Saving, Search and Incomplete Information*

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Abstract

This paper documents that the excess sensitivity of consumption growth to lagged (expected) labor income growth conceals a robust negative sensitivity of consumption growth to lagged (expected) unemployment growth. To understand this empirical regularity, we embed search frictions in a heterogeneous agent, precautionary savings model and study the implications for unemployment and consumption dynamics both at the microeconomic and macroeconomic level. When agents can separate aggregate from idiosyncratic shocks, the model cannot replicate the aggregate stylized time series facts. Nevertheless, introducing incomplete information (defined as the inability to distinguish between aggregate and idiosyncratic shocks) delivers time series predictions that are relatively consistent with the empirical evidence.

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1 Introduction

Following the seminal work by Zeldes (1989), Deaton (1991) and Carroll (1992, 1997), precautionary savings models that feature liquidity constraints, undiversifiable labor income risk and some notion of impatience have been widely used to explain consumption dynamics both in an infinite and in a finite horizon setting.[1] At the same time, models featuring search frictions have been used to explain both the existence of equilibrium unemployment and unemployment dynamics. Although problems remain in explaining some business cycles phenomena (for example, the large variability in the vacancy-unemployment ratio, Shimer (2003)), the Mortensen-Pissarides (1994) framework has been extensively used to understand unemployment fluctuations. Nevertheless, few models have combined the basic insights from the two approaches to jointly examine the implications for unemployment and consumption dynamics.[2]

We think that this provides a potentially important gap in the literature because it is hard to argue a priori that unemployment and consumption should be studied separately. To confirm this intuition, we start our investigation by documenting a stylized fact from aggregate data, namely that non-durables consumption growth is negatively related to unemployment growth over and above the excess sensitivity of consumption growth to labor income growth. Carroll and Dunn (1997) is an earlier study that is consistent with this finding but they focus on unemployment expectations from survey data rather than actual unemployment figures.[3] This finding seems consistent with microeconometric evidence from, for instance, Gruber (1997), who finds that food consumption drops by around 7% during unemployment.

To explain this negative correlation, it seems natural to embed search frictions in the precautionary savings model, thereby endogenously modeling consumption and unemployment. Gomes, Greenwood and Rebelo (2001) is a closely related paper that investigates the joint comovement of unemployment and consumption in a general equilibrium setting but they do not endogeneize the search intensity decision during the unemployment state and do not focus on the aggregate relationships documented in this paper. Betinez-Silva (2000) solves a model similar to the microeconomic model we study and finds that search intensity is decreasing over the life-cycle (a prediction consistent with microeconometric evidence) but does not investigate the aggregate implications of the model. More recently, Lentz (2004) and Algan et. al. (2003) offer empirical evidence suggesting that wealthier households search less than poorer ones for a new job and therefore exhibit higher unemployment durations. Nevertheless, our understanding of how these non-linear microeconomic models aggregate and whether they can replicate the observed comovements between consumption and unemployment remains at a nascent stage. Our paper takes a step in that direction by investigating how a precautionary savings and search model with ex post heterogeneity aggregates and whether the model can generate the observed aggregate time series relationships.

We view our setup as a step towards enhancing our understanding from combining precautionary savings and search models for aggregate fluctuations. We therefore abstract at this stage from general equilibrium considerations and take both wages and interest rates as exogenous. We make this choice because even the partial equilibrium model is quite complex and needs to be solved numerically so that substantial comparative statics need to be performed in trying to understand the economic intuition and implications of the model. The theoretical setup extends the saving and liquidity constraints, or so called "buffer stock saving model", proposed by Deaton (1991) to accommodate search frictions and study the interaction between unemployment and consumption dynamics. We build an explicit microeconomic model with heterogeneous agents to understand the model's comparative statics and investigate the predictions of the model about excess sensitivity at the microeconomic level. We then aggregate the model explicitly (avoiding the fallacy of composition) and study the interaction between aggregate endogenous variables.

We find that when households can distinguish aggregate from idiosyncratic shocks (complete information), the model cannot replicate the macroeconomic stylized facts, even though it does better than the model without any search. This takes place because aggregate shocks are permanent and the liquidity constraint or the possibility of facing an unemployment spell does not affect the intuition from the permanent income hypothesis that permanent shocks should affect consumption one for one. As a result, consumption growth is almost as volatile as labor income growth while it does not react to lagged changes in labor income, despite the substantial uncertainty at the microeconomic level.

Introducing incomplete information changes these predictions. Optimal consumption and search intensity choices maintain the same shape as a function of cash on hand, yet the signal extraction problem generates higher saving since the transitory component of idiosyncratic shocks is mixed with the permanent aggregate shock, implying that all innovations are viewed as transitory. The increase in saving is small since the shocks are still viewed as transitory but this small increase in saving is sufficient to generate excess sensitivity of consumption growth to lagged labor income growth both at the microeconomic and macroeconomic level. At the same time, consumption growth becomes smoother than earnings growth (contrary to the complete information model) while the contemporaneous negative correlation of consumption growth and unemployment growth is predicted for a wide range of structural parameter values. Nevertheless, the sensitivity of consumption growth to lagged unemployment growth cannot be replicated by the model, a shortcoming that can be traced to the univariate time series properties of aggregate unemployment growth generated by the model. The simulation results are therefore encouraging and suggest that future extensions (perhaps through endogeneizing the job destruction process) might offer a better understanding of the joint comovement between consumption and unemployment over the business cycle.

The paper is organized as follows. Section 2 uncovers a robust negative relationship between unemployment changes and consumption growth. Section 3 describes the economic environment and discusses the numerical solution method and the results for the complete information model. Section 4 analyzes the incomplete information model results and section 5 concludes.

