however, treating the $Q$s explicitly makes the value functions applicable to all values of parameters. For example, when $\kappa \to \infty$ and $\omega > 0$ it is never optimal to set $N = U$. In contrast, when $\kappa = 0$ we always have $N = U$.

[5]The parameters are chosen to generate an AWE.

Figure 2: Female Labor Supply - the Added Worker Effect in the Model




Note: The figure shows the policy rules $S$ as functions of $\omega$. See text for a description of each of the 4 panels of the figure.

$U$ the wife accepts the offer (fourth panel).[6]

Finally, the blue rectangular in the figure is used to denote the part of the state space where women 'hoard jobs' (see GW). Because search is costly, individuals keep their jobs, and wait for an $s$ shock to quit to $O$.

**Analytical Results** We characterize analytically the thresholds $\omega_i$, $i = 1, 2, 3, 4$ shown in Figure 2.

**Proposition 1.** *The solution for* $\omega_1$ *satisfies*

$$\omega_1 = \frac{\beta(p_{U,f} - p_{O,f})}{\Delta_1 \widetilde{\kappa}_1}\left[s\widetilde{\xi}_2 + \lambda_1 \widetilde{\xi}_1\right] \tag{7}$$

*where* $\widetilde{\xi}_1 = u(w_m + w_f) - u(w_m)$, $\widetilde{\xi}_2 = u(b + w_f) - u(b)$, $\Delta_1 = [1 - \beta(1 - s - p_{U,f})][1 - \beta(1 - s - p_{U,f})(1 - s - p_{U,m})]$, $\lambda_1 = (1 - s - \beta(1 - p_{U,m} - s)(1 - s - p_{U,f}))$, $\widetilde{\kappa}_1 = [\kappa + (1 - \kappa)\frac{\beta(p_{U,f} - p_{O,f})}{1 - \beta(1 - s - p_{U,f})}]$.

*The solution for* $\omega_2$ *satisfies*

$$\omega_2 = \beta \frac{p_{U,f} - p_{O,f}}{\Delta_2 \widetilde{\kappa}_2}\left[p_{U,m}\widetilde{\xi}_3 + \lambda_2 \widetilde{\xi}_4\right] \tag{8}$$

*where* $\lambda_2 = (1 - p_{U,m} - \beta(1 - s - p_{U,m})(1 - s - p_{O,f}))$, $\widetilde{\kappa}_2 = \left[\kappa + \beta\frac{(p_{U,f} - p_{O,f})}{1 - \beta(1 - s - p_{O,f})}\right]$, $\widetilde{\xi}_3 = u(w_m + w_f) - u(w_m)$, $\widetilde{\xi}_4 = u(b + w_f) - u(b)$ and $\Delta_2 = [1 - \beta(1 - s - p_{O,f})]\,[1 - \beta(1 - s - p_{O,f})(1 - s - p_{U,m})]$.

[6] MO have shown that the AWE, nearly 2/3 of the times in the U.S. data, consists of a direct flow to $E$.

*Moreover we have that*

$$(9) \qquad \omega_3 = \frac{1}{\widetilde{\kappa}_3}\left[u(\sum_g w_g) - u(w_m) + \beta s(1-s-p_{O,f})\frac{u(b+w_f)-u(b)}{1-\beta(1-s-p_{O,f})(1-p_{U,m})}\right]$$

*where* $\widetilde{\kappa}_3 = \left[1+\beta\frac{s(1-s-p_{O,f})}{1-\beta(1-p_{U,m})(1-s-p_{O,f})}\right]$, *and finally*

$$(10) \qquad \omega_4 = u(b+w_f) - u(b).$$

Proof: see online appendix.

The above results can be used to derive qualitative effects of parameter changes. To assess the quantitative impact of these changes, we proceed with the numerical solution of equations (1) to (6).

**Calibration (1980s)** Table 1 shows the baseline calibration. We set $\beta = 0.99$. We let $u(I) = \log(I)$ and normalize $w_m = 1$. The other parameters are chosen to be consistent with the situation in the 1980s. The female wage is set to generate a pay gap of 32% in line with Siegel (2014). The labor market frictions are chosen to match the corresponding moments in our CPS sample: We set $p_{U,m} = 0.30$ to match the monthly job finding rate of men of around 29%. We set $s = 0.0137$ to get an unemployment rate for men of 4.37%.[7] We set $p_{U,f} = 0.21$ to match the job finding rate of women. In the US many $O$ individuals are 'marginally attached'. These agents have a transition rate to $E$ nearly half as large as of unemployed agents (Jones and Riddell (1999) and MO). In our model 'marginally attached' are women who are $O$ but accept job offers. They have $\omega_1 < \omega < \omega_3$ (i.e. the 'labor hoarding' region). Therefore, we set $p_{O,f} = 0.105$.

