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Joint Search and Aggregate Fluctuations ^{*}

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Abstract

We develop a theory of incomplete markets where households that consist of two ex ante identical, and ex post heterogeneous agents can provide mutual insurance through adjustments in labor supply. We do so by taking stock from the vast literature of search models of the labor market and trace the differences between bachelor and couples household economies. Our main goal is to address whether joint search within the household unit can help reconcile the suggestive business cycle properties of aggregate employment, unemployment and labor force participation. We use data from the CPS on labor market transitions of married couples and we show that joint insurance is an important factor in explaining why the labor force is nearly acyclical. When we turn to the model however we find that these predictions are not entirely consistent with our theory. We then go on to explore what important additions need to be made to our benchmark framework to bring the model closer to the data.

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1 Introduction

The idea that economic agents lack sufficient access to markets to insure against misfortune has been one of the founding blocks of modern macroeconomics. By now the literature that assigns a central role to heterogeneity and postulates that risk sharing is far from perfect is voluminous and has addressed most interesting aspects of macroeconomic theory (see Heathcote et al (2008) for a survey) . It is not entirely clear though how far from complete markets, the actual risk sharing opportunities available to economic agents are. For instance the baseline incomplete markets paradigm builds on the assumption that households are formed by bachelor agents who, by trading claims on the aggregate capital stock, can self-insure against shocks in labor income. Over time alternative sources of insurance (either private or government provided) have been introduced to this framework, but much less common however is the idea that within the family a considerable amount of employment and productivity risk diversification can be provided in the form of adjustments of the family members' labor supplies.

In this paper we set out to achieve two ambitious and closely related goals; first we perform an accounting exercise of the differences between economies where risk sharing is limited because agents stand alone against uncertain contingencies, and those where households are formed by unions of two ex ante identical (ex post heterogeneous) members that can mutually insure against economic risks. We do so by taking stock from the vast literature of search models of the labor market and the kind of risks that arise in this environment are uncertainty about the job quality and the possibility of rationing of employment opportunities. On both these margins joint labor supply decisions present households with an array of economically meaningful opportunities that we explore.

Second (and this is the main contribution of our paper) we use the model to understand whether granting joint insurance and labor supply to couples, can help match the suggestive business cycle correlations of aggregate employment, unemployment and labor force participation. Our substantive theme here is that if recessions are periods of high incidences of unemployment or low opportunities to find work then this induces household members to search jointly and intensively to insure against potential earnings losses. By contrast in bachelor household frameworks inactive workers are either those who have experienced a sequence of bad shocks, or those who have accumulated sufficient wealth to finance leisure or both. We do not believe that either is realistic is but rather view inactivity as a state that entails the presence of a main provider at home.

In section 2 of our paper we use the data from the CPS to illustrate that joint insurance through adjustments of labor supplies of household members can indeed explain the low procyclicality of the US labor force. We show that if it weren't for fluctuations in the employment status of the main earner in the family (husbands in our sample), secondary earners (wives) would have a considerably more pro-cyclical labor force participation. Further on there is a small literature on the added worker effect which, at least when it asked a similar question to

ours, we found it to be conducive to our hypothesis.

Then we turn to the theory in section 3. We build a general equilibrium framework that features realistic frictions in the labor market, and is flexible enough to allow for a comparison between the bachelor and couples household economies. The question we ask is whether family self insurance in the model economy can match the empirical facts, or to put differently we would like to use the model as a laboratory to see how far joint labor supply can go towards matching the qualitative patterns that we find in the data. When we introduce aggregate fluctuations however, we find that the model fails miserably on both margins. We only get some improvement in the cyclical nature of unemployment (in the bachelor household model it's more procyclical) but this comes at a cost of a more volatile labor force. Further on there are virtually no gains in the correlation of the labor force with aggregate output at business cycle frequencies.

We explain that these predictions are consistent with two important failings of our model; first the benchmark economy features too few risks and too many choices to assign an important role to intra-family insurance. Second our simulations suggest that with two ex ante identical agents in the model, it is extremely difficult to match the patterns of specialization of household members in home and market work and simultaneously match the average monthly flows of the labor flows from one state to the other (the latter is a crucial target for our calibration). We argue that if a model is to fare well against the data in terms of the aggregate labor market, it must also match the persistence of the identity of the main and the secondary earners in the family. Both of these possibilities however are left to future work.

1.1 Related literature

This paper is related to several strands in the literature: First a central motivation of our work is that traditional theories that rely on realistic frictions in the labor market have had a hard time to match the cyclical patterns of the labor force (see for example Veracierto (2008)). The reason is that the strong inter-temporal substitution motive that grants to these theories ample fluctuations in aggregate employment, convinces agents to flow into the labor force in good times and abandon it in bad. Further on when agents have to confront the frictions that impede instantaneous transitions between employment and unemployment these theories contain the counterfactual implication that aggregate unemployment is procyclical.

It is this implication along with the apparent a-cyclical nature of the US labor force that has guided theoretical research in the field to restrict attention to models that feature only two labor market states (employment and unemployment), or equivalently feature large fixed costs of moving in and out of the labor force. In turn we argue that this runs into the difficulty of explaining why labor flows between activity and inactivity are large even at a monthly horizon, and we show that rather it is joint insurance within the household that explains the patterns

that we see in the data.

Further on there has been an enormous interest on the implications of heterogeneity and incomplete insurance markets for the aggregate labor fluctuations (for example Gomes et al (2001) and Chang and Kim (2007)). All of these attempts however build on the bachelor household paradigm which is precisely our point of departure here. Interestingly Chang and Kim (2006) develop a framework where families consist of two members (a male and female) and use it to address how individual supply rules affect the value of the aggregate elasticity of labor supply. As far as incomplete markets models go this work is admittedly the closest to our intentions but many of the ingredients are different. First we emphasize the role of family in circumventing frictions in the labor market (such as the limited availability of job opportunities) whilst in CK (2006) the role assigned to frictions is secondary. Second contrasting the properties of two economies (the one with bachelor households and the ones with couples) in various environments is one of the main themes that we pursue. Most importantly none of the models of incomplete insurance markets from this literature takes up seriously on the task of matching the patterns of worker reallocation between employment unemployment and inactivity, but we do. For this reason we introduce a wealth of shocks to make our model consistent with the relevant empirical labor market flows.

There appears to be a sizeable literature that highlights the role of family labor supply as a mean of insuring against idiosyncratic labor income risks. In Attanasio et al (2005, 2008) and Heathcote et al (2008) an additional margin of insurance provided by female labor market participation becomes a valuable instrument to buffer shocks in labor income, and these papers go on to analyze the effects of various changes in the economic environment on the historical trends of female labor supply. This is not the interpretation we want to give to our story however. For all we are concerned our model is one of complete markets within the household unit and incomplete outside. More akin to our attempt is the recent work by Guler et al (2008) that characterizes the effects of joint search to optimal reservation wage policies. Relative to them, they use a stylized search model, we build a general equilibrium framework with realistic heterogeneity that accounts for the observed labor market flows as well as the effects of shocks in aggregate productivity.

The rest of this paper is organized as follows: Section 2 uses the estimated flows from the CPS to provide evidence that joint insurance and labor supply are key factors that explain the low procyclicality of the US LF participation. In section 3, we develop the bachelor household model and the couple household model. In section 4, we show and discuss the basic results and implications of our theory. Section 5 concludes and the computational details are delegated to the appendix.

2 Labor Market Flows in the US

Table (1) summarizes the US labor market business cycle statistics. The data are constructed from the CPS and they correspond to observations spanning the years 1976 to 2005. They are logged and HP filtered and all quantities refer to quarterly aggregates and are expressed relative to a de-trended measure of GDP. Unemployment is extremely counter-cyclical and more than 6 times as volatile as aggregate output. Aggregate employment has two thirds of the volatility of output at business cycle frequencies and is very procyclical. The LF is not volatile and its contemporaneous correlation with GDP is low (.22).

TABLE 1: US BUSINESS CYCLE: LABOR MARKET STATISTICS

	Employment	Unemployment	LF	LF Couples	LF Wives
	Aged 16 and Above			Aged 22 to 55	
$\frac{\sigma_x}{\sigma_y}$	0.66	6.68	0.34	0.35	0.47
$\rho_{x,y}$	.81	-.88	.22	.05	.2

The last columns of Table (1) present a breakdown of the relevant quantities into demographic groups that are of particular interest to us. For married couples aged 22 to 55 in our sample, aggregate statistics are no different than those of the full population (aged 16 and above). The labor force for this demographic is somewhat less procyclical (and hence even more puzzling from the point of view of theory) owing to the strong acyclical attachment of males in the sample, but also to the low contemporaneous correlation with GDP of female labor force participation. The volatility of both males (not shown) and females are higher than the aggregate volatility for this demographic group (column 4). In turn this might suggest that there is negative correlation of labor force participations of wives and husbands in our sample.

We note that this break down corresponds to an imperfect measure of our notion of couples in the model. Ideally we would like to have duads of agents that are linked with near perfect insurance opportunities and make labor supply decisions jointly, but the data preclude us from doing so. In what follows we treat household units that comprise of two spouses as an ideal ground to provide evidence for our theory.

Implications for models: Fixed participation? Are these observations consistent with the tendency of macro labor market theory to restrict attention to environments where economic agents can be either employed or unemployed at any point in time? We provide an answer to this question by looking at the monthly transitions of the US workforce across adjacent labor market states.

In Table (2) we summarize the relevant flows estimated from the CPS. Each month roughly 7 % of OLF (out of labor force) workers join the labor force, and

3 % of employed workers quit and become inactive. Further on to dilute the suspicion that these results are driven by demographics Table (3) presents the analogous matrix for the sub-sample of workers aged 22 to 55.