2 The Consumption-Unemployment Relationship

In this section we demonstrate a robust negative correlation between consumption growth and unemployment growth[4]. We use U.S. quarterly data from 1959:01 to 2002:04. Aggregate real per capita consumption C_t, is measured as the sum of consumption of non-durables (excluding shoes and clothing) and services deflated by the chain-type price index of personal consumption expenditures. Real per capita after tax income is denoted as Y_t (see Appendix A for the construction of the series) which is also deflated by the same price index. The construction of both series is in line with what is proposed by Blinder and Deaton (1985), Pischke (1995) and Ludvigson and Michaelides (2001). Table 1 summarizes the basic properties of the aggregate data. Specifically, consumption growth is less than half as volatile as labor income growth (with the relative standard deviation of consumption to labor income growth being around 0.4) while unemployment rate growth exhibits higher volatility than labor income growth.

2.1 OLS results

Table 2 replicates the robust excess sensitivity of consumption growth to lagged labor income changes (Panel A). The point estimate from the regression is statistically significant at better than 5 percent level and equal to .107. Adding lagged unemployment growth as an additional determinant of consumption growth generates the results in Panel B. Both estimates are statistically significant at better than 5 percent with the unemployment coefficient being negative, intuitively implying that when the unemployment rate rises, consumption growth is revised downwards. Moreover, the earnings excess sensitivity coefficient estimate is adjusted downwards indicating that part of the excess sensitivity to labor income could be due to omitting unemployment from the first regression. Overall, the OLS regressions indicate that consumption is sensitive to both labor income growth and unemployment changes.

2.2 Instrumental variables (IV)

2.2.1 Two stages least squares ($2SLS$)

We next check the robustness of these correlations by estimating the response of consumption growth to expected labor income growth and expected unemployment growth, proxying expected values with actual contemporaneous growth rates and using instrumental variables techniques to estimate the relevant coefficients. This is essentially reproducing the Campbell-Mankiw (1989) results while extending the analysis to investigate the potential empirical impact of unemployment growth on consumption fluctuations.

Table 3 uses three different sets of instruments to first reproduce the Campbell-Mankiw (1989) results and then investigate the potential effect of expected unemployment on consumption growth. All instruments are lagged for two periods to avoid the potential effects of measurement error following an MA(1), a common route to tackle this problem in the literature. The estimates are highly significant and the signs of all coefficients are consistent with the OLS results. Specifically, omitting unemployment growth from the specification generates a coefficient on expected labor income growth equal to 0.44, while including unemployment growth reduces this coefficient to 0.236 while generating a coefficient on expected unemployment growth equal to -0.04, with both coefficients statistically significant at the 5% level. These conclusions are robust to alternative instrument specifications that we do not report. Moreover, the overidentifying restrictions test (last column of Table 3) indicates that the model cannot be rejected at better than 5 percent level of significance.

2.2.2 Robustness to Weak IVs

Two requirements must be satisfied for IV estimation to be unbiased and produce reliable inference: instrument exogeneity and instrument relevance. Exogeneity refers to the instruments being orthogonal to the error term while relevance dictates that instruments must be "significantly" related with the endogenous regressors. Instruments that are weakly correlated with what they are instrumenting can produce biased estimates and the first order asymptotics may be a poor guide for their actual distribution. As a result, standard statistical inference can be unreliable.

We first test all three sets of instruments (with the null being that the instruments are weak) using the minimum eigenvalue of the matrix analog of the F-statistic (Stock and Yogo, 2003). Both in terms of $2SLS$ bias and $2SLS$ size distortion, there seems to be no evidence to reject the null of weak IVs[5]. For this reason we compute three fully robust Gaussian tests when instruments are weak. These statistics can test for the joint significance of the estimates in the presence of weak instruments. This is due to the fact that all statistics have well defined asymptotics which do not depend on instrument relevance. In what follows, we abstract from explicitly reviewing the tests and refer the reader to the relevant papers below.

We start by employing the $Anderson-Rubin$ (AR) statistic, due to Anderson and Rubin (1949) and Moreira (2001). Under the general conditions of weak instruments $AR \xrightarrow{d} \chi^2_K/K$

(where K is the number of IV's) irrespective of instrument relevance. Our null hypothesis is that both endogenous variables are statistically insignificant. Table 4 summarizes the results of the AR test. With four instruments the test suggests that income and unemployment rate growth are jointly significant at the 5 percent level and adding more instruments does not alter this conclusion. We next report results from the Kleibergen statistic (Kleibergen, 2001) which rejects the null for all instrument sets at the 5% level. Moreover, the LR statistic provides results along these lines rejecting the null at the 5 percent level of significance for all instrument sets.

Taken together, these robust inference tests suggest that the estimates are jointly significant despite the presence of weak instrumental variables[6].

3 The Complete Information Model

Typically, heterogeneous agent consumption models with undiversifiable labor income risk and occasionally binding liquidity constraints are solved at an annual frequency. There is no strong a priori reason for this choice. One possibility involves the fact that household level data (like the Panel Study of Income Dynamics) collect information on household labor income at an annual frequency. Given that in theoretical models the labor income process usually needs to be specified in advance to derive the consumption implications, researchers write down and solve models at an annual frequency for which labor income dynamics can be based on observed outcomes. This will not work in our case because we would like to study high frequency interactions between consumption and unemployment. Good unemployment data at the monthly frequency exist and are readily available from the BLS but the same does not hold for aggregate consumption data. In fact, we know from Wilcox (1992) that aggregate consumption data suffer from serious problems even at the quarterly frequency.

We think that solving the quarterly frequency model strikes a reasonable compromise between the measurement error inherent in aggregate consumption data and the rich time series dynamics exhibited empirically by unemployment (and our theoretical search model) at the quarterly frequency. Equivalently, we think that studying the implications of a search model at an annual frequency will neither be intuitively appealing nor empirically plausible since most households find a new job after an unemployment spell of around one quarter.