We set $\kappa = 0.25$ to match the unemployment population ratio of 3.24%. $\omega$ is uniformly distributed in $[-\overline{\omega}, 1-\overline{\omega}]$, where $\overline{\omega}$ is chosen the match the female employment rate in the 1980s (61.08%). We obtain $\overline{\omega} = 0.131$.[8]

Finally, we set $b = 0.68$ to obtain an AWE of 4.68%. Recall that $b$ captures income from $UI$ payments, but also income from assets, severance payments and other insurance arrangements.[9]

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[7] Assuming the same separation rate for married men and women is a good approximation of the US data since the $EU$ rate in the 1980s has been 0.0109 for men and 0.0105 for women. Moreover, in MO we showed that with the same $s$, the $EO$ rate of women can be considerably larger than the rate for men if we assume the presence idiosyncratic productivity shocks. Our aim is to offer a simple framework here, in future work we will enrich it with productivity shocks and household wealth.

[8] This implies that some women dislike staying at home or being unemployed. Negative values of leisure are common in the micro-search literature.

[9] If we focus on UI and set $b = 0.5$, the model produces a larger AWE, however, the quantitative effects of the next section are unaffected. We also experimented with allowing benefits to be received by households with a low $\omega$, so that the wife is always in the LF. Again our results were unaffected.

Ideally to introduce benefits for women we would allow for 4 states (e.g. unemployed .with benefits' and 'without benefits') as in GM. This requires to keep track of employment histories. Our model is as a first step towards this agenda.

Table 1: Model calibration

| Parameter | Value | Target (80s) |
|---|---|---|
| $p_{U,m}$ | 0.30 | CPS |
| $p_{U,f}$ | 0.21 | CPS |
| $p_{O,f}$ | 0.105 | Jones and Ridell |
| $s$ | 0.0137 | $u - rate_m = 4.37\%$ |
| $\kappa$ | 0.25 | $u - pop_f = 3.24\%$ |
| $w_m$ | 1 | Normalization |
| $w_f$ | 0.68 | Gender Gap |
| $b$ | 0.7 | AWE of 4.68% |
| $\overline{\omega}$ | 0.131 | $e - pop_f = 61.08\%$ |

Note: The table shows the parameter values assigned in the 1980s calibration of the model. The data moments refer to married individuals of ages 25-55. See online appendix for details.

# 3 Experiments

**Decline in the gender gap** We first investigate the effects of narrowing the gender gap ($\frac{w_f}{w_m} = 0.8$). The results are in the Column 3 of Table 2. The higher $w_f$ increases employment and increases the AWE. The new AWE is 6.35% nearly halfway between the moment in the 1980s and the 2000s.

Since women join the LF to provide insurance, a drop in the gender gap increases the value of insurance: women can make up for a larger fraction of the lost family income. However, since now more women participate, their employment rate increases from 61% to 67.5%, the cost of insurance measured in terms of $\omega$ increases.[10]

**Changes in frictions** We keep $w_f = 0.68$ and consider only changes in the frictions. We set $(p_{U,m}, p_{U,f}, p_{O,f}, s) = (0.34, 0.25, 0.125, 0.0117)$, consistent with our estimates for the 2000s. The results are shown in Column 4 of Table 2. Female employment increases to 62.1% and unemployment drops due to the looser frictions.

Recall that when the job finding rate of men increases, the AWE drops. When it is easier to find jobs, providing insurance becomes less urgent, in the limit, when $p_{U,m} = 1$, the AWE equals zero. However, there are now two forces which go in the opposite direction: First, the rise in $p_{U,f}$ lowers expected search costs and women flow more readily to $U$. Second, the rise in $p_{O,f}$ means that direct flows from $O$ to $E$ increase; the AWE attributed to these flows increases as well. The net effect is positive and the AWE increases to 5.71%.

**Gender gap and frictions** In Column 5 we consider the joint impact of the changes in the frictions and the lower gender pay gap. We find that with these two changes together the AWE increases to 7.73%.