TABLE 2: MATRIX FOR FLOW RATES OF AGENTS AGED ABOVE 16

	E	U	I
E	.9543	.0146	.0311
U	.2743	.4983	.2274
I	.0466	.0245	.9289

TABLE 3: MATRIX FOR FLOW RATES OF MARRIED COUPLES AGED 22 TO 55

	E	U	I
E	.9662	.0112	.0226
U	.2891	.5159	.195
I	.0623	.0282	.9095

A point that merits some attention is the fact that roughly 5 % of OLF workers find a job and become employed in the following month. There are two relevant possibilities: The first is that this is an immediate consequence of time aggregation since monthly horizons are more than enough for a worker to make a transition between inactivity and employment without having a recorded unemployment spell. The second pertains to the search behavior of passive searchers and marginally attached and discouraged workers. For these groups the work Jones and Riddell (1998,1999) demonstrates that they have transition probabilities into employment that are half as large as those of unemployed workers, and this implies that some of the flows between states U and I can be broadly interpreted simply as time variation in optimal search intensity for these groups. These implications have already been explored in the literature and it appears that adjusting the transition probabilities to embrace the idea that marginally attached workers should be treated as unemployed rather than inactive doesn't make a big difference in the matrices of Tables (2) and (3) (see Krusell et al (2009)).

Hence we draw two conclusions from these calculations. First that the line between economically active and inactive workers is somewhat arbitrarily drawn by the theoretical models of the labor market and second that our model, calibrated at monthly frequencies should allow all agents (independent of their labor market status) to receive job offers and experience transitions between nonemployment and employment.

How can we use the data to demonstrate our point?. One possibility

would be to run limited dependent variable models (such as linear probability or probit models) and estimate the effect of the husbands employment status, on the wife's labor force transitions, and this would allow us to control for some relevant aspects of heterogeneity. Such attempts however, to determine the magnitude of the added worker effect (AWE) are numerous in the literature and we can summarize these estimates without relying on our own empirical work (we do so in the following paragraphs). Further on this kind of analysis would have very little to say about the contribution of the joint labor supply on the low procyclicality of the LF which is precisely our focal point here.

Contrasting the (cyclical) behavior singles vs couples, even after controlling for demographic characteristics, would fare no better as an alternative, since our notion of singles is a very different one from what the data could potentially suggest. In our framework singles are those agents who have an own idiosyncratic productivity and more importantly don't possess ties with any other agent in the economy that could alleviate the risk from this process. In the data unmarried agents or even those who form a household unit on their own, could have joint insurance with other agents in the economy (a broad interpretation of family) and this consideration would cloud the conclusions we could potentially draw.

Rather we treat the two spouses (husband and wife) in the household unit as the closest data analogue to our notion of partnerships with joint labor supply and insurance. Using data on individual transitions we want to test the following prediction: If it weren't for employment fluctuations over the business cycle of primary household earners, the labor force participation of secondary earners would be considerably more procyclical. We focus on individuals aged 22 to 55 and for this demographic group married agents account for roughly 60 % of the population (for the entire sample of agents aged above 16 they form 36% of all individuals). In our sample we treat husbands as primary and wives as secondary earners.

For each period t we estimate the transition probabilities of a wife from state i to state j conditional on her spouse making a transition from state k to l . We denote this object by $p_t^f(i, j, k, l)$ and analogously we let by $p_t^m(k, l)$ be the unconditional probability that the husband (and household head in our sample) makes the transition from state k to state l over the course of a month. Due to data limitations we cannot define conditional transition probabilities for all relevant labor market states. For this reason we restrict our attention to $i, j \in \{LF, OLF\}$ (that is wives can either be in the labor force or inactive) and $k, l \in \{E, N\}$ (husbands can either be employed or not). Finally we let $n_t(i, k)$ be the share of the population of couples with a secondary earner is state i and a primary earner in state k .

The evolution of these measures is central to our experiment. With the estimates $p_t^f(i, j, k, l)$, $p_t^m(k, l)$ and $n_t(i, k)$ we construct counterfactual Markov transition matrices for couples over the relevant state space $\{LF, OLF\} \times \{E, N\}$ and counterfactual populations over time. The typical element of the matrices is given $p_t^f(i, j, k, l)\bar{p}^m(k, l)$ where $\bar{p}^m(k, l)$ denotes the transition probability of

the husband averaged over all periods. What we mean to accomplish by that is to have data on household transitions whereby the probability distribution of primary earners across labor market states is independent of time or, in other words, to shut down business cycle variation in the labor market flows between non-employment and employment for husbands.

First we use these matrices to construct population measures at one and three month ahead horizons. The way we do that is by feeding the actual populations n_t once and track the measures over the relevant horizon using our constructed matrices. We denote by \bar{n}_t the constructed measure based on the time averaged probabilities for husbands.

Second to make our comparison meaningful we also compute populations based on the actual transition probabilities (that is without averaging) so that the typical element of the transition matrix is $p_t^f(i, j, k, l)p_t^m(k, l)$, and we let \tilde{n}_t be the analogous measure under this calculation. The reason is that since there are small errors that compile over time, the comparison between \bar{n}_t and \tilde{n}_t is much more meaningful than between \bar{n}_t and n_t .

Figure (1) plots the labor force participation rate (based on measure n_t that we draw from the data) for wives over the sample period with the three month ahead counterfactual time series (based on \bar{n}_t). Reassuringly the correlations between actual and counterfactual measures is high above .99 at our longest horizon. The correlation between n_t and \tilde{n}_t is even higher. Notice that this high correlation is a direct consequence of the fact that averaging out the transition probabilities of husbands over the years 1976 and 2005 (as opposed to using any other method of eliminating business cycles) involves no loss of generality since for this demographic flow rates are remarkably stable over time (there is no secular trend in employment say).

TABLE 4: EXPERIMENTS

	Actual n_t	Actual \tilde{n}_t	CounterFactual \bar{n}_t	Actual \tilde{n}_t	CounterFactual \bar{n}_t
		One Month Horizon		Three Month Horizon	
$\frac{\sigma_x}{\sigma_y}$	.3604	.3770	.3805	.4294	.4362
$\rho_{x,y}$	.2963	.2988	.3703	.2570	.3216

In table (4) we summarize the results from this experiment. We compare the relative standard deviations and contemporaneous correlation of our constructed measures with a de-trended measure of GDP. The first column refers to the cyclical properties of the labor force participation rate of married wives based on the actual population measure n_t (the one we get from the data). ¹ Columns 2 to 3 and 4 to 5 compare the analogous objects based on the measures \tilde{n}_t and \bar{n}_t ,

¹The differences in the quantities $\frac{\sigma_n}{\sigma_y}$ and $\rho_{n,y}$ relative to Tables (2) and (3) stem from the fact that the population is normalized to unity.

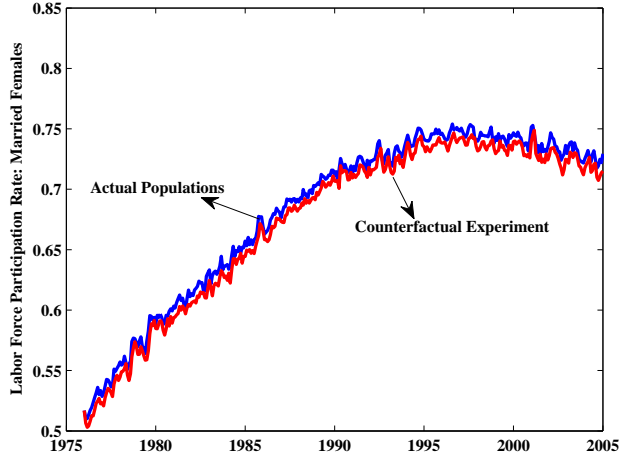


FIGURE 1: ACTUAL AND COUNTERFACTUAL LABOR FORCE PARTICIPATION RATES OF MARRIED WOMEN

for one and three months horizons respectively. As the horizon expands the errors that compile over time make the processes display considerably more volatility. The result however is both qualitatively and quantitatively encouraging. The cyclical correlation of labor force participation for wives jumps from .2988 to .3703 in columns 2 and 3 and from .257 to .3216 in columns 4 and 5 (which roughly corresponds to a 25% increase in cyclicity). Further on in light of this higher correlation with GDP we can argue that the increase in volatility from \tilde{n}_t to \bar{n}_t is mostly due to the business cycle.

We give the following interpretation for this result; If the US economy was populated by bachelor households then the labor force would be substantially more volatile and procyclical. Off course this conclusion is reached rather prematurely we are unable to control for observed heterogeneity and our notion joint insurance cannot be perfectly captured by couples. We can only do so much as to summarize a related literature below that has estimated the magnitude of the added worker effect and when it asked a similar question to ours we found it to be conducive to our hypothesis.

The literature on added worker effects. We give a brief summary of a related literature that uses panel data to investigate the effect of income shocks experienced by the husband on the spousal supply of labor. Our reading suggests that at least with respect to data and methodology there are three strands in

this literature.

First there are models that use variation in annual hours of work to identify how the husband's recorded unemployment spells affect the wife's labor supply. There doesn't appear to be a consensus in this empirical work for the magnitude of the AWE. For instance Heckman and MaCurdy (1980) find a small but significant AWE but the work of Pencavel (1982) doesn't. The reason for this is twofold. First there are other forms of insurance that minimize the loss of income due to an unemployment spell, and the work of Cullen and Gruber (2000) shows that unemployment benefits do indeed have a massive crowding out effect on family self insurance. Second more recently Stevens (2001) argues that the empirical literature fails to identify unemployment spells that result in substantial earnings losses (essentially the distinction of job leavers and job losers) and he shows that for displaced workers family insurance does have an important role.

There is a recent subset of studies that focus on the responses of spousal labor supply to shocks other than unemployment (health shocks in particular) such as Gallipoli and Turner (2008(a), 2008(b)) for Canada and Coyle (2004) for the US. This work documents the complete lack of AWEs although in the context of health shocks this lack of mutual insurance has an obvious interpretation; since disability and health shocks entail an intra-household transfer of time (that allows wives to 'care' for the their ill spouse) they are unable to increase hours in the market to make up for the lost income.

What is more related to our story is the subset of studies that use short run transitions across labor market states (employment, unemployment and inactivity). These studies tend to find significant added worker effects even when controlling for observed heterogeneity (which is missing from our experiment). Lundberg (1985) uses monthly employment histories from a sample of the Seattle and Denver Income Maintenance experiments to conclude that if a husband is unemployed then the probability that the wife enters the LF increases by 25 % and the probability of leaving the LF is 33 % lower. The wives are also 28 % less likely to leave employment for unemployment. Furtheron Speltzer (1997) uses a sample from the CPS monthly data and estimates limited dependent variable models of the probability that wives enter the LF on demographics and the husbands employment transitions. His estimates show that there is an important AWE even when observable heterogeneity is taken into account ².