It should be pointed out, however, that the quarterly frequency assumption continues to avoid potentially important time aggregation issues: heterogeneous agents facing different shocks probably make their decisions at non-equidistant time intervals and the times between decisions may depend on the realization of the different shocks households face. Reis (2003), for instance, offers a discussion of these issues but we abstract from such time aggregation problems for the purpose of this study and investigate the implications of the model at a quarterly frequency.

3.1 Labor Income

Labor income risk is undiversifiable because of moral hazard and adverse selection considerations, and it cannot be ignored by households. When employed, we assume that labor income of household i follows:

$$Y_{it} = P_{it} U_{it} \tag{1}$$

where

$$P_{it} = G_t P_{it-1} N_{it} \tag{2}$$

This process is decomposed into a permanent, P_{it}, and a transitory component, U_{it}. We assume that $\ln U_{it}$ and $\ln N_{it}$ are each independent and identically (normally) distributed with zero means and variances σ_u^2 and σ_n^2, respectively. The log of P_{it} evolves as a random walk with a stochastic drift assumed to be common to all individuals (the aggregate shock). Finally, $\ln G_t$ is assumed to be normally distributed with mean μ_g and variance σ_g. Given these assumptions, the growth in individual labor income follows

$$\Delta \ln Y_{it} = \ln G_t + \ln N_{it} + \ln U_{it} - \ln U_{it-1} \tag{3}$$

where the unconditional mean growth for individual earnings is μ_g, and the unconditional variance equals $(\sigma_g^2 + \sigma_n^2 + 2\sigma_u^2)$. Individual earnings growth in (3) has a single Wold representation that is equivalent to the MA(1) process for individual earnings growth estimated using household level data (Abowd and Card [1989], MaCurdy (1981) and Pischke [1995]). Moreover, the individual earnings growth is negatively serially correlated while aggregate shocks are i.i.d.. Furthermore, aggregate shocks are a small component of the total volatility in individual wage growth, consistent with the small magnitude of time effects in earnings regressions.[7]

3.2 Job Destruction

There is an exogenous probability that the individual will become unemployed in a particular period. We denote this probability by δ_t (the job destruction rate, which is exogenous). During unemployment, the individual has access to unemployment insurance which is a constant fraction (ω) of labor income: $ub_{it} = \omega Y_{it}$ and the duration of this benefit is assumed to last as long as the agent is unemployed. Given the lower mean wage received in this state, individuals will want to start working so that unemployment duration does not persist for long periods in equilibrium.

Job destruction rates are strongly countercyclical in the data and tend to lead recessions. We therefore introduce a negative correlation between the job destruction rate and the aggregate earnings shock in some calibrations. To do so we model the exogenous probability as

$$\delta_t = \delta\zeta_t$$

where δ is the mean destruction rate every quarter and ζ_t is an aggregate log-normally distributed shock with mean $-0.5\sigma_\zeta^2$ and variance σ_ζ^2 that may be negatively correlated with the aggregate component of the earnings shock.

3.3 Search Effort

When an individual is unemployed, he/she will have to decide how much to search in order to find a job. In this we follow Lentz (2004) and assume that the probability of finding a job in period $t+1$ is given by:

(4) $$\mu(\lambda s_{it}) = 1 - \exp(-\lambda S_{it}/P_{it})$$

The latter is strictly increasing and concave in S_{it} and is normalized by the permanent component of labor income primarily due to the normalization we later use to solve the model. λ is a parameter that controls the offer arrival rate and it is assumed to be exogenous. In a general equilibrium framework λ would be endogenously determined and would reflect market tightness.

The search cost can either be monetary or utilitarian. One hopes that the results from the model will be quite similar in either specification. We have solved the model with both and find that the monetary specification yields more intuitive results over a wider range of structural parameters. We therefore work in the baseline case with a monetary cost and discuss some of the differences that arise relative to the utilitarian specification later on in the paper.

3.4 Model

We consider the problem of a household that maximizes expected intertemporal utility

(5) $$MAX_{\{B_t^e, B_t^u, S_t\}_{t=0}^{\infty}} E_0 \sum_{t=0}^{\infty} \beta^t U(C_t)$$

subject to

(6) $$C_t + \eta_t(B_t^u + S_t) + (1 - \eta_t)B_t^e \leq X_t$$

(7) $$X_{t+1} = [\eta_t B_t^u + (1 - \eta_t)B_t^e]R_f + (1 - \eta_{t+1})Y_{t+1} + \eta_{t+1}\omega Y_{t+1}$$

(8) $$C_t \geq 0$$

(9) $$B_t^{e,u} \geq 0$$

$$S_t \geq 0 \tag{10}$$

All variables are in real terms. B_t^e is the real amount of the riskless asset (bonds) during employment spells and B_t^u is the real amount of the asset during unemployment spells and are both held between the beginning of period t and the beginning of period $t+1$. E_t denotes the mathematical expectation operator based on information available up to the beginning of period t, while β is the discount factor that satisfies $0 < \beta < 1$. $U(C_t)$ is a function that describes the felicity derived from consumption at time t, X_t is cash on hand at the beginning of period t, R_f is the gross riskless rate which is assumed time-invariant, and Y_t is labor income received at the beginning of period t. $\eta_t \in \{0, 1\}$ denotes the state of employment at time t, where $\eta = 1$ stands for unemployed and $\eta = 0$ for employed. Finally ω is the replacement ratio when unemployed.

The budget constraint (6) will hold with equality, given the assumption of non-satiation. We assume that the period-by-period felicity function is of the constant relative risk aversion (CRRA) form

$$U(C_t) = \frac{{C_t}^{1-\rho}}{1-\rho}, \quad \rho \neq 1, \quad \rho > 0 \tag{11}$$

In the utilitarian specification of the search cost, the utility function is assumed to be $U(C_t) = \frac{(C_t - \eta_t S_t)^{1-\rho}}{1-\rho}$.