**Adding shifts in preferences** In the previous models, the female employment rate

[10]The region $[\omega_1, \omega_2]$ shifts towards the right. 'Marginal workers' now incur higher costs, but since the higher wage dominates, the interval expands.

Table 2: The experiments

| | Data | Gender Gap | Frictions | Gender Gap & Frictions | Gender Gap & Frictions & Preferences |
|---|---|---|---|---|---|
| AWE | 8.33% | 6.35% | 5.71% | 7.73% | 8.27% |
| $e - pop_f$ | 70.54% | 67.49% | 62.12% | 68.76% | 70.53% |
| $u - pop_f$ | 2.55% | 3.58% | 2.39% | 2.63% | 2.71% |

Note: The table shows changes in model outcomes when we shift the parameters (gender gap, frictions and preferences) as in the 2000s. The column *Gender Gap* shows the effect of the lower gender gap; the column *Frictions* the effect of smaller frictions. The column *Gender Gap & Frictions* puts together the new gender gap and the changed frictions. The final column adds a shift in preferences to match the employment rate of married women in the 2000s.

always remained below its value observed in the 2000s. Therefore, we additionally calibrate the distribution of $\omega$ to generate an employment population ratio of 70.5%. Thus, in Column 6 we set $\overline{\omega} = 0.1495$ which lowers the costs of market activities.[11]. We now obtain an AWE of 8.27% remarkably close to the data moment. A drop in the utility cost of working increases the number of 'marginal workers' in the economy. More households have $\omega < \omega_4$ and utilize female labor supply as an insurance mechanism against unemployment risks.

Changing the distribution of $\omega$, while leaving the gender pay gap and the frictions at their initial values, leads only to a small increase in the AWE to 4.95% (not reported in the table). Thus, the change in preferences contributes only slightly to the increase in the AWE. The change in the gender pay gap and the frictions explain roughly 85% of the observed increase in the AWE.

# 4 Conclusion

We documented a new data fact, an increase in the AWE since the 1980s. We constructed a simple model which accounts for the rise in the AWE. Our analysis is a first step towards a more elaborate model, which includes wealth, shocks to preferences and productivity, and which accounts jointly for the labor market flows and the AWE.

[11] This is in line with, for example, Heathcote, Storesletten, and Violante (2009)

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# A Data appendix

## A.1 CPS: Brief Description, Monthly Flows and the AWE

The Current Population Survey (CPS) is a monthly survey of about 60,000 households (56,000 prior to 1996 and 50,000 prior to 2001), conducted jointly by the Census Bureau and the Bureau of Labor Statistics.[12] Survey questions cover employment, unemployment, earnings, hours of work, and a variety of demographic characteristics such as age, sex, race, marital status, and educational attainment. Although the CPS is not an explicit panel survey it does have a longitudinal component that allows us to construct the monthly labor market flows and to estimate the AWE. Specifically the design of the survey is such that the sample unit is interviewed for four consecutive months and then, after an eight-month rest period, interviewed again for the same four months one year later. Households in the sample are replaced on a rotating basis, with one-eighth of the households introduced to the sample each month. Given the structure of the survey we can match roughly three-quarters of the records across months.[13]

Using these matched records, we calculate the gross worker flows (for the aggregate and by gender age group and marital status). The flows are estimates of a Markov transition matrix where the three states are employment, unemployment and out of the labor force.

We use the CPS classification rule to assign each member of a household to a labor market state. This rule is as follows: Employed agents are those who did (any) work for either pay or profit during the survey week. Unemployed are those who do not have a job, have actively looked for work in the month before the survey, and are currently available for work. "Actively looking" means that respondents have used one (or more) of the nine search methods considered by the CPS (6 methods prior to 1994) such as sending out resumes, responding to job adds, being enrolled with a public or private employment agency etc. Individuals who search "Passively" by attending a job training program or simply looking at adds are not considered as unemployed because these methods, according to the CPS, do not result in a sufficiently high arrival rate of job offers. The exception is workers on temporary layoff, i.e those workers who expect to be recalled by their previous employer. Those are counted as unemployed even if they do not search actively. Finally, out of labor force are all agents who are neither employed nor unemployed (based on the above definitions).

Given this information we calculate the conditional probability that an agent who is in state $i$ in the previous month (interview date) is in state $j$ this month, where $(i, j) \in \{E, U, O\}$. We use the household weights provided by the CPS so that these objects are representative of the US population and we remove seasonal effects using a standard ratio to moving average approach (Shimer, 2012).