²The sample used by Speltzer (1997) spans the months June to December in the years 1988 - 1989 and 1990 -1991 which is a much smaller range than what we use, and off course it is an entirely different empirical perspective. Our approach is much more similar to Lundberg (1985) who after estimating the transition probabilities plots the impulse response functions of a spousal hours and labor force participation when the husband's unemployment rate falls by 5 percentage points. She gets a similar result to us. Further on Speltzer (1997) shows that there are two variables that drive the AWE to be near insignificant; these are the previous year unemployment spells of the husband and the previous year LF participation of the wife. He interprets this as evidence of a spurious AWE due to assortative mating, but it is also consistent with the AWE in the data being driven by couples that can use more readily the family self insurance margin (and this shows as higher propensity to experience transitions between labor market states).

We conclude this section by noting that when the relevant literature (on the AWE) has asked the 'right' question the answer has been conducive to our intuition. It is clear that insofar as monthly transitions between labor market states are concerned joint insurance is important and further on our own empirical work illustrates that it's important in explaining the cyclical patterns of the US labor force. Further on if there is anything to be taken from the literature on spousal labor supply that can guide us in building the right theory its the following; the AWE is more pronounced when markets are incomplete (so that the loss of income due to unemployment translates into a drop in consumption), when the wife's contribution to household resources is significant (so that the insurance role of labor supply adjustments of secondary earners is important) and when the household production (or leisure) technology allows for substitutability between the time inputs of the household members. Below we explain why our framework bodes well with these requirements.

3 The model

We develop two related models in which households face uninsurable idiosyncratic labor income risk. In the first model a household consists of one agent, a bachelor. In the second model, and this is the key contribution of our paper, a household consists of two agents, a couple, who share their income risk.

3.1 Bachelor economy

We consider an economy populated by a unit mass of strictly risk averse bachelor households that are identical in preferences and value the consumption of a general multipurpose market good c . We denote the discount factor for these agents by β_S and the period utility deriving from consumption by $u(c)$.

At any point in time a household member can be either employed, unemployed or not part of the labor force and we assume that labor supply decisions are formed at the extensive margin and are subject to the frictions that impede instantaneous transitions across these adjacent labor market states. In particular employed agents spend a fraction \bar{h} of their unitary time endowment each period in market activities associated with a utility cost which we denote by $\Phi(\bar{h})$. For non employed agents we assume that job availability in the economy is limited: We endow them with a technology that transforms units of search effort s into arrival rates of job opportunities $p(s)$ at a cost $k(s)$ per unit of time. As we elaborate below on the basis of these optimal choices, we classify household members as either unemployed (active searchers) or out of labor force workers.

Further on we assume that households face idiosyncratic labor productivity risks and we summarize this in two independent stochastic processes ϵ and

x . The former (ϵ) is an agent specific process (an own labor productivity component) that is a persistent state variable in the agents value function independent of her labor market status. The latter x is a job specific component that pertains to the quality of active jobs and available job opportunities in the economy. These objects evolve stochastically over time according to the transition cumulative distribution functions $\pi_{\epsilon',\epsilon} = Pr(\epsilon_{t+1} < \epsilon', \epsilon_t = \epsilon)$ and $\pi_{x',x} = Pr(x_{t+1} < x', x_t = x)$ respectively. Further on we assume that the initial assignment of job quality x derives from a general density $H(x)$.

Financial markets are incomplete and agents can self insure by trading non contingent claims on the aggregate capital stock, earning a return R_t each period, subject to an ad hoc borrowing limit $a_t \geq \bar{a} \quad \forall t$. Wages per efficiency units of labor w_t as well as rental rates R_t are determined in competitive markets where it is assumed that a representative firm aggregates all inputs into a multipurpose final good. The technology is of the standard form $Y_t = K_t^\alpha (L_t \lambda_t)^{1-\alpha}$ where capital K_t depreciates at rate δ each period and $L_t = \int \int \int \epsilon x h_{a,\epsilon,x} I_{h_{a,\epsilon,x}=\bar{h}} d\Gamma_t$ denotes the aggregate efficiency units of the labor input. Finally Γ_t is the density over the relevant state space (of employment status, productivity and wealth) and λ_t is the TFP process which evolves according to the non-stochastic transition cdf $\pi_{\lambda'|\lambda} = Prob(\lambda_{t+1} < \lambda' | \lambda_t = \lambda')$. The law of motion for the distribution of workers is defined as: $\Gamma_{t+1} = \mathcal{T}(\Gamma_t, \lambda_t)$ where \mathcal{T} is the relevant transition operator.

The timing of events. Each period t (and after the resolution of all relevant uncertainty) a non-employed agent chooses optimally the number of search units s_t to exert and finances her consumption out of the current stock of savings. Her choice of s_t maps into a probability $p(s_t)$ of receiving a job offer in the next period. When this opportunity arrives the new value ϵ_{t+1} and the value x_{t+1} are sampled and the aggregate state vector $\{\Gamma_{t+1}, \lambda_{t+1}\}$ is revealed and the agent will decide whether she wants to give up search and become employed. Notice that given that all jobs entail a fixed cost $\Phi(\bar{h})$ the realization of the relevant state vector might not be such that the prospective match (job) generates a positive surplus for the worker. In that case the agent continues to search in the labor market.

Similarly for an employed agent the sampling of the new values for x_{t+1} and ϵ_{t+1} generates the risk of separation. In this case the worker may decide that it is not worthwhile to spend \bar{h} of her time working and would rather search for new opportunities next period. For this worker optimal consumption and savings decisions are borne out of the stock of wealth and labor earnings, conditional on her keeping her current employment status.

Value functions. Consider the problem of an agent with a stock of wealth a_t and a productivity endowment ϵ_t who is currently non employed. She must optimally allocate resources between current consumption and savings and choose the number of units of search effort to exert to maximize her well-being. In the

notation we let V^n be the lifetime utility for this worker. We also define an auxiliary object $Q^e = \max\{V^n, V^e\}$ which is the outer envelope over the relevant menu of choices for this worker conditional on her receiving a job offer next period. Applying standard arguments we can represent her program recursively as:

$$V^n(a, \epsilon, \Gamma, \lambda) = \max_{a' \geq \bar{a}, s} u(c) - k(s) + \beta_S \left(\int_{\epsilon', \lambda'} p(s) \int x' Q^e(a', \epsilon', x', \Gamma', \lambda') d H(x') \right. \\ \left. + (1 - p(s)) V^n(a', \epsilon', \Gamma', \lambda') d\pi_{\epsilon'|\epsilon} d\pi_{\lambda'|\lambda} \right) \quad (3.1)$$

Subject to the constraint set:

$$a' = R_{\lambda, \Gamma} a - c \quad (3.2)$$

Notice that the distribution Γ becomes a state variable in the worker's value function. In order to forecast prices in the current context and to make optimal savings and labor market search decisions knowledge of Γ' is necessary since this object determines the economy's aggregate capital stock and effective labor in the next period.³

In a similar fashion we can represent the employed worker's lifetime utility as a solution to the following functional equation:

$$V^e(a, \epsilon, x, \Gamma, \lambda) = \max_{a' \geq \bar{a}} u(c) - \Phi(\bar{h}) \\ + \beta_S \left(\int_{\epsilon', \lambda', x'} Q^e(a', \epsilon', x', \Gamma'|\lambda') d\pi_{\epsilon'|\epsilon} d\pi_{\lambda'|\lambda} d\pi_{x'|x} \right) \quad (3.3)$$

$$a' = R_{\lambda, \Gamma} a + w_{\lambda, \Gamma} \bar{h} \epsilon x - c \quad (3.4)$$

A few comments are in order here: First our classification criterion for nonemployed workers is of the following form:

$$\text{IF } s^* \begin{cases} < s_{min} & \text{Worker is OLF} \\ \geq s_{min} & \text{Worker is Unemployed} \end{cases}$$

³We use primes to denote next period variables. Furtheron we chose to use integrals instead of the conventional expectation operators to clarify that the relevant uncertainties faced by employed and non employed workers differ in the current context. The initial draws of x derive from the general distribution $H(x)$ and the continuation match qualities are determined by $\pi_{x'|x}$ so that in general:

$$\left(\int_{x'} Q^e(a', \epsilon', x', \Gamma', \lambda') d\pi_{x'|x} d x' \right) \neq \int_{x'} Q^e(a', \epsilon', x', \Gamma', \lambda') d H(x')$$

That is to say that we classify a worker as unemployed if she chooses effort above a given threshold s_{min} , and as out of the labor force otherwise. This mapping is consistent with the notion that inactive agents search less intensively in the labor market and as coarse as it may seem it is very close to the analogous criterion used by the CPS.⁴

Further on we normalize the value of income for both unemployed and OLF workers to zero so that their consumption is financed exclusively out of the stock of savings. This assumption is made mainly to avoid the complications of having to talk about eligibility in government insurance schemes as it is not clear how benefits would be distributed across the population. For instance inactive workers in principle should not receive any sort of replacement income but in our model there is a considerable amount of mobility between the two non employment states. In turn keeping track of benefit histories would add to the computational burden of our exercise without being clear how it would affect the main results.⁵

3.1.1 Competitive Equilibrium

The equilibrium consists of a set of value functions $\{V^n, V^e\}$, and a set of decision rules for consumption, asset holdings ($a'_e(a, x, \epsilon, \lambda, \Gamma)$ and $a'_n(a, \epsilon, \lambda, \Gamma)$), search ($s(a, \epsilon, \lambda, \Gamma)$) and labor supply ($h(a, x, \epsilon, \lambda, \Gamma)$). It also consists of a collection of quantities $\{K_t, L_t\}$ and prices $\{w_t, R_t\}$ and a law of motion of the distribution $\Gamma_{t+1} = T(\Gamma_t, \lambda_t)$ such that:

- Given prices households solve the maximization program in 3.1 and 3.3 and optimal policies derive.