3.5 Calibration of Parameters

We consider the unit of analysis to be one quarter and set β equal to 0.988, and the constant real interest rate, r, equal to 0.02/4. Carroll (1992) estimates the variances of the idiosyncratic shocks using data from the *Panel Study of Income Dynamics*, and our benchmark simulations use values close to those: 10 percent per quarter for σ_u and $8/\sqrt{4}$ percent for σ_n. We set σ_g equal to $0.02/\sqrt{4}$, μ_g equal to 0.03/4 and the benchmark coefficient of relative risk aversion equal to 2. The standard deviation of job destruction is set at 1% (that is, equal to the standard deviation of the aggregate component of earnings). We adjust the mean job destruction rate (δ) and the parameter through which search intensity affects the probability of finding a job when unemployed (λ) to generate in simulated data an unemployment rate close to 6 percent and an average probability of finding employment after one quarter of around 80 percent. This results in a value for δ of 0.05 and a value for λ of 8. Finally, we set the replacement rate during unemployment equal to 67%.[8]

3.6 Solution Method

We generalize the Deaton (1991) solution to allow for search during the unemployment state by deriving three Euler equations associated with the three control variables. Letting U_C denote the marginal utility of consumption and V^e, V^u the value of being employed and unemployed respectively, the three Euler equations are given by (see appendix B for further details):

$$U_C(C_{it}^e) = MAX\{U_C(X_{it}), \beta(1+r)E_t[(1-\delta_{t+1})U_C(C_{it+1}^e) + \delta_{t+1}U_C(C_{it+1}^u)]\} \tag{12}$$

$$\begin{aligned} U_C(C_{it}^u) &= MAX\{U_C(X_{it} - S_{it}), \beta(1+r)[\mu(\lambda s_{it})E_t U_C(C_{it+1}^e) \\ &\quad +(1-\mu(\lambda s_{it}))E_t U_C(C_{it+1}^u)]\} \end{aligned} \tag{13}$$

and

$$U_C(C_{it}^u) = MAX\{U_C(X_{it} - B_{it}^u), \beta\mu'(\lambda s_{it})E_t[V_{it+1}^e - V_{it+1}^u]\} \tag{14}$$

The first two Euler equations are a straightforward generalization of Deaton (1991). If the individual is employed in period t and is liquidity constrained, consumption cannot be higher than X_{it} and as as result the marginal utility of consumption cannot be lower than $U_C(X_{it})$. If on the other hand, the agent does not hit the borrowing limit, then current marginal utility equals the expected, discounted future marginal utility (Hall, 1978). The latter takes into account the possibility that the individual may become unemployed in the next period, hence it is weighted by the (exogenous) probabilities δ_{t+1} and $1-\delta_{t+1}$.

The same logic applies for an unemployed individual in the current period. Now, however, expected marginal utility of next period consumption has to be weighted by the (endogenous) probabilities of finding a job or not. The third Euler equation derives the decision for search. It states that at the optimum an unemployed agent will choose search effort to equate the marginal cost of search to the discounted future benefits of it, adjusted for the relevant marginal increase in the probability of an additional unit of search. The term $E_t[V^e_{it+1} - V^u_{it+1}]$ is the expected difference between the value function of an unemployed agent at t who becomes employed at $t+1$ and the value function of the same agent who remains unemployed in $t+1$.

Given the non-stationary process followed by labor income, we normalize asset holdings and cash on hand by the permanent component of earnings P_{it}, denoting the normalized variables by lower case letters (Carroll, 1992). Defining $Z_{t+1} = \frac{P_{t+1}}{P_t}$, taking advantage of the homogeneity of degree $(-\rho)$ of marginal utility implied by CRRA preferences, and using the identity $c^e_{it+1} = x_{it+1} - b^e_{it+1}$ (see appendix for the proposed numerical algorithm), we have

$$(15)\quad U_c(x_{it} - b^e_{it}) = MAX\{U_c(x_{it}), \beta(1+r)E_t[(1-\delta_{t+1})U_c(c^e_{it+1})Z^{-\rho}_{t+1} + \delta_{t+1}U_c(c^u_{it+1})Z^{-\rho}_{t+1}]\}$$

$$\begin{aligned} U_c(x_{it} - b^u_{it} - s_{it}) &= MAX\{U_c(x_{it} - s_{it}), \beta(1+r)E_t[\mu(\lambda s_{it})U_c(c^e_{it+1})Z^{-\rho}_{t+1} \\ &\quad +(1-\mu(\lambda s_{it}))U_c(c^u_{it+1})Z^{-\rho}_{t+1}]\} \end{aligned} \tag{16}$$

and

$$U_c(x_{it} - b^u_{it} - s_{it}) = MAX\{U_c(x_{it} - b^u_{it}), \beta\mu'(\lambda s_{it})E_t[Z^{1-\rho}_{t+1}[V^e_{it+1} - V^u_{it+1}]]\}$$

The normalized state variable x evolves differently according to whether the individual is unemployed or not in the current period and the next. The four different possibilities are:

$$x^{e,e}_{it+1} = (b^e_{it}R_f)Z^{-1}_{t+1} + U_{it+1} \tag{17}$$

$$x^{e,u}_{it+1} = (b^e_{it}R_f)Z^{-1}_{t+1} + \omega U_{it+1} \tag{18}$$

$$x^{u,u}_{it+1} = (b^u_{it}R_f)Z^{-1}_{t+1} + \omega U_{it+1} \tag{19}$$

$$x^{u,e}_{it+1} = (b^u_{it} R_f) Z^{-1}_{t+1} + U_{it+1} \tag{20}$$

3.7 Benchmark Model Results

The consumption policy functions are plotted in figure 1 and the search intensity (expressed as the probability of finding a job when unemployed) in figure 2. Saving is zero when the constraints are binding and increases with cash on hand beyond a certain point generating a concave consumption function that has the familiar shape from the buffer stock saving literature. Search intensity is increasing in wealth for low values of cash on hand and decreases beyond a certain level of cash on hand (figure 2). As wealth increases, the expected value of being employed relative to being unemployed shrinks (the difference in the expected value functions on the right hand side in the third Euler equation). Thus, search incentives are decreasing in wealth beyond a certain level and richer agents can afford longer unemployment spells. For low levels of wealth, the agent would rather consume an additional dollar rather than incur a search cost, implying that search intensity might fall to zero for very low levels of wealth. Moreover, as wealth rises from low levels the marginal effect on the probability of finding a job rises and can outweigh the marginal disutility through the search cost via the expected welfare benefit from finding a job. As a result the search cost increases over low wealth levels and decreases beyond a certain level of wealth. It should be noted that when search is instead modelled as a cost on utility, the shape of the search policy function remains the same (see the non-separable utility case in Lentz and Tranaes (2003)).

Figure 3 illustrates what happens when the unemployment insurance system becomes less generous by decreasing the replacement rate from 0.67 to 0.5. The search intensity increases for a given level of cash on hand, while maintaining the same non-monotonic shape as a function of wealth. The increase in search illustrates the potentially important effects on behavior that different unemployment insurance systems may have. Figure 4 plots search intensity from increasing the coefficient of relative risk aversion from $\rho = 2$ to $\rho = 5$. For low levels of cash on hand, the marginal disutility of the search cost is even higher than before and search expenditure is decreased for any given level of cash on hand. For higher levels of cash on hand the profiles are similar.

3.8 Time Series Analysis

3.8.1 Individual Statistics

Table 5 produces average time series statistics from tracking different individual histories over time. The first column reproduces results for the case without any unemployment risk (the Deaton (1991) model).[9] Impatient households consume on average their mean labor income and save around 13% of their mean earnings. The standard deviation of individual consumption growth is substantially lower than the standard deviation of labor income growth (0.06 and 0.15 respectively) as households can buffer very well their labor income shocks with a small amount of savings. The presence of liquidity constraints on its own does not immediately imply that individual consumption is sensitive to lagged labor income changes: indeed the coefficient on excess sensitivity at the microeconomic level is not statistically significant.

Comparing the benchmark specification to these results, we note that saving for the employed agents is higher in the presence of unemployment risk. Unconditional labor income growth becomes more volatile reflecting the lower benefits received during unemployment spells and the standard deviation of consumption growth also rises as a result but is still smoother than labor income growth. Consumption drops when moving from employment to unemployment, and the same takes place for saving since saving is used to smooth consumption across the employment states. The excess sensitivity coefficient remains statistically insignificant from zero further strengthening the conclusion that excess sensitivity at the micro level does not follow from the mere presence of liquidity constraints.

Making the agent more risk averse (prudent) by raising ρ to $\rho = 5$ generates higher saving than in the benchmark model in both the employment and unemployment states. As a result, consumption is smoother than income and the drop in consumption when moving from employment to unemployment is lower than in the benchmark case. Reducing the unemployment benefit again generates higher saving, generating a very smooth consumption growth series. Similar comparative statics results are computed and reported in table 5 when increasing transitory labor income uncertainty (σ_u) from 0.1 to 0.2 and when the exogenous job destruction probability is increased from $\delta = 0.05$ to $\delta = 0.1$. Introducing the negative correlation between the aggregate earnings shock and the job destruction rate does not substantially affect the conclusions for the individual statistics relative to the benchmark case. This finding reflects the small component of the aggregate shock to the total idiosyncratic earnings uncertainty faced by the household.[10]

3.8.2 Aggregate Statistics

Table 6 reports the statistics from averaging individual consumption decisions in the cross section and then computing the time series statistics implied by the model. The first column reports the results from aggregating the Deaton (1991) model. Individual consumption smoothing does not survive the aggregation procedure since what is important for aggregate statistics is the reaction to the aggregate shock, not the smoothing of individual transitory shocks. The relative smoothness ratio (defined as the ratio of the standard deviation of consumption to earnings growth) is 0.92, implying that some consumption smoothing does survive the aggregation procedure, but not to the extent that it can replicate the magnitudes observed in the data.[11]

All the search models generate a smoother aggregate consumption growth series, a direct result of the higher saving taking place to buffer unemployment shocks in addition to labor income fluctuations. Specifically, the relative smoothness ratio (s.d. of consumption growth relative to s.d. of earnings growth) varies from 0.73 to 0.84, with the more plausible parameterizations generating a figure around 0.8. Consumption growth is therefore smoother than before but not as smooth as in the data. Nevertheless, both the excess sensitivity coefficient on labor income and unemployment growth remain statistically insignificant from zero. The mean probability of finding employment in the next quarter when unemployed in the current quarter is around 80% for most parameter configurations, while the unemployment rate is around 6% for most parameter calibrations. The latter implies that frictional unemployment is around 1% given that the mean exogenous destruction rate is 5%.

We conclude that the complete information, infinite horizon, partial equilibrium model we have studied cannot generate both the macroeconomic stylized facts that have motivated the paper.

3.8.3 Utility Cost Specification

We have also solved the model when search intensity is incurred as a utility rather than monetary cost. The Euler equations remain essentially the same except that the search intensity does not appear in the budget constraints any more but only shows up in the marginal utility of consumption. Specifically, marginal utility when unemployed is given by $U_C(C, S) = (C - S)^{-\rho}$.

The results from simulations of the individual statistics are reported in table 7. For the benchmark case the conclusions are similar to the conclusions from table 5 (monetary cost specification), except that the drop in consumption when moving from employment to unemployment is not as high. In changing different structural parameters of the model, however, normalized consumption during unemployment spells is higher than during employment, a prediction that is counterfactual. Given this counterfactual prediction for some combination of structural parameters, we decided to proceed with the monetary cost specification.