Tables 3 and 4 present the estimates of the monthly flows for the 1980s and the 2000s. The sample covers all married individuals of ages 25-55. Men are represented on the left panel of the tables and women on the right. There are several noteworthy features: First, as claimed in text we have assumed that married men always participate in the LF. This simplification was motivated by the fact that the employment rate of married

[12]This is based on the data appendix of Mankart and Oikonomou (2015).

[13]Unfortunately, there is some sample attrition from individuals who abandon the survey (see for example Nagypál (2005) for a discussion of these issues).

Table 3: Monthly Flow Rates: 1980s

| | A: Married Men | | | B: Married Women | | |
|---|---|---|---|---|---|---|
| | | To | | | To | |
| From | E | U | O | E | U | O |
| E | 0.984 | 0.011 | 0.005 | 0.939 | 0.011 | 0.050 |
| U | 0.293 | 0.639 | 0.069 | 0.212 | 0.506 | 0.282 |
| O | 0.103 | 0.065 | 0.832 | 0.048 | 0.021 | 0.932 |

Note: The table shows average monthly transition probabilities across the three labor market states: employment $E$, unemployment $U$ and $O$ for selected subgroups. Panels A and B show the flow rates for husbands and wives, respectively, while panel C shows the rates for household heads. See the online data appendix for further details on how the estimates are constructed.

Table 4: Monthly Flow Rates: 2000s

| | A: Married Men | | | B: Married Women | | |
|---|---|---|---|---|---|---|
| | | To | | | To | |
| From | E | U | O | E | U | O |
| E | 0.987 | 0.008 | 0.005 | 0.942 | 0.010 | 0.048 |
| U | 0.346 | 0.573 | 0.081 | 0.252 | 0.460 | 0.289 |
| O | 0.103 | 0.049 | 0.848 | 0.054 | 0.019 | 0.927 |

Note: The table shows average monthly transition probabilities across the three labor market states: employment $E$, unemployment $U$ and $O$ for selected subgroups. Panels A and B show the flow rates for husbands and wives, respectively, while panel C shows the rates for household heads. See the online data appendix for further details on how the estimates are constructed.

men exceeded 90 percent in both periods and the unemployment rate was roughly equal to 4 percent (see main text). Therefore, men who are $O$ in our sample are so because of disability shocks, schooling etc, since our theory does not incorporate these features it seems a reasonable approximation to ignore these individuals. This is clearly consistent with the vast literature of search and matching models which typically assume that agents can be either employed or unemployed.

Second, as explained in the main text our model generates transition in and out of the LF for married women in response to spousal unemployment shocks and separation shocks. This holds in particular for women who joint $U$ to provide insurance and in the case where we observe transitions from $O$ directly to $E$. Clearly since the model assumes $\omega$ is constant the model flows will not match the data patterns. To bring the model close to the data one need to enrich the former with shocks to $\omega$, idiosyncratic productivity, wealth as in, for example, Mankart and Oikonomou (2015). Despite this the numbers reported in the tables show clearly that assuming that exogenous separations arrive at equal rates to men and women is a valid simplification (since the $EU$ flows are very close).

We now briefly explain the estimation of the AWE shown in Figure 1 in the text. Our approach is discussed in detail in Mankart and Oikonomou (2015) and basically follows a large number of earlier papers that showed similar estimates from the CPS and other household surveys. The sample for our estimation is again married individuals (age 25-55). We concentrate on household where the husband is $E$ in month $t-1$ and either $E$ or $U$ in month $t$. The wife is $O$ in $t-1$ and either remains $O$ in $t$ or she joins the LF ($E$ or $U$). With this data set we regress a dummy variable which takes the value one if the wife joins the LF on demographic characteristics (age, education, children, see below) and on another dummy which takes the value 1 if the husband becomes unemployed in $t$ and $t$ belongs in a given set of month/year observations. As discussed in text our sample starts in 1980 (Jan) and ends in 2014 (Dec), we define 3 year intervals to estimate the effect of spousal unemployment on LF participation.

Table 5 presents the estimation output. $EU1982$ is the dummy which captures the husbands unemployment spell when observations lie in the years 1980-1982, $EU1985$ covers the years 1983-1985 and so on. The estimated coefficients are the ones we plotted in Figure 1 in text.