⁴More specifically the CPS classifies non employed workers on the basis of the following algorithm. First a non-employed respondent is asked whether he would like to have a job. Those who reply 'no' are automatically considered as OLF workers. Those who reply 'yes' are then asked to indicate what steps they have taken towards finding employment in the previous month, and in particular they are asked to outline their methods of search (there are twelve such methods). Those that have not searched but also those who have not exerted sufficiently active search effort are classified as OLF workers. Further on active search effort consists of using any of the proposed methods of search other than or beyond reading newspaper ads. See Shimer (2003) for further details.

⁵Arguably the unemployment insurance in the current context would crowd out family self-insurance (see Cullen and Gruber (2000)) but it would also crowd out the precautionary role of assets (see Engen and Gruber (2001)). Further more although empirically one effect may not make up for the other it seems to be the case for the incomplete market model that we use here. For instance Young (2004) finds that the optimal level of UI in an economy with search frictions is always zero and part of the explanation is that in general equilibrium wealth accumulation minimizes the utility costs from a lack of buffer provided by the government. In the context of our model it seems likely that introducing UI would only shift the regions in the state space where all the action takes place without any significant impact on the main conclusions. On the other hand eliminating UI can be interpreted as a necessary feature of our analysis because we want to get the maximum AWE we can out of the model.

- The final goods firm maximizes its profits:

$$w_t = K_t^\alpha \lambda_t^{1-\alpha} L_t^{-\alpha} \quad \text{And} \quad r_t = K_t^{-\alpha} \lambda_t^{1-\alpha} L_t^{1-\alpha}$$

- Goods and factor markets clear:

$$Y_t + (1 - \delta)K_t = \int \mathcal{I}_{h=\bar{h}}(a'_w(a_t, \epsilon_t, x_t, \Gamma_t, \lambda_t) + c_w(a_t, \epsilon_t, x_t, \Gamma_t, \lambda_t)) d\Gamma_t$$

$$+ \int \mathcal{I}_{h=0}(a'_n(a_t, \epsilon_t, \Gamma_t, \lambda_t) + c_n(a_t, \epsilon_t, \Gamma_t, \lambda_t)) d\Gamma_t \quad \text{Resource Constraint}$$

$$L_t = \int \epsilon x h_{a,\epsilon,x,\lambda,\Gamma} \mathcal{I}_{(h_{a,\epsilon,x,\lambda,\Gamma}=\bar{h})} d\Gamma_t \quad \text{Labor Market}$$

$$K_t = \int a_t d\Gamma_t \quad \text{Savings Market}$$

- Individual behavior is consistent with the aggregate behavior.⁶

⁶The law of motion of the measure Γ can be represented as follows:

$$\Gamma'_e(\mathcal{A}, \mathcal{E}, \mathcal{X}) = \int_{a'_e \in \mathcal{A}, \epsilon' \in \mathcal{E}, x' \in \mathcal{X}} \mathcal{I}_{h(a', \epsilon', x', \Gamma', \lambda')=\bar{h}} d\pi_{\epsilon'|\epsilon} d\pi_{x'|x} d\Gamma_e$$

$$+ \int_{a'_n \in \mathcal{A}, \epsilon' \in \mathcal{E}, x' \in \mathcal{X}} \mathcal{I}_{h(a', \epsilon', x', \Gamma', \lambda')=\bar{h}} p(s(a, \epsilon, x, \Gamma, \lambda)) d\pi_{\epsilon'|\epsilon} dH(x') d\Gamma_n$$

$$\Gamma'_n(\mathcal{A}, \mathcal{E}) = \int_{a'_e \in \mathcal{A}, \epsilon' \in \mathcal{E}} \mathcal{I}_{h(a', \epsilon', x', \Gamma', \lambda')=0} d\pi_{\epsilon'|\epsilon} d\pi_{x'|x} d\Gamma_e$$

$$+ \int_{a'_n \in \mathcal{A}, \epsilon' \in \mathcal{E}} \mathcal{I}_{h(a', \epsilon', x', \Gamma', \lambda')=0} p(s(a, \epsilon, x, \Gamma, \lambda)) d\pi_{\epsilon'|\epsilon} dH(x') d\Gamma_n$$

$$+ \int_{a'_n \in \mathcal{A}, \epsilon' \in \mathcal{E}} \mathcal{I}_{h(a', \epsilon', x', \Gamma', \lambda')=0} (1 - p(s(a, \epsilon, x, \Gamma, \lambda))) d\pi_{\epsilon'|\epsilon} dH(x') d\Gamma_n$$

Where Γ_n and Γ_e denote the marginal cdfs for non-employed and employed workers respectively and \mathcal{A} \mathcal{E} \mathcal{X} are subsets of the relevant state space.

3.2 Couples economy

We introduce households that consist of two members in the economy retaining as many elements from the singles environment as possible. In particular we have a measure one of agents (so a total mass a half of households) and each one of them is endowed with a unit of time. Household members derive utility from consumption and the felicity function is given again by the general form $u(c_t)$. We denote the time preference parameters for households in this case by β_C .

As far as intra-household allocations are concerned we adopt the unitary model whereby the household as a whole is treated as a decision unit and the members share the same common utility function; income and wealth are pooled and consumption and labor supply or search decisions are formed jointly to maximize the households well being. Each agent in the economy has her own idiosyncratic productivity and consequently household members differ in their productive endowments and we denote by ϵ_t and x_t the vector of productivities of the members of a generic household. Further on to conserve on the notation we let $\Pi_{\epsilon|\epsilon}$ be the joint cdf for the household members own productivities.

Having labor supply decisions formed jointly within households that comprise of two members gives rise to opportunities of specialization in market and non-market work that were absent in a world of bachelor agents. Ideally a household would like to have at any point in time, the most productive agent in the market but it cannot do so without confronting the frictions that impede instantaneous transitions across labor market states. In what follows we adopt the convention that the array (k, l) $k, l \in \{E, N\}$ denotes a household whose first and second members are in state k and l respectively. Also it will prove useful to define the following objects beforehand:

$$Q^{en} = \max\{V^{nn}, V^{en}\} \tag{3.5}$$

$$Q^{ne} = \max\{V^{nn}, V^{ne}\} \tag{3.6}$$

$$Q^{ee} = \max\{Q^{en}, Q^{ne}, V^{ee}\} \tag{3.7}$$

These objects define the relevant menu of choices for our households. For instance a household with one employed member can in any given period decide to withdraw her from the labor market and allocate both agents to search. This option is described in equation (3.5). Analogously in (3.7) a household with both members employed, can withdraw them to non-employment, or keep one working or both. With these definitions we can represent the dynamic programming problem of a household with two non-employed members as:

$$\begin{aligned}
V_{a,\epsilon,\lambda,\Gamma}^{nn} &= \max_{a' \geq \bar{a}, s_1, s_2} u(c_t) - \sum_i k(s_i) \\
&+ \beta_C \left(\int_{\epsilon', \lambda'} p(s_1)p(s_2) \int_{x'_1, x'_2} Q^{ee}(a', \epsilon', x'_1, x'_2, \lambda', \Gamma') dH(x'_1), dH(x'_2) \right. \\
&+ p(s_1)(1-p(s_2)) \int_{x'_1} Q^{en}(a', \epsilon', x'_1, \lambda', \Gamma') dH(x'_1) \\
&+ p(s_2)(1-p(s_1)) \int_{x'_2} Q^{ne}(a', \epsilon', x'_2, \lambda', \Gamma') dH(x'_2) \\
&+ (1-p(s_2))(1-p(s_1)) Q^{nn}(a', \epsilon', \lambda', \Gamma') d\pi_{\epsilon'|\epsilon} d\pi_{\lambda'|\lambda} \left. \right) \quad (3.8)
\end{aligned}$$

subject to:

$$a' = R_{\lambda,\Gamma} a - c \quad (3.9)$$

Optimal choices for these agents consist of current consumption and a pair of search intensity levels. Note that nothing precludes household members from setting $s_i \neq s_j$ although with standard convexity assumptions this can only be the case if the productivity endowments ϵ_i and ϵ_j are unequal. Further on with probability $p(s_1)p(s_2)$ both members receive an offer and the sampling from the distribution of qualities $H(x)$ is independent. Both joint search coupled with the limited availability of job opportunities, and the independent sampling introduce risk sharing possibilities to households (through adjustments of labor supply) that were non-existent in the singles economy.

The lifetime utility for a household with the first member employed solves the following functional equation:

$$\begin{aligned}
V_{a,\epsilon,x_1,\lambda,\Gamma}^{en} &= \max_{a' \geq \bar{a}, s_2} u(c_t) - k(s_2) - \Phi(\bar{h}) \\
&+ \beta_C \left(\int_{\epsilon', \lambda'} (p(s_2) \int_{x'_1, x'_2} Q^{ee}(a', \epsilon', x'_1, x'_2, \lambda', \Gamma') d\pi_{x'_1|x_1} dH(x'_2) \right. \\
&+ (1-p(s_2)) \int_{x'_1} Q^{en}(a', \epsilon', x'_1, \lambda', \Gamma') d\pi_{x'_1|x_1} \left. \right) d\pi_{\epsilon'|\epsilon} d\pi_{\lambda'|\lambda} \quad (3.10)
\end{aligned}$$

$$a' = R_{\lambda,\Gamma} a + w_{\lambda,\Gamma} \bar{h} x_1 \epsilon_1 - c \quad (3.11)$$

For the sake of brevity we omit object V^{ne} since the recursive representation is similar to that of equation (3.10). Finally for a household with both members employed we can write:

$$\begin{aligned}
V_{a,\epsilon,x_1,x_2,\lambda,\Gamma}^{ee} &= \max_{a' \geq \bar{a}} u(c_t) - \sum_i \Phi(\bar{h}) \quad (3.12) \\
&+ \beta_C \left(\int_{\epsilon', \lambda'} \left(\int_{x'_1, x'_2} Q^{ee}(a', \epsilon', x'_1, x'_2, \lambda', \Gamma') d\pi_{x'_1|x_1} d\pi_{x'_2|x_2} \right) d\pi_{\epsilon'|\epsilon} d\pi_{\lambda'|\lambda} \right)
\end{aligned}$$

$$a' = R_{\lambda,\Gamma}a + w_{\lambda,\Gamma}\bar{h} \sum_i x_i \epsilon_i - c \quad (3.13)$$

3.2.1 Competitive Equilibrium

The definition is similar to the one in section 3.1 and for the sake of brevity is omitted.