The reason for this surprising prediction might be enlightening in the modelling decision between monetary and utility specifications for the search cost. The household is trying to equate through precautionary saving marginal utilities across employment and unemployment states. This implies higher saving when employed (relative to the no unemployment model). When the agent is unemployed, however, search costs affect the marginal utility of consumption which implies that a higher level of consumption is needed to equate marginal utilities across the states. Alternatively, another parameter is needed within the utility function on how search affects the utility of consumption. We have also experimented with that approach but found that the model has already a significant number of parameters and therefore decided to follow the monetary cost approach on a parsimony argument.

4 Incomplete Information Model

We next investigate the implications of being unable to distinguish between aggregate and idiosyncratic earnings shocks following the same methodology as in the previous section. The closest precursors of this assumption can be found in various forms in Deaton (1991), Pischke (1995) and Ludvigson and Michaelides (2001). The idea is simple. Given that economy-wide shocks account for a very small fraction of the variance in individual earnings growth (Pischke (1995), for instance), households may have little incentive to distinguish aggregate from idiosyncratic shocks to their earnings. Pischke (1995) shows that informational assumptions can have important effects on aggregate consumption when individual households behave according to the permanent income hypothesis while Deaton (1991) and Ludvigson and Michaelides (2001) illustrate the importance of this assumption in the context of variants of buffer stock saving models.

There are two other similar (but different) assumptions about information. Goodfriend (1992) assumes that information about the macroeconomy arrives with a lag while Reis (2003) assumes that individuals endogenously choose when to respond to the aggregate shock, and this happens when aggregate shocks have cumulated to an amount that cannot be optimally ignored. In our setup, the individual optimally chooses to ignore the aggregate shock because aggregate fluctuations make up a very small component of total idiosyncratic variance in earnings.

4.1 Labor Income

If aggregate and idiosyncratic shocks cannot be separated by the individual, the assumptions we have made so far imply that the individual will base decisions on the following labor income process

$$\Delta \ln Y_{it} = \mu + \epsilon_{it} - \psi \epsilon_{it-1} \tag{21}$$

where μ is a constant and $\psi > 0$. The determination of the parameters of this perceived labor income process are determined by matching the variance and first order covariance implied by the actual earnings process (3) with the one perceived by the individual given by (21). This generates a quadratic equation for ψ in terms of the actual variances of the underlying true shocks and we pick the root of that equation that lies between zero and one (and is therefore relatively consistent with microeconometric data).[12]

4.2 Benchmark Model Results

The model is solved with a similar set of Euler equations as in the complete information case but with a few minor differences. First, given that the permanent component of labor income is not observed, the normalizations are done by the current level of labor income (Y_{it}) instead of the permanent component of labor income. Second, the current innovation in labor income growth becomes an exogenous state variable since it follows an MA(1) process. We discretize that shock using 7 shocks and note that a high current realization of the shock is expected to be reversed next period. Third, given that P_{it} is not directly observed, we assume that the probability of finding a job based on the search intensity is given by $\mu(\lambda s_{it}) = 1 - \exp(-\lambda S_{it}/Y_{it})$. All other assumptions and parameters remain the same as in the complete information model to facilitate comparisons between the two setups.

The consumption policy functions are plotted in figure 5. Consumption equals cash on hand when the liquidity constraint is binding and increases with cash on hand beyond a certain point generating a concave consumption function. High current earnings realizations are associated with low consumption branches because the earnings shocks are perceived to be transitory. Search intensity (expressed as the probability of finding a job when unemployed) is plotted in figure 6. Search intensity is increasing in wealth for low values of cash on hand and decreases beyond a certain level of cash on hand, having the same shape as in the complete information model. For poor households, a good realization of labor income is associated with higher search intensity for a given level of cash on hand. As in the complete information model, the marginal effect on the probability of finding a job outweighs the marginal disutility through the search cost via the higher expected wage from employment. At high wealth levels, on the other hand, a good realization of labor income is associated with lower search intensity. With higher wealth, the expected value of being employed relative to being unemployed shrinks. Moreover, high current innovations are expected to be reversed partially next period. Thus, search incentives are decreasing in labor income innovations at a given level of cash on hand beyond a certain wealth level and richer agents can afford longer unemployment spells.

Figure 7 illustrates what happens (at the mean earnings innovation) when the unemployment insurance system becomes less generous by decreasing the replacement rate from 0.67 to 0.5. The search intensity increases for all levels of cash on hand, while maintaining the same non-monotonic shape as a function of wealth, exactly as in the complete information model. Figure 8 plots search intensity after increasing the coefficient of relative risk aversion from $\rho = 2$ to $\rho = 5$, verifying that the shape of the policy functions does not change depending on the information structure.

4.3 Time Series Analysis

4.3.1 Individual Statistics

Table 8 produces average time series statistics from tracking different individual histories over time. The first column reproduces the results from Deaton (1991), illustrating that impatient consumers consume on average their mean labor income and save around 10% of their mean earnings. Individual consumption growth is smoother than individual earnings growth by around a half, (the standard deviations of the two growth rates are 0.082 and 0.151 respectively): households can buffer very well their labor income shocks with a small amount of savings. Even with incomplete information, however, the presence of liquidity constraints on its own does not immediately imply that individual consumption is sensitive to lagged labor income changes: the coefficient on excess sensitivity at the microeconomic level is not statistically significant for this parameter configuration.

Comparing the benchmark specification to these results, we note that saving for both the employed and unemployed agents is higher in the presence of unemployment risk. Consumption drops when moving from the employment to the unemployment state (by around 12%). Given the higher generated saving, consumption can actually be smoothed but not to the extent that is possible in the absence of information frictions or unemployment possibilities.