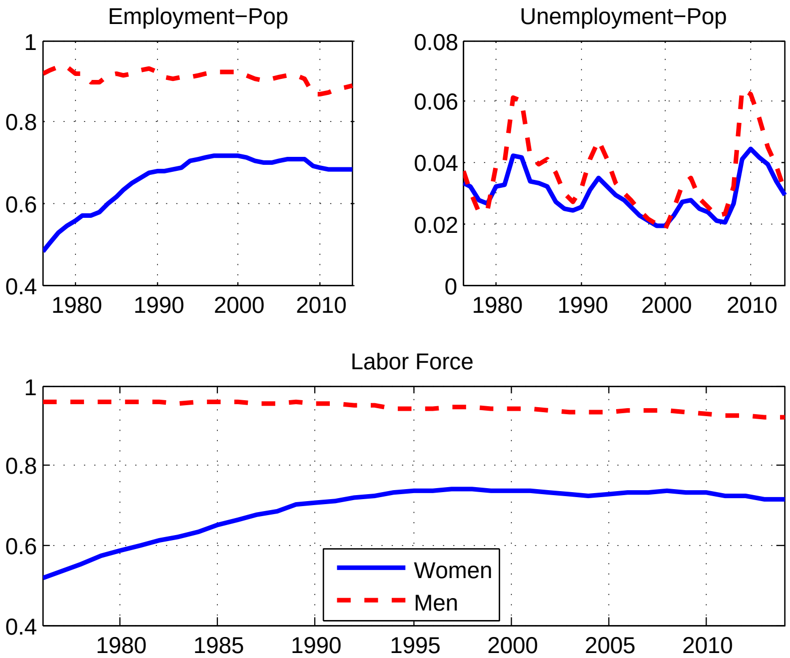
There are several points worth making. First, in Mankart and Oikonomou (2015) we have run a number of different specifications to estimate the AWE, all of the models we considered gave us a strong AWE. This continues to hold in the case of the 'trend estimates' we present here, for brevity we left out further models from the tables. It is worth noting, that i) probit model estimates produce very similar results (the coefficients are as usual harder to interpret than in the liner probability model) ii) running the model with yearly $EU$ dummies and running separately for 3 year or 10 year intervals also did not change our estimates. As we explain in Mankart and Oikonomou (2015) spousal unemployment seems to be the single most important variable in these estimations. The demographic characteristics exert a much more moderate explanatory power over the dependent variable. Hence if we allow the coefficient of these variables to assume different values for each sub-period does not influence our output.

Table 5: Added worker effect over time

| | AWE |
|---|---|
| EU 1982 | 0.0357 |
| | (0.0072)*** |
| EU 1985 | 0.0593 |
| | (0.0093)*** |
| EU 1988 | 0.0562 |
| | (0.0104)*** |
| EU 1991 | 0.0554 |
| | (0.0095)*** |
| EU 1994 | 0.0473 |
| | (0.0136)*** |
| EU 1997 | 0.0588 |
| | (0.0162)*** |
| EU 2000 | 0.0796 |
| | (0.0153)*** |
| EU 2003 | 0.0764 |
| | (0.0153)*** |
| EU 2006 | 0.1302 |
| | (0.0181)*** |
| EU 2009 | 0.0776 |
| | (0.0132)*** |
| EU 2012 | 0.0949 |
| | (0.0161)*** |
| No of Kids | −0.00002 |
| | (0.0027) |
| No of Kids$\leq$ 5 | −0.0249 |
| | (0.0005)*** |
| Black | 0.0539 |
| | (0.0020)*** |
| White | 0.0110 |
| | (0.01298)*** |
| Educ 2 | 0.0131 |
| | (0.0003)*** |
| Educ 1 | −0.0069 |
| | (0.0003)*** |
| $Age_f$ | −0.0164 |
| | (0.0029)*** |
| $Age_f^2$ | 0.00043 |
| | (0.0001)*** |
| $Age_f^3$ | $-3.9e-6$ |
| | $(6.2e-7)$*** |
| $Age_m$ | −0.0012 |
| | (0.0003)*** |
| Const. | 0.3375 |
| | 0.0357*** |
| $R^2$ | 0.0067 |
| No of obs. | 893734 |

Note: This table shows estimates time-varying estimates of the added worker effect (AWE) from a linear probability model. The changes in the AWE are reflected by time dummies. Figure 1 in the paper is based on these estimates.

Figure 3: Male and Female Employment and Participation from the 1980s to the 2000s




Note: The graph shows the employment rate, the unemployment population ratio and the LF participation rate of married men and women (age 25-55) over the period 1980-2014. The series are estimated using the CPS micro-data files.