3.3 Discussion

Our story is similar to Chang and Kim (2006, 2007) and Gomes Greenwood and Rebelo (2001) who use models of heterogeneous agents with aggregate uncertainty and assess their labor market implications. There as well as in our case the distribution of match (job) rents is governed by the idiosyncratic productivity endowments and according to their realizations, each period agents adjust their labor market status. To this framework we add the following ingredients: We introduce both own productivity shocks ϵ and match quality shocks x and we assume that search in the labor market is subject to a technology that maps search effort s into arrival rates of job offers $p(s)$. We devote a few paragraphs to discuss why we think these additions are crucial.

Why do we need a rich structure of shocks? The answer here is simple. Without them we wouldn't be able to match the worker flows which we summarize in Tables 2 and 3. Since our model has to disassociate the behavior of agents who make frequent transitions between employment and unemployment from those who move in and out of the labor force it is imperative that we introduce both own productivity and match quality shock. For instance in our calibration we choose the moments of the two processes in such a way so that the transitions between unemployment and employment are governed by the x type shocks and those between unemployment and inactivity by the ϵ . Further on decomposing the overall labor market risk in these two processes seems to be empirically relevant since in the data firm effects as well as individual effects both account for substantial fractions of the individual earnings uncertainty (see Abowd et al (1999)).

The search technology. We adopt a very parsimonious representation of the search technology. In particular we assume that there two levels of search intensity that a worker can exert $s \in \{s_I, s_U\}$ where the subscripts I and U stand for inactive (out of labor force) and unemployment (active searchers)

respectively. Associated with these choices are the following probabilities of receiving a job offer next period:

$$p(s) = \begin{cases} p_I & \text{if } s = s_I \\ p_U & \text{if } s = s_U \end{cases}$$

Further on the search costs are assumed to be of the form: $k(s) = 0$ if $s = s_I$ and $k(s) = k$ if $s = s_U$. These discrete choices are enough to capture our division between workers that search actively, and hence are counted as unemployed, and those whose optimal choice of search does not translate into a large enough contact rate with potential employers and hence are considered out of the labor force workers. Adding more thresholds would in general complicate things for us by requiring that the model be consistent with a larger set of targets. For instance if we were to include two thresholds of search for inactive workers we would have to make the model match the populations of agents who don't search at all (and this is a large fraction of respondents in the CPS) and those who do search albeit in a passive way. We don't believe that these considerations are important and that they would impact the results. Notice that there is in general nothing that precludes us from setting ($p_I = 0$) but in principle to match the observed flows from inactivity to employment in our model's horizon it must be that $p_I > 0$.

We give the following interpretation to our technology: p_U and p_I are treated as technological upper bounds to the number of matches that are possible each period from states U and I respectively. When we increase the values of these parameters we also need to increase the variance of the x shocks to keep the transition rates close to the data, since by the standard intuition a mean preserving spread in a match quality distribution would make searchers more selective. Generally we set $p_U \ll 1$ for our main result the reason being that with limited job availability we want give couples meaningful insurance opportunities against unemployment spells. Further on these bounds must not be too tight since in our model these probabilities are constant over the business cycle. If say we were to set $p_U = .28$ (the steady state UE rate in the data) there would be no room for an increase job finding rates when the expansion comes, and unemployment in the economy would be counter-factually procyclical.

This last point merits some attention. If in our model the flows between labor market states were governed by the firms' willingness to create jobs over the business cycle (as in Mortensen and Pissarides (1994)) then the probabilities p_I and p_U would change over time. However the implications of such a model would be no different from ours, since search and matching models generate procyclical search intensity (so agents would flow from inactivity to unemployment) which is precisely what we want to avoid by introducing couples. Further on our model generates endogenous separations and job finding by virtue of the processes x and ϵ and the fixed cost of participation in the labor market. Whether firms bear the costs of investment in search (as in the Mortensen and Pissarides framework) or workers as we assume here is completely irrelevant. The only thing that matters is how these investments change over the business cycle.

4 Calibration and Baseline Results

4.1 Parametrization

We briefly discuss our choice of parameters and functional forms: We adopt a period utility function of the form:

$$u(c_t) = \log(c_t)$$

Following Chang and Kim (2007) we set the disutility from working equal to $B\frac{\bar{h}^{1+\gamma}}{1+\gamma}$ and we normalize γ to unity (this is unimportant in the current context). Parameter B is chosen to target the average employment population ratio of 60 % in the data. Since we draw no distinction between male and female population in the economy we don't have to worry about matching the division of employment between these two demographics and we set the disutility of labor for a household that comprises of two employed members equal to $2B\frac{\bar{h}^{1+\gamma}}{1+\gamma}$. We do however show how the model fares in terms of the specialization of home vs market activity in primary and secondary earners against the data.

For the search technology we set $p_U = .5$ and $p_I = .1$ in our benchmark which given the empirical labor market flows seem like reasonable values. The cost of search for unemployed workers k is chosen to target the fraction of the population of nonemployed workers that are unemployed (i.e. those that set $s = s_U$). In the US data the unemployment rate is on average 5.5 % over our sample period.

Given that the model's horizon is one month we fix the time preference parameter for couples β_C to .995 and the depreciation rate δ to .0083. These values turn out to be roughly consistent with an (average steady state) interest rate $R = 1 + r - \delta$ of 1.0041 (a yearly analogue of 5 %). The discount factor for singles β_S is chosen so that the produced capital labor ratios (and hence the interest rates) in the two economies are equal.

Further on the share of capital to value added α is calibrated to .33 and we assume that the employed agents spend roughly a third of their time endowment in market work (hence we set $\bar{h} = 0.33$). Following Chang and Kim (2007) the aggregate TFP process is calibrated such that the quarterly first order autocorrelation is $\rho_\lambda = 0.95$ and the conditional standard deviation $\sigma_\lambda = 0.007$. Table 5 summarizes these choices.

Finally our idiosyncratic labor productivity processes are of the following form:

$$\begin{aligned}\log(x_t) &= \rho_x \log(x_{t-1}) + v_{x,t} \\ \log(\epsilon_t) &= \rho_\epsilon \log(\epsilon_{t-1}) + v_{\epsilon,t}\end{aligned}$$

These choices is guided by the relevant literature that uses similar representations of the stochastic process of labor income (see Heathcote et al (2008)). Further

TABLE 5: THE MODEL PARAMETERS (QUARTERLY VALUES)

Parameter	Symbol	Baseline
std of TFP shock	σ_λ	0.007
AR1 of TFP shock	ρ_λ	0.95
Share of capital	α	0.33
Depreciation rate	δ	0.025
Discount Factor Couples	β_C	0.995
Fraction of time working	\bar{h}	0.33
Offer Rate: OLF	p_I	.1
Offer Rate: Unemployed	p_U	policy parameters
Labor Disutility	B	
Discount Factor Singles	β_S	
Search cost	k	jointly calibrated
Moments of x	σ_x, ρ_x	(see text)
Moments of ϵ	$\sigma_\epsilon, \rho_\epsilon$	

on we assume that the innovations are mean zero processes (i.e. $v_{x,t} \sim \mathcal{N}(0, \sigma_x)$ and $v_{\epsilon,t} \sim \mathcal{N}(0, \sigma_\epsilon)$).

Our calibration procedure is as follows: For each one of the models (singles, couples) we choose the moments of the idiosyncratic productivity processes ρ and σ along with B and k to match the observed labor market flows. We have six parameters for six targets but this doesn't mean that we can match the worker flows perfectly. It turns out that there is a range of the ρ and σ parameters where the models perform well in some dimensions and bad in some others. In turn we set our targets so that fit is good and the calibration matches aspects of the data that are really important for our exercise. As we explain our couples economy is able to match the flow rate from unemployment to employment and the flows in and out of the labor force. What it cannot match is the division between the EU and EI flows, given a total outflow rate from employment.

4.1.1 Solution method

We solve the model with aggregate uncertainty using the bounded rationality approach whereby agents forecast future prices using a finite set of moments of the distribution Γ_t . As in Krusell and Smith (1998) we find that first moments (means) are sufficient for very accurate forecasts in our context (approximate aggregation holds). A detailed description of the algorithm is delegated to the appendix.

4.2 Steady State Findings

We use this section to provide information on the models' performances in a number of relevant dimensions. In Table 6 we summarize the estimated worker

TABLE 6: ESTIMATED LABOR MARKET FLOWS: SINGLES VS COUPLES

	Bachelor Households			Couples Households		
	E	U	I	E	U	I
E	.9507	.00432	.0450	.9515	.00567	.0428
U	.2801	0.5831	.1368	.2830	.5051	.2119
I	.0503	.0322	.9175	.0507	.0381	.9112

flows from the bachelor and the couple economy. We use Table 2 for our targets (so the flows for all agents that are aged 16 and above independent of marital status) because when we compare the business cycle properties of our economies relative to the data we don't have aggregate statistics (say output) for different demographic groups. In both cases the decomposition between movements in and movements out of labor market states is such that the model output is consistent with an employment population ratio to 60 % rate an unemployment rate to 5.5 % and a outflow rate from unemployment to employment of 28 % which is what we find in the data.

Both models can match the total outflow from employment to non-employment but the composition between the number of workers who leave their jobs to search intensively (unemployed) and those who leave their jobs but don't is off targets. In particular in the data the EU rate is around 1.4 % on average and the EI is 3.11 % but even the couples economy produces values for these objects of .567 % and 4.28 % respectively.

Further on a striking difference in terms of the performance of the two models is the resulting UI flows. We find that in the data the couple household economy can easily attain a target of 21 % (which is the data counterpart for this quantity) whilst with bachelor households the best we can do is a value of 14 %. This discrepancy is at the center of our notion of joint insurance here. In the steady state there is a large fraction of families where one member is employed and another not and also a large number of families were both members are unemployed. In the first case the choice of search intensity for the non-employed member is affected by the own productivity state ϵ and the composite productivity of their partner's (ϵ and x). Changes in household income in this case (a change in productivity of the employed agent) entail a wealth effect on the labor supply of non employed agents which could induce them to drop out of the labor force. Similarly when both members of a household are unemployed and one of them receives a job offer and becomes employed, there is an analogous wealth effect to the labor supply of the other family member. We show below that this happens a lot in the equilibrium with couples. In contrast in a bachelor household economy this

channel is absent and the two factors that determine the choice of labor market status are wealth and productivity. Since wealth is run down in nonemployment, productivity must be less persistent to match the data.