As a result, the excess sensitivity coefficient becomes negative and statistically significant at the 5% level, reflecting the negative serial correlation in individual labor income growth rates.

These conclusions are remarkably robust when changing the structural parameters of the model. Making the agent more risk averse (prudent) by raising ρ to $\rho = 5$ generates higher saving that can actually generate a smoother consumption growth series than when $\rho = 2$, and a lower consumption drop when moving from the employment to the unemployment state. Reducing the unemployment benefit again generates higher saving, inducing a drop in the relative smoothness ratio and significant excess sensitivity.[13] Similar comparative statics results are computed and reported in table 8 when increasing transitory labor income uncertainty (σ_u) from 0.1 to 0.2 and when the exogenous job destruction probability is increased from $\delta = 0.05$ to $\delta = 0.1$ and when the correlation between the aggregate earnings shock and the job destruction parameter is changed to from zero to -0.7.

4.3.2 Aggregate Statistics

Incomplete information implies that households save in the presence of temporarily good shocks. Given that part of the good shock is aggregate in nature, such saving survives the aggregation procedure. Thus, in the Deaton (1991) model (first column of table 9) consumption smoothing can be achieved with relative smoothness falling to 0.59. Moreover, the delayed reaction to aggregate shocks generates a positive and statistically significant coefficient at the aggregate level, while the model generates a very high and robust contemporaneous correlation between consumption growth and labor income growth (0.85).

The benchmark search-consumption model in the second column also generates similar magnitudes for the relative smoothness ratio (0.61 relative to 0.59) and contemporaneous correlation between consumption and labor income growth (0.79 relative to 0.85). The excess sensitivity coefficient continues to be positive and statistically significant but is slightly lower, falling from 0.25 to 0.17. Moreover, the contemporaneous correlations between consumption, income and unemployment growth are relatively consistent with the empirical magnitudes. The correlation between consumption and earnings growth is between 0.64 and 0.82 in the simulations, which is a bit higher than its observed counterpart (0.49). The correlation between unemployment and earnings growth varies between -0.60 and -0.69, which is a bit lower than the estimated -0.43 correlation from table 1. Finally, the correlation between consumption and unemployment growth varies between -0.3 and -0.5, which encompasses the actual correlation in the data (-0.42).

Along these predictions, the incomplete information model seems to be doing reasonably well. Nevertheless, there is one prediction that is clearly at odds with the data and it concerns the effect of lagged unemployment growth on current consumption growth. The model predicts consistently a small but positive and statistically significant coefficient which is exactly the opposite sign to what is estimated in the data. In the model, when unemployment arrives, individuals use saving to smooth the shock so that there is a drop in both consumption and saving. Given that individuals typically become employed next period and unemployment (and its growth rate) are not strongly serially correlated, consumption picks up next period generating the positive coefficient. In the data, unemployment is non-stationary and using unemployment growth rates is admittedly a shortcut to generate a stationary series. Even this stationary series is serially autocorrelated, however, indicating that further work is needed in understanding the sources of the mean unemployment rate and unemployment risk over time. We think that this avenue for future work will improve the empirical predictions of the model but leave it to future research to determine the exact modelling choices that are needed to generate implications that are more consistent with the empirical regularities. For instance, even though a unit root test on the unemployment series is not rejected, it is not clear whether this arises from a slowly evolving structural break in the series.

These conclusions are robust to different perturbations of the structural parameters as the rest of table 9 illustrates. We conclude that the incomplete information, infinite horizon, partial equilibrium model goes some way towards explaining some of the observed time series regularities but further work is needed to understand the implications of the model for unemployment dynamics over the business cycle and its joint determination with consumption.

5 Conclusion

This paper documents that the excess sensitivity of consumption growth to lagged (expected) labor income growth conceals a robust negative sensitivity of consumption growth to lagged (expected) unemployment growth. Incorporating search frictions in a heterogeneous agent, precautionary savings model and aggregating individual life histories cannot replicate the aggregate (and microeconomic) stylized facts. Nevertheless, introducing incomplete information (defined as the inability to distinguish between aggregate and idiosyncratic shocks) delivers time series predictions that are relatively consistent with the macroeconomic empirical evidence but further work is needed to understand the joint determination of consumption and unemployment over the business cycle.

A Data Construction

This appendix gives data details for our aggregate variables.

Y denotes after tax per capita labor income deflated by the consumption of nondurables and services deflator.

C denotes per capita consumption of nondurables and services (excluding shoes and clothing) deflated in the same way.

To construct Y we use the following series from the Bureau of Economic Analysis (BEA):

Add wage income (WGSAL) and other labor income (OTHLAB) and subtract personal contributions for social insurance (CONTRIB). We do not add in transfer payments because, throughout the sample, these data are heavily influenced by retroactive payments and massive one-time increments, as well as seasonal adjustment problems. To determine the taxes paid on this labor income, we construct $TAOLAB = \frac{WGSAL+OTHLAB}{PERSINC}$, where PERSINC is the total disposable personal income (that is, wages, rent, interest and dividends). TAOLAB is thus the share of labor income in total disposable income. After tax labor income is then

$$ATLABINC = WGSAL + OTHLAB - CONTRIB - TAOLAB * TAXPAY,$$

where $TAXPAY$ is defined as personal tax and nontax payments from the national income and product accounts. We multiply proprietors' income by $TAOLAB$ (new variable called $PROPINC$) and construct the share of proprietors' labor income in total disposable income as $TAOPROP = \frac{PROPINC}{PERSINC}$, so that after tax proprietors' income is

$$ATPROPINC = PROPINC - TAOPROP * TAXPAY$$

and the real after tax per capita series used in the paper follows as

$$Y = \frac{(ATLABINC + ATPROPINC)}{(POP * JC)}$$

where POP is the population series and JC is the personal consumption chain type deflator.