# B Model Proofs

## B.1 Value Functions and Derivations

The Bellman equations derived in text can be rewritten as follows:

$$W_{EE} = u(w_m + w_f) - \omega + \beta(1-s)^2 \max\{W_{EE}, W_{EU}, W_{EO}\}+$$
$$\beta s(1-s)\max\{W_{EU}, W_{EO}\} + \beta s(1-s)\max\{W_{UE}, W_{UU}, W_{UO}\} + \beta s^2 \max\{W_{UU}, W_{UO}\}$$

$$W_{EU} = u(w_m) - \omega\kappa + \beta(1-s)p_{U,f}\max\{W_{EE}, W_{EU}, W_{EO}\}+$$
$$\beta(1-p_{U,f})(1-s)\max\{W_{EU}, W_{EO}\} + \beta s p_{U,f}\max\{W_{UE}, W_{UU}, W_{UO}\}$$
$$+\beta(1-p_{U,f})s\max\{W_{UU}, W_{UO}\}$$

$$W_{EO} = u(w_m) + \beta(1-s)p_{O,f}\max\{W_{EE}, W_{EU}, W_{EO}\}+$$
$$\beta(1-p_{O,f})(1-s)\max\{W_{EU}, W_{EO}\} + \beta s p_{O,f}\max\{W_{UE}, W_{UU}, W_{UO}\}$$
$$+\beta(1-p_{O,f})s\max\{W_{UU}, W_{UO}\}$$
$$W_{UE} = u(b + w_f) - \omega + \beta[p_{U,m}(1-s)\max\{W_{EE}, W_{EU}, W_{EO}\} + p_{U,m}s\max\{W_{EU}, W_{EO}\}+$$
$$(1-p_{U,m})(1-s)\max\{W_{UE}, W_{UU}, W_{UO}\} + (1-p_{U,m})s\max\{W_{UU}, W_{UO}]$$

$$W_{UU} = u(b) - \omega\kappa + \beta p_{U,m}p_{U,f}\max\{W_{EE}, W_{EU}, W_{EO}\}+$$
$$\beta(1-p_{U,f})p_{U,m}\max\{W_{EU}, W_{EO}\} + \beta(1-p_{U,m})p_{U,f}\max\{W_{UE}, W_{UU}, W_{UO}\}$$
$$+\beta(1-p_{U,f})(1-p_{U,m)}\max\{W_{UU}, W_{UO}\}$$

$$W_{UO} = u(b) + \beta p_{U,m}p_{O,f}\max\{W_{EE}, W_{EU}, W_{EO}\}+$$
$$\beta(1-p_{O,f})p_{U,m}\max\{W_{EU}, W_{EO}\} + \beta(1-p_{U,m})p_{O,f}\max\{W_{UE}, W_{UU}, W_{UO}\}$$
$$+\beta(1-p_{O,f})(1-p_{U,m)}\max\{W_{UU}, W_{UO}\}$$

For these expressions and from Figure 2 (policy functions) we now derive the $\omega$s.

**The expression for $\omega_4$** Consider first the case where $\omega = \omega_4$. In this case we have that: $W_{UE} = W_{U0}$. Moreover, from the graph we can infer the following: i) $\max\{W_{EE}, W_{EU}, W_{EO}\} = W_{EO}$ ii) $\max\{W_{EU}, W_{EO}\} = W_{EO}$ iii) $\max\{W_{UE}, W_{UU}, W_{UO}\} = W_{UO} = W_{UE}$. $\max\{W_{UU}, W_{UO}\} = W_{UO}$. Given these properties the Bellman equations become:

$$W_{UO} = u(b) + \beta p_{U,m}p_{O,f}W_{EO}+$$
$$\beta(1-p_{N,f})p_{U,m}W_{EO} + \beta(1-p_{U,m})p_{O,f}W_{UN} + \beta(1-p_{O,f})(1-p_{U,m)}W_{UO}$$
$$W_{UE} = u(b + w_f) - \omega + \beta(1-s)p_{U,m}W_{EO}+$$
$$\beta(1-p_{U,m})(1-s)W_{UO} + \beta s p_{U,m}W_{UE} + \beta(1-p_{U,m})sW_{UO}$$

It is simple to show that $W_{UE} - W_{UO} = 0 \rightarrow u(b + w_f) - \omega_4 - u(b) = 0$. This gives the value for $\omega_4$.