To give sense of the magnitudes of these differences we report the values for the implied stochastic processes in the two models. First given the above intuition we estimate $\rho_\epsilon^C = .7$ and $\rho_\epsilon^S = .5$ (so that persistence is larger in the couples economy). Second it turns out that the required conditional standard deviation of the shocks in the singles economy is twice as large as the analogous object in the couples model, so we get that $\sigma_x^S = .095$ and $\sigma_\epsilon^S = .42$ and $\sigma_x^C = .043$ and $\sigma_\epsilon^C = .21$ although the overall household risk in both cases may be similar. Finally in both models match quality shocks need to be equally and very persistent so that we set $\rho_x^C = \rho_x^S = .99$.

With these numbers in our baseline calibration we get that employed agents care more about match quality than own productivity shocks. That is to say an agent in a high x job can let her own productivity ϵ component drift to a very low level before she considers quitting her job (since it is likely to drift back again due to low persistence) but when the match quality deteriorates she is almost certain to become non-employed. On the other hand the transition between unemployment and OLF is governed by the ϵ shocks and in this case they have to be less permanent to give us the UI and IU flow rates that we see in the data.

These numbers don't have a particular interpretation since our model confounds risks from many sources and below we provide more relevant statistics by estimating wage processes from a sample of agents out of our steady state calibration. For the moment suffice is to say although our model features two independent stochastic processes for labor income risk it is yet too parsimonious to match some aspects of the data and the rest of this section is devoted to analyzing that.

Other calibrations. We briefly discuss how the model performs when different values for the stochastic processes are chosen. First when we increase the persistence we always get a smaller UI flow rate and a larger EU flow. For instance in the couples model with $\rho_\epsilon^C = .88$ and $\sigma_\epsilon^C = .13$ we get UI equal to .14 and the EU flow rate equals .008 (much closer to the data). The reason is that the assignment of household members to market work and leisure is much more persistent in this case so when the employed member loses her job the family assigns her to become unemployed rather than withdraw her from labor force. In contrast in our baseline calibration with $\rho_\epsilon^C = .7$ the pool of non employed agents is more or less equally productive, in terms of ϵ , as the pool of employed agents and there are frequent changes in the identity of the main earner within the family (this is something that we scrutinize below).

Further on changes in the other parameters present us with much worse tradeoffs. For instance decreasing the value of ρ_x increases the UE flow rate to above .4 (a similar result applies if we decrease the value of σ_x) since now

match quality shocks become less important and there are virtually no gains in the other flows.

Overall our criterion in choosing the best model is the following. First we demand that the equilibrium output is such that the UE flow rate is .28 (as in the data). The reason is that, as we said before we want expansions to increase the job finding rate in the economy without necessarily hitting the upper bound on the number of matches (which is $p_U = 1/2$). When this target is met we adjust the relevant parameters to match as close as possible the flows between unemployment and inactivity and the total outflow from employment. Why this order? Because we found that models that match all the relevant flow rates between employment and unemployment usually feature too few transitions between inactivity and the labor force; and too few transitions mean that these models could potentially have the labor force close to being fixed. In section 4.3 which contains our main results we also report the cyclical properties for the economy that sets $\rho_\epsilon^C = .88$ and $\sigma_\epsilon^C = .13$ as an alternative calibration.

How readily can household members substitute in terms of their labor income? To answer this question we look at the persistence of employment status over time in a cohort of agents (a sample of 5000 families) simulated from the steady state distribution. For each period we assume that a family's primary earner is the agent that had the highest recorded annual labor income. Annual horizons serve to mitigate the effect of frictions on recorded employment histories.

To uncover the persistence we simply estimate the Markov transition matrix of primary and secondary earners (that is to say the probability that the identity of the household head changes from one year to the next). By this metric we find that roughly 30 % of our families alternate roles as primary and secondary earners in the labor market each year. Further on when we use the number of hours as our index, and drop productivity from the calculation we find that this rate decreases to 20%.

Arguably the employment status of agents is a much more persistent state, and the reason that our theory cannot match this aspect of the data is precisely that we put two ex ante identical agents within each household. In reality agents differ in fixed productivity and command different rewards in the labor market based on age, sex experience among other things. We can only do so much as to summarize some of these features in our two stochastic processes but our model requires low persistence in the ϵ risk to match the flows between inactivity and unemployment.

To see how specialization in market work vs leisure is determined within the household consider the decomposition inactivity and unemployment in the steady state summarized in Table 7. Roughly a 35 % of all OLF agents in the economy live in households where both members are inactive and the remaining 65 % percent are in families where one member is either unemployed or employed. In the data the analogous fractions are 24 % and 76 % respectively, for a population

aged between 16 and 65, and 50 % for ages 16 and above. Clearly demographics play a significant role here but we think that our model strikes a good balance between the two samples in the data.

Further on insofar as the cross section of unemployed agents is concerned we observe that our model overestimates the fraction of agents that are part of households where both members are non-employed. In the data for instance conditional on unemployment the probability that an agent is part of a family where the second member is also unemployed is 7% when the couple occupies the age bracket 16-65. Analogously the probability that the other member is out of the labor force is 19%. The model produced values of 20% and 27% respectively and again this probably is symptomatic of the fact that independent shocks and identical agents exacerbate the role of insurance in the couples economy.

TABLE 7: DECOMPOSITIONS OF UNEMPLOYMENT AND INACTIVITY

Unemployed	UU	UI	UE
Bechmark Model	.2	.27	.53
US Data: Ages 16-65	.07	.19	.74
US Data: Ages >16	.1	.22	.68
OLF	II	UI	IE
Bechmark Model	.354	.026	.62
US Data: Ages 16-65	.24	.026	.734
US Data: Ages >16	.5	.02	.48

The implied process of wages. Since in our model idiosyncratic labor incomes confound risks from various sources (search frictions and the joint stochastic processes of productivity) to evaluate how realistic our choices are we need to estimate the realized profiles of wages for individuals in our economy. We use a simple representation of the logarithm of annual (time aggregated) wages: $\ln w_t = \phi \ln w_{t-1} + v_t$ and use a sample of 10000 individuals over 20 years to estimate the implied values for ϕ and the variance of the shock σ_v . Further on since in our model the distinction between household heads and secondary earners seems to be virtually irrelevant (with two ex ante identical agents) we pool the estimates from all household members in the simulated population.

Both of these values seem to be far away from the data. Our estimates are $\phi_S = .1$ for the singles economy and $\phi_C = .4$ for couples (notice that couples is much closer to a high persistence process that is empirically relevant). Furtheron there is a wealth of estimates for the data analogues for these statistics (see Heathcote et al (2008)) and all of them yield a value for ϕ in the neighborhood of .9. ⁷ Given that both of our models imply that labor income is less persistent

⁷In Chang and Kim (2007) a model that accounts for selection effects yields a value for the persistence component of .73

than in the data we conclude that only temporary components of shocks are important in matching the labor market flows.

4.3 Cyclical properties

Table 8 presents the results from our benchmark calibration with $p_U = 1/2$ $p_I = .1$ for both the couples and the bachelor household economies. We restrict attention to key labor market statistics and all quantities are expressed relative to a de-trended measure of GDP (They are logged and HP filtered with a parameter $\lambda = 1600$). The data are quarterly aggregates of the simulated aggregate paths.

In the singles economy unemployment is extremely procyclical (contemporaneous correlation with GDP is .65) and so is the labor force. The model produces a contemporaneous correlation with GDP equal to .65 and .97 for these quantities whilst in the data the analogous statistics are -.81 and .2 respectively. Further on aggregate unemployment is not nearly as volatile as in the the data (1.78 vs 6.68) and the LF is nearly 50% more volatile (.32 vs .22 in the data).

The benchmark couples model (columns 3-4) produces a slightly different set of statistics. Unemployment now becomes more acyclical (the contemporaneous correlation with GDP is .22) and more volatile than with bachelor households. It is closer to the data. Aggregate employment is more volatile and equally procyclical and the LF is nearly twice as volatile (.62) and only marginally less procyclical (.95) than in the previous case. Finally columns 5-6 contain the results of the economy that sets $\rho_\epsilon^C = .88$ and $\sigma_\epsilon^C = .13$. There aggregate unemployment is slightly more countercyclical (contemporaneous correlation with GDP is -.05) and more volatile ($\frac{\sigma_u}{\sigma_Y} = 3.5$). Aggregate employment is still more volatile than in the bachelor household model and equally procyclical, and the LF is again more volatile (although less than the baseline couples model) and again somewhat less procyclical ⁸.

These results are extremely disappointing from the point of view of our theory. How so? Well in section 2 we showed that the labor force participation of females in our sample was substantially more procyclical and volatile when the influence of the husband's employment status was removed. We interpreted this result as indicating that if the US economy was populated by bachelor agents (and joint insurance opportunities didn't exist) then the LF would be considerably more procyclical. By this metric the model fails miserably in replicating this feature of the data. When we move from the singles to the couples economy (so more insurance) we see that the volatility of the LF increases and there are virtually

⁸Note that although the differences are small they are not the result of sampling variation; in the Appendix we outline an algorithm due to Young (2009) that computes the equilibrium in the economy by working with the histogram instead of simulating panels of a finite number of agents. There is no sampling variation due to the Law of Large Numbers.

TABLE 8: RESULTS: CYCLICAL PROPERTIES OF LABOR MARKETS

	Bachelors		Couples		Couples	
	Benchmark		Benchmark		High	ρ_ϵ
	$\frac{\sigma_x}{\sigma_y}$	$\rho_{x,y}$	$\frac{\sigma_x}{\sigma_y}$	$\rho_{x,y}$	$\frac{\sigma_x}{\sigma_y}$	$\rho_{x,y}$
Unemployment	1.78	.65	2.7	.22	3.5	-.05
Employment	0.54	0.96	.85	0.97	.77	.96
Labor Force	0.32	0.97	.62	0.95	.41	.95

no gains in the cyclical correlation of this statistic ⁹. The comparison of the two economies therefore sends the qualitative patterns to the opposite direction and this comes out of a model that features considerable insurance as we showed in section 4.2.

It is clear that this failure of all the models to generate statistics close to the US data is due to the overwhelming motive in these economies to allocate agents to activity (employment and unemployment) during economic expansions. In the upturn jobs become more attractive and the typical agent increases her optimal level of search intensity. However before these agents can be allocated to employment they have to spend time in the pool of unemployed workers due to the existence of frictions. This is why aggregate unemployment becomes procyclical (or nearly procyclical) in the models.

Further on the larger volatility that we get in the couples model is possibly a result of three features all of which relate to the identity of the marginal worker in the economy. First our singles model has considerably more uncertainty in the idiosyncratic process and thus individual decisions are guided less by the aggregate state (expansion vs recession) and more by the labor income. Second the distribution of agents over the relevant state space is different in the two economies and bachelors OLF agents have sufficient wealth to finance leisure whilst in the couples model inactivity usually entails the presence of a main earner at home. In the latter case households use more readily labor supply as a margin of insurance and business cycles move more workers between labor market states. Finally another reason we get larger volatilities is precisely that households have secondary earners and in this case the aggregate elasticity of labor supply is considerably larger (as in Chang and Kim (2006)) ¹⁰.

⁹Notice that repeating the analysis of section 2 here would be meaningless since our economy is not inhabited by males and females but by identical agents. Further on we argued that households change very frequently the identity of the main earner.

¹⁰Chang and Kim (2006) build a model similar to ours that features husbands and wives in the household, incomplete markets and an extensive margin of labor supply and they get a much larger amplification of business cycle shocks to aggregate employment than what the values of elasticity of labor supply they assume would otherwise give. In their model as well as in ours the aggregate elasticity of labor supply is borne out of the reservation wage distributions

We find that all of these possibilities are relevant here; for instance when we increase the volatility of idiosyncratic endowments in the couples economy we do get some fall in volatility in the aggregate labor market (we don't report this because this model produces wrong labor market flows). Uncertainty however cannot be the only reason since our alternative calibration of the couples economy, features a similar level of unconditional uncertainty and yet produces a slightly different set of statistics.

4.3.1 Other models.

We take stock from the results of this section to discern whether there are important features that our model misses out on and that could potentially change its implications. For one thing with two ex ante identical agents we argued that our model is unable to match patterns of specialization within the household in terms of market work and leisure. And yet this appears to be important since in the US data over our sample period we find that the LF participation of husbands is considerably higher and acyclical (it has a zero contemporaneous correlation with GDP).

But matching these aspects would probably have something to say about volatility but very few for the cyclical correlation. This is precisely what happens in our calibration of the model with $\rho_\epsilon^C = .88$ and $\sigma_\epsilon^C = .13$. There the assignment of roles within the family is much more persistent (note that this is why the model produces a higher EU flow) and whilst the labor force becomes less volatile the cyclical correlation doesn't budge, because there is always a marginal worker that flows in economic activity in expansions. Analogously if we were to assign a gender to each member of our families and we assumed that secondary earners are less productive, as in the data, then we could hypothetically go a lot further towards matching volatility of the labor force. The problem is that this addition would kill off the insurance margin since the contribution to household resources of a wife when she increases her labor supply would also be considerably smaller than in our model, and in this sense matching aspects of intra-household correlation of incomes would also be important.

For the same reason what doesn't seem to hold promise is to incorporate some departure from complete insurance within the family in our framework. If our modeling of household consumption and employment decisions was based on the collective approach as in Chiappori (1988) then, it is well understood, that household members would behave much more like bachelor agents. In contrast the unitary model that we adopt maximizes the added worker effect which we found to be responsible for the cyclical behavior of the labor force.

Then when should we expect for family self insurance to be most important?

and not the willingness to substitute leisure inter-temporally. The problem is that their analysis doesn't go as far as to discern which one of the ingredients is responsible for the results; They don't compare with a bachelor household economy (so as to single out secondary earners) vs the extensive margin of labor supply. Further on husbands and wives in their model are not ex ante identical.

We answer; when there are unemployment risks (that entail large losses of income) and when there are incomplete markets so that consumption is affected. Our model builds on these assumptions but here risks are partly choices since the decision to move out of employment depends on the reservation wage that increases in wealth. For a constrained worker a fall in match quality doesn't necessarily mean unemployment since the match surplus becomes negative only when wealth is sufficiently high. But on the other hand wealthier workers are nearly permanent income agents (Krusell and Smith (1998)).

Not even search and matching models of the labor market as in Mortensen and Pissarides (1994) escape this critique since there the job surplus falls with wealth (see Bils et al 2008). Moreover if we were to add firms in the background that make hiring and firing decisions in our framework and we endowed agents with a search technology as we did here, then the search intensity of the economy's workforce would still be too procyclical (see Shimer (2003), Merz (1995)). Further on the problem is that such as model would also have to deal with the low equilibrium volatility of unemployment and vacancies and hence it would create an additional concern.

5 Conclusion

In this paper we contrast the properties of economies where lack of insurance opportunities means that agents stand alone against uncertain contingencies with those where risk sharing exists in households that comprise of two ex ante identical members. We ask how the implications for the labor market are affected in an otherwise standard incomplete market model with search frictions and endogenous labor force participation, depending on the structure of the household, and especially how the two economies respond to fluctuations in aggregate productivity.

What we get is that the model is completely unable to match the empirical patterns that we see in the data. The labor force in the artificial economy is too pro-cyclical and too volatile relative to the data and it is also too volatile relative to a model that populates the economy with bachelor agents. Using data from the CPS we were led to the converse implication. We found that joint insurance is an important factor that explains why the participation of secondary earners (wives in our sample) is not correlated with aggregate output.

We explain why although our theory is incomplete in some respects, we build a model that we anticipated to give us a very large effect (possibly the maximum) from joint search and insurance. Instead it produces disappointing results. In the outset we explore what other relevant additions need to be made to our baseline framework to be able to match the data. We single out the following; first matching better the cross sectional aspects of intrahousehold division of time

in home vs market work and second matching better the cross sectional aspects of risks. These are possibilities that we explore in future work.

It is important to note that our contribution goes far beyond analyzing the cyclicity of the key labor market statistics in a search model with imperfect insurance. A generation of macro-economists believed that the key of explaining fluctuations in aggregate employment is the elasticity of the labor supply of secondary household earners (females). And whilst we find some theoretical work that is conducive to this intuition our conclusions point to the fact that it is misleading to draw implications for the aggregate elasticity of labor supply from models that circumvent the effort of matching the cross sectional aspects of labor supply.

Our attempt can be viewed as a necessary step to a more ambitious research agenda. We yet don't have a clear understanding of how allocations are affected in economies where insurance is abundant in the family. There must be a wealth of policy or welfare related questions where these alternative environments produce different answers. For instance in incomplete market models with bachelor households wealth encodes the history of productivity and those agents who build up a stock of wealth can finance leisure and drop out of work. In contrast in social planning economies most productive agents are always send to work. We suspect that allocations in couples economies must be somewhat in between, and the interest lies in determining how much.

References

- [1] Abowd, J.M., Kramarz, F. and D.N. Margolis (1999). **High Wage Workers and High Wage Firms.** *Econometrica* 67(2), 1251-333.
- [2] Adda, J. and Cooper, R. (2003). **Dynamic Economics** . MIT Press .
- [3] Aiyagari, R. (1994). **Uninsured Idiosyncratic Risks and Aggregate Saving.** *Quarterly Journal of Economics* 109(3), 659-684.
- [4] Attanasio, O. Low, H. and Sanchez-Marcos, V (2005). **Female labor supply as insurance against idiosyncratic risk.** *Journal of the European Economic Association* 2(3), 755-764.
- [5] Attanasio, O. Low, H. and Sanchez-Marcos, V (2008). **Explaining Changes in Female Labor Supply in a Life-Cycle Model.** *American Economic Review* 98(2), 1517-1552.
- [6] Bilal, M. and Chang, Y. and Kim, S. (2009 (a)). **Comparative Advantage and Unemployment.** *NBER Working Paper 15030*.
- [7] Bilal, M. and Chang, Y. and Kim, S. (2009 (b)). **Heterogeneity and Cyclical Unemployment.** *NBER Working Paper 15166*.
- [8] Blundell, R., Chiappori, P. A., Magnac, T., and Meghir, C. (2007). **Collective Labor Supply Heterogeneity and Non-Participation** . *Review of Economic Studies* / 74(2), 417-445.
- [9] Chang, Y. Kim, S. (2006). **From Individual to Aggregate Labor Supply: A quantitative Analysis based on a Heterogeneous Agents Macroeconomy.** *International Economic Review* 47(1), 1-35.
- [10] Chang, Y. Kim, S. (2007). **Heterogeneity and Aggregation: Implications for Labor-Market Fluctuations.** *American Economic Review* 97(5), 1939-1956.
- [11] Chiappori, P. A (1988). **Rational Household Labor Supply** . *Econometrica* / 56(1), 63-89.
- [12] Coyle, C. (2004). **Health Shocks and Couples' Labor Supply Decisions.** *NBER Working Paper*.