**The expression for** $\omega_3$ Assume now that $W_{EE}(\omega_3) = W_{EO}(\omega_3)$. From Figure 2 (after simplifying the expressions which involve the max operator in the value functions) we can write:

(11)
$$W_{EE}(\omega_3) - W_{EO}(\omega_3) = 0 \rightarrow u(\sum_g w_g) - \omega_3 - u(w_m) + \beta s(1 - s - p_{O,f})(W_{UE} - W_{UO})$$

Moreover, we can illustrate that

$$W_{UE}(\omega_3) - W_{UO}(\omega_3) = 0$$
$$\rightarrow u(b + w_f) - \omega_3 - u(b) + \beta(1 - s - p_{O,f})(1 - p_{U,m})(W_{UE}(\omega_3) - W_{UO}(\omega_3))$$
$$(W_{UE}(\omega_3) - W_{UO}(\omega_3)) = \frac{u(b + w_f) - \omega_3 - u(b)}{1 - \beta(1 - s - p_{O,f})(1 - p_{U,m})}$$

Making use of this expression we can write (11)

$$\omega_3 \left[1 + \beta \frac{s(1 - s - p_{O,f})}{1 - \beta(1 - p_{U,m})(1 - s - p_{O,f})}\right] =$$
$$u(\sum_g w_g) - u(w_m) + \beta s(1 - s - p_{O,f}) \frac{u(b + w_f) - u(b)}{1 - \beta(1 - s - p_{O,f})(1 - p_{U,m})}$$

as was claimed in text.

**The expressions for** $\omega_1$ **and** $\omega_2$ Now to define $\omega_1$ and $\omega_2$ we have:

$$W_{EU}(\omega_1) = W_{EO}(\omega_1) \quad and \quad W_{UO}(\omega_2) = W_{UU}(\omega_2)$$

Lets begin with $\omega_1$. From Figure 2 we have that

$$W_{EU}(\omega_1) - W_{EO}(\omega_1) = 0 \rightarrow$$
$$\beta(1 - s)(p_{U,f} - p_{O,f}) \underbrace{(W_{EE} - W_{EU})}_{>0} + \beta s(p_{U,f} - p_{O,f}) \underbrace{(W_{UE} - W_{UU})}_{>0} - \kappa\omega_1 = 0$$

defines $\omega_1$. To recover the terms $(W_{EE} - W_{EO})$ and $(W_{UE} - W_{UO})$ we use the Bellman equations for these objects. We can easily show that:

$$W_{EE}(\omega_1) - W_{EU}(\omega_1) = u(w_m + w_f) - \omega_1(1-\kappa) - u(w_m) + \\ \beta(1-s)(1-s-p_{U,f})(W_{EE} - W_{EU}) + \beta s(1-s-p_{U,f})(W_{UE} - W_{UO})$$

$$W_{UE}(\omega_1) - W_{UO}(\omega_1) = u(b + w_f) - \omega_1(1-\kappa) - u(b) + \beta p_{U,m}(1-s-p_{U,f})(W_{EE} - W_{EO}) \\ + \beta(1-p_{U,m})(1-s-p_{U,f})(W_{UE} - W_{UO})$$

We need to solve a system of two equations to find the capital gains. Solving the system gives:

$$W_{EE}(\omega_1) - W_{EU}(\omega_1) = \frac{(1-\beta(1-p_{U,m})(1-s-p_{U,f}))\xi_1 + \beta s(1-s-p_{U,f})\xi_2}{\Delta}$$
$$W_{UE}(\omega_1) - W_{UO}(\omega_1) = \frac{(1-\beta(1-s)(1-s-p_{U,f}))\xi_2 + \beta p_{U,m}(1-s-p_{U,f})\xi_1}{\Delta_1}$$

where $\xi_1 = u(w_m + w_f) - \omega_1(1-\kappa) - u(w_m)$, $\xi_2 = u(b + w_f) - \omega_1(1-\kappa) - u(b)$ and $\Delta_1 = [1-\beta(1-s-p_{U,f})][1-\beta(1-s-p_{U,f})(1-s-p_{U,m})]$.