- [13] Cullen, J. and Gruber, J. (2000). **Does Unemployment Insurance Crowd out Spousal Labor Supply?**. *Journal of Labor Economics*. 18(3), 546-572.
- [14] Engen, E. and Gruber., J. . (2001). **Unemployment Insurance and Precautionary Saving**. *Journal of Monetary Economics* 47(3), 545-579.
- [15] Gallipoli, G. and Turner, L. (2008(a)). **Disability in Canada: A Longitudinal Household Analysis**. *Mimeo*
- [16] Gallipoli, G. and Turner, L. (2008(b)). **Household Responses to Individual Shocks: Disability and Labor Supply**. *Mimeo*
- [17] Gomes, J. Greenwood, J. and Rebelo, S. (2001). **Equilibrium unemployment**. *Journal of Monetary Economics* 48(1), 109-152.
- [18] Guler, F. Guvenen, F. Violante. (2009). **Joint-Search Theory: New Opportunities and New Frictions**. newblock *Mimeo*
- [19] Heathcote , J. and Storesletten , K. and Violante , G. (2009). **Quantitative Macroeconomics with Heterogeneous Households**. *Annual Review of Economics Forthcoming*.
- [20] Heckman , J., and MaCurdy , T. (1980). **A Life Cycle Model of Female Labor Supply**. *Review of Economic Studies* 47 (1). 47-74
- [21] Jones, and Riddell, W. (1999). **The Measurement of Unemployment: An Empirical Approach**. newblock *Econometrica* 67(1), 147-162.
- [22] Krusell , P. and Mukoyama , T. and Sahin , A. (2007). **Labour Market Matching with Precautionary Savings and Aggregate Fluctuations**. *Mimeo* .
- [23] Krusell, P., Mukoyama , T., Rogerson, R., and Sahin , A. (2009). **A Three State Model of Worker Flows in General Equilibrium** . *NBER Working Paper No. 15251* .
- [24] Krusell, P. and Smith, A. (1998). **Income and Wealth Heterogeneity in the Macroeconomy**. *The Journal of Political Economy* 106(5), 867-896.

- [25] Lentz, R., and Tranaes, T. (2005). Search and Savings: Wealth Effects and Duration Dependence. newblock *Journal of Labor Economics* 23(3), 467-490.
- [26] Low, H., Meghir, C, and Pistaferri, L (2009). Wage Risk and Employment Risk over the Life Cycle. *American Economic Review* *Forthcoming*.
- [27] Lundberg, S. (1985). **The Added Worker Effect**. *Journal of Labor Economics* 3(1), 11-37.
- [28] Merz, M (1995). **Search in the labor market and the real business cycle**. *Journal of Monetary Economics* 36(2), 269-300
- [29] Mortensen, D., and Pissarides, C (1994). **Job Creation and Job Destruction in the Theory of Unemployment**. *Review of Economic Studies* 61(3), 397-415.
- [30] Pencavel, J. (1982). **Unemployment and the Labor Supply Effects of the Seattle-Denver Income Maintenance Experiments**. *Research in Labor Economics*. 1-31.
- [31] Pissarides, C (1985). **Short-Run Equilibrium Dynamics of Unemployment, Vacancies and Real Wages**. *American Economic Review* 75(4), 676-690.
- [32] Pissarides, C. (2000). **Equilibrium Unemployment Theory, 2nd Edition**. *MIT Press*, Cambridge, MA.
- [33] Shimer, R. (2003). **Search Intensity** *Mimeo*
- [34] Shimer, R. (2005(a)). **The Cyclical Behavior of Equilibrium Unemployment and Vacancies** *American Economic Review* 95(1) 25-49.
- [35] Shimer, R. (2005(b)). **Reassessing the Ins and Outs of Unemployment**. *Mimeo*
- [36] Spletzer, J. (1997). **Reexamining the Added Worker Effect** *Economic Inquiry* 35 417-427.
- [37] Stevens, M. (2002). **Worker Displacement and the Added Worker Effect** *Journal of Labor Economics* 20(3) 504-537.

- [38] Veracierto, M. (2008). **On the cyclical behavior of employment, unemployment and labor force participation.** *Journal of Monetary Economics* 55(6), 1143-1157.
- [39] Young, E. R. (2004). **Unemployment Insurance and Capital Accumulation** *Journal of Monetary Economics* 51 (8), 1683-1710.
- [40] Young, E. R. (2009). **Solving the Incomplete Markets Model with Aggregate Uncertainty Using the Krusell-Smith Algorithm and Non-Stochastic Simulations.** *Journal of Economic Dynamics and Control* Forthcoming.

6 Appendices

6.1 Computational strategy for steady-state equilibrium

In steady state, factor prices are constant and the distribution of agents over the relevant state space Γ is time invariant. The calibration consists of three nested loops. The outer loop is the estimation loop where we set the endogenous parameters $\{B, k, \rho_\epsilon, \sigma_\epsilon, \rho_x, \sigma_x\}$ is chosen, We solve the model and check whether the generated moments (labor market flows) are close enough to their empirical counterparts. If not, we try a new set of parameters.

The middle loop is the market clearing loop. We guessed an interest rate r which implies a wage rate w and then solve for the value functions and the steady state distribution Γ). The steady state distribution yields an aggregate savings supply. If the implied marginal product of capital is equal to the guessed interest rate, we found the equilibrium. If not, we update our interest rate guess. For the singles version of our model instead of changing interest rates to clear the market of savings we adjust the discount factor β_S and keep constant the aggregate rate of return R .

The inner loop is the value function iteration. Details are as follows:

1. We choose an unevenly spaced grid for asset holdings (a) (with more nodes near the borrowing constraint) and a grid for individual productivities ϵ and x . We experiment with different number of nodes for the asset grid, usually between $N_a = 101$ and $N_a = 161$. The number nodes for the idiosyncratic labor market risks are $N_\epsilon = 5$ and $N_x = 2$. These are equally spaced and the transition matrix of idiosyncratic shocks is obtained by the discretization procedure described by Adda and Cooper (2003).
2. Given our guess for the interest rate r , we solve for the individual value functions, V^n, V^e in the bachelor model and V^{nn}, V^{en}, V^{ee} in the couples model. This is done by finding the optimal savings and search intensity choice at each node. Values that fall outside the grid are interpolated with cubic splines. Once the value functions have converged we recover the optimal policy functions of the form $a'(a, \epsilon)$, $s(a, \epsilon)$ and $h(a, \epsilon)$.
3. The final step is to obtain the invariant measure Γ over the relevant state space (asset productivities and employment status).
 - (a) We first approximate the optimal policy rules on a finer grid which $N_{a_{BIG}} = 2000$ nodes and we initialize our measure Γ_0 .
 - (b) We update it and obtain a new measure Γ_1
 - (c) The invariant measure is found when the maximum difference between Γ_0 and Γ_1 is smaller than a pre-specified tolerance level.

- (d) By using the invariant measure, we compute aggregate labor supply and asset supply. This implies a new marginal product of capital which we then compare to our initial guess.

6.2 Computational strategy for equilibrium with aggregate fluctuations

Aggregate shocks imply that factor prices are time varying. When solving their optimization program agents have to predict future factor prices. Therefore they have to predict all the individual policy decisions in all possible future states. This requires agents to keep track of every other agent. Thus in order to approximate the equilibrium in the presence of aggregate shocks, one has to keep track of the measure of all groups of agents over time. Since Γ is an infinite dimensional object it is impossible to do this directly. We therefore follow Krusell and Smith (1998) and assume that agents are boundedly rational and use only the mean of wealth and aggregate productivity to forecast future capital K and factor prices w and R .

Compared to the steady-state algorithm we now have two additional state variables that we must add in the list of the existing state variables in the inner loop: aggregate productivity λ and aggregate capital K . As the outer loop, we iterate on the forecasting equations for aggregate capital and factor prices.¹¹ The details are as follows:

- (a) We approximate the aggregate productivity process with 2 nodes and use again the methodology of Adda and Cooper (2003) to obtain the values and transition probabilities. We choose a capital grid around the steady-state level of capital K^{ss} , particularly we $N_k = 6$ equally spaced nodes to form a grid with range $[0.95 * K^{ss}; 1.05K^{ss}]$.
- (b) As already mentioned, we choose the means of aggregate capital and aggregate productivity as explanatory variables in the forecasting equations. We use a log-linear form

$$\ln K_{t+1} = \kappa_0^0 + \kappa_1^0 \ln K_t + \kappa_2^0 \ln \lambda_t \quad (6.1)$$

$$\ln w_t = \omega_0^0 + \omega_1^0 \ln K_t + \omega_2^0 \ln \lambda_t \quad (6.2)$$

$$\ln R_t = \varrho_0^0 + \varrho_1^0 \ln K_t + \varrho_2^0 \ln \lambda_t \quad (6.3)$$

- (c) We initialize the coefficients so that K_{t+1} , w , R are equal to their steady state values.
- (d) Given equations 6.1 to 6.3, we solve the value function problems as before, just that now the state vector is four-dimensional. Values that

¹¹In the steady state algorithm, there were three loops. Since we use the steady state values for the endogenous parameters, we do not have an estimation loop here.

are not on the asset grid are interpolated using cubic splines. Values that are not on the aggregate capital grid are interpolated linearly.

- (e) Instead of simulating the economy with a large finite number of agents we use the procedure of Young (2009) and simulate a continuum of agents. This procedure has the advantage of avoiding cross-sectional sampling variation. We simulate the economy for 10,000 periods and discard the first 2,000. In each period we get an observation for K , w and R . We use the simulated data to run OLS regressions on equations 6.1 to 6.3 which yield new coefficient estimates κ^1 's, ω^1 's, ϱ^1 's. If these coefficients are close to the previous ones we stop, otherwise we update equations 6.1 to 6.3 with the new coefficients and solve the problem again.

The convergent solutions for the forecasting equations of our models are as follows:

TABLE 9: COUPLES ECONOMY BASELINE.

Equation	Constant	$\ln(K_t)$	$\ln(\lambda_t)$	R^2
$\ln(K_{t+1})$	.05427	.98317	.04203	.99996
$\ln(w_t)$	-.16841	.39621	.55531	.99627
$\ln(R_t)$	.04858	-.01355	.01546	.99108

TABLE 10: SINGLES ECONOMY.

Equation	Constant	$\ln(K_t)$	$\ln(\lambda_t)$	R^2
$\ln(K_{t+1})$	.07115	.98175	.02802	.99997
$\ln(w_t)$	-.32154	.39338	.60769	.99636
$\ln(R_t)$	.04485	-.01026	.01023	.98717

TABLE 11: COUPLES ECONOMY HIGH ρ_ϵ CALIBRATION.

Equation	Constant	$\ln(K_t)$	$\ln(\lambda_t)$	R^2
$\ln(K_{t+1})$	.06117	.98221	.03501	.99997
$\ln(w_t)$	-.2184	.39011	.56834	.99598
$\ln(R_t)$	.04766	-.01145	.01342	.99101