With the above it is simple to obtain the expression of $\omega_1$ in text. Put together all the terms multiplying $\xi_1$ gives:

$$\frac{\beta(p_{U,f} - p_{O,f})}{\Delta_1}[1-s-\beta(1-p_{U,m})(1-s-p_{U,f}) + s\beta p_{U,m}(1-s-p_{U,f}] = \\ \frac{\beta(p_{U,f} - p_{O,f})}{\Delta_1}[1-s-\beta(1-p_{U,m}-s)(1-s-p_{U,f})]$$

and the terms multiplying $\xi_2$ may be written as:

$$\frac{\beta s(p_{U,f} - p_{O,f})}{\Delta_1}[\beta(1-s)(1-s-p_{U,f}) + 1 - \beta(1-s)(1-s-p_{U,f})] = \frac{\beta s(p_{U,f} - p_{O,f})}{\Delta_1}$$

Therefore we have that:

$$\frac{\beta s(p_{U,f} - p_{O,f})}{\Delta_1}\xi_2 + \frac{\beta(p_{U,f} - p_{O,f})}{\Delta_1}[1-s-\beta(1-p_{U,m}-s)(1-s-p_{U,f})]\xi_1 - \kappa\omega_1 = 0$$

Now let $\widetilde{\xi_1} = u(w_m + w_f) - u(w_m)$, $\widetilde{\xi_2} = u(b + w_f) - u(b)$. Taking all the terms multiplying $\omega_1$ on the RHS of the previous equation we get:

$$\frac{\beta s(p_{U,f} - p_{O,f})}{\Delta_1}\xi_2 + \frac{\beta(p_{U,f} - p_{O,f})}{\Delta}[1-s-\beta(1-p_{U,m}-s)(1-s-p_{U,f})]\xi_1 = \\ \omega_1[\kappa + (1-\kappa)\frac{\beta(p_{U,f} - p_{O,f})}{1-\beta(1-s-p_{U,f})}]$$

We now apply the same procedure to recover $\omega_2$.

$$W_{UU}(\omega_2) - W_{UO}(\omega_2) = 0 \rightarrow$$
$$\beta p_{U,m}(p_{U,f} - p_{O,f}) \underbrace{(W_{EE} - W_{EO})}_{>0} + \beta(1 - p_{U,m})(p_{U,f} - p_{O,f}) \underbrace{(W_{UE} - W_{UO})}_{>0} - \kappa\omega_2 = 0$$

To recover the terms $(W_{EE} - W_{EO})$ and $(W_{UE} - W_{UO})$ we use the Bellman equations for these objects. We can easily show that:

$$W_{EE}(\omega_2) - W_{EO}(\omega_2) = u(w_m + w_f) - \omega_2 - u(w_m) +$$
$$\beta(1 - s)(1 - s - p_{O,f})(W_{EE} - W_{EO}) + \beta s(1 - s - p_{O,f})(W_{UE} - W_{UO})$$

$$W_{UE}(\omega_2) - W_{UO}(\omega_2) = u(b + w_f) - \omega_2 - u(b) + \beta p_{U,m}(1 - s - p_{O,f})(W_{EE} - W_{EO})$$
$$+\beta(1 - p_{U,m})(1 - s - p_{O,f})(W_{UE} - W_{UO})$$

We need to solve a system of two equations to find the capital gains. Solving the system gives:

$$W_{EE}(\omega_2) - W_{EO}(\omega_2) = \frac{(1 - \beta(1 - p_{U,m})(1 - s - p_{O,f}))\xi_3 + \beta s(1 - s - p_{O,f})\xi_4}{\Delta_2}$$
$$W_{EE}(\omega_2) - W_{EO}(\omega_2) = \frac{(1 - \beta(1 - s)(1 - s - p_{O,f}))\xi_4 + \beta p_{U,m}(1 - s - p_{O,f})\xi_3}{\Delta_2}$$

where $\xi_3 = u(w_m + w_f) - \omega_2 - u(w_m)$, $\xi_4 = u(b + w_f) - \omega_2 - u(b)$ and $\Delta_2 = [1 - \beta(1 - s - p_{O,f})][1 - \beta(1 - s - p_{O,f})(1 - s - p_{U,m})]$.

From this we can derive the following:

$$\beta\frac{p_{U,f} - p_{O,f}}{\Delta_2}\left[p_{U,m}\widetilde{\xi}_3 + (1 - p_{U,m} - \beta(1 - s - p_{U,m})(1 - s - p_{O,f}))\widetilde{\xi}_4\right] =$$
$$\left[\kappa + \beta\frac{(p_{U,f} - p_{O,f})}{1 - \beta(1 - s - p_{O,f})}\right]\omega_2$$

which is the expression we have in text.

These analytical expressions can be utilized to calibrate the model.