To obtain the unemployment series u_t, we use monthly data from the Bureau of Labor Statistics and pick each third value to build the quarterly series. Real interest rates are constructed as nominal 3-month Treasury Bill rates minus actual inflation based on the Consumer Price Index.

Appendix B: Euler Equations and Numerical Solution Method

There are two value functions associated with the utility cost model depending on employment status (V^e, V^u). They are determined recursively according to

$$\text{(A1)} \qquad V^e_{it}(X_{it}) = MAX_{B^e_{it}} U(X_{it} - B^e_{it}) + \beta E_t[(1 - \delta_{t+1})V^e_{it+1}(X_{it+1}) + \delta_{t+1} V^u_{it+1}(X_{it+1})]$$

and

$$\text{(A2)} \qquad \begin{aligned} V^u_{it}(X_t) &= MAX_{B^u_{it}, S_{it}} U(X_{it} - B^u_{it} - S_{it}) \\ &\quad + \beta[\mu(s_{it}) E_t V^e_{it+1}(X_{it+1}) + (1 - \mu(s_{it})) E_t V^u_{it+1}(X_{it+1})] \end{aligned}$$

Combining the first order necessary condition with respect to B^u_{it}, the two envelope conditions $\{\frac{\partial V^e_{it}}{\partial X_{it}} = U_c(C^e_{it})$ and $\frac{\partial V^u_{it}}{\partial X_{it}} = U_C(C^u_{it})\}$ and the possibility of a binding liquidity constraint, we can derive the first two Euler equations given by (15) and (16). The third Euler equation can be derived by differentiating (A2) and imposing the possibility of a binding constraint on search intensity. The normalization by the growing components is done to make the model stationary. This utilizes the fact that the value functions are homogeneous of degree $(1-\rho)$, a property that they inherit from the CRRA utility function.

Two sufficient conditions for the individual Euler equations to define a contraction mapping are the conditions in Theorem 1 of Deaton and Laroque (1992) for a mathematically identical model of commodity prices ($\beta = \frac{1}{1+d}$):

$$\text{(A3)} \qquad \frac{1+r}{1+d} E_t Z_{t+1}^{-\rho} < 1$$

If this condition holds, there will exist a unique set of optimum policies satisfying the three Euler equations. We next simplify these conditions to gain an intuitive understanding of the economics of the problem. Given that $Z_{t+1} = G_{t+1}N_{t+1}$, with $\{N\}$ being log normally distributed, we have $E_t(G_{t+1}N_{t+1})^{-\rho} = \exp(-\rho\mu_g + \frac{\rho^2\sigma_g^2}{2}) * \exp(-\rho\mu_n + \frac{\rho^2\sigma_n^2}{2})$. Then

$$\text{(A4)} \qquad \begin{aligned} E_t \frac{1+r}{1+d} Z_{t+1}^{-\rho} &= E_t \frac{1+r}{1+d} E_t Z_{t+1}^{-\rho} \\ &= \frac{1+r}{1+d} * \exp(-\rho\mu_g + \frac{\rho^2\sigma_g^2}{2}) * \exp(-\rho\mu_n + \frac{\rho^2\sigma_n^2}{2}) \end{aligned}$$

Taking logs of the two conditions and using the approximation $\log(1+x) \approx x$ for small x, (A3) becomes

$$\text{(A5)} \qquad \frac{r-d}{\rho} + \frac{\rho}{2}(\sigma_n^2 + \sigma_g^2) < \mu_g$$

which is the condition derived by Deaton (1991) with $\mu_n = 0$ and is the same condition as in Carroll (1997) where μ_n is non-zero.

The condition can be satisfied for high μ_g or d. First, a high expected earnings growth profile (as measured by μ_g) guarantees that the individual will not want to accumulate an infinite amount bonds but would rather borrow now, expecting earnings to increase in the future. Second, if the rate of time preference exceeds the expected stock return, more risk averse (higher ρ) individuals will not satisfy the convergence conditions.

The single state variable (normalized cash on hand, $x_t = \frac{X_t}{P_t}$) is discretized into say (100) grid points with more points at lower values of cash on hand where the value function is more curved and the policy functions have a kink. Given that the value functions converge, we can solve simultaneously the three functional equations for the three policy functions. Note that the value functions also need to be computed and updated until convergence when computing the search intensity function. Interpolations along the single continuous state variable are performed using cubic spline interpolation and the upper bound of cash on hand is found by a trial and error method that ensures simulated liquid assets never exceed the chosen upper bound for cash on hand.

The incomplete information model is solved in a similar manner with two main differences. First, the normalization is done by Y_{it} instead of P_{it} since P_{it} cannot be directly observed by the individual. Second, the innovation in the growth rate of individual labor income becomes a state variable since labor income growth is perceived to follow an MA(1) process with a negative coefficient. Current innovations in labor income are reversed next period and given their transitory nature, high earnings shocks are associated with lower consumption than low earnings shocks.

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Notes

[1]Hubbard, Skinner and Zeldes (1995), Attanasio, Banks, Meghir and Weber (1999), Gourinchas and Parker (2002) and Cagetti (2003) offer supporting evidence from microeconomic data for the life-cycle model.

[2]Hansen and Imrohoroglu (1992), Wang and Williamson (1996), Costain (1999) and Alvarez and Veracierto (2001) do not explicitly incorporate undiversifiable, idiosyncratic labor income risk.

[3]Malley and Moutos (1996) also document a robust negative correlation between unemployment growth and the consumption growth of motor-vehicles.

[4]The results and conclusions do not change qualitatively when trends are removed either by an HP or a band-pass filter. This holds both for excess sensitivity regressions run with detrended variables and the relative smoothness ratios between consumption, unemployment and labor income. We chose not to report these results both due to space considerations and because we wanted to relate our empirical results with the "excess sensitivity" literature that performs the analysis in growth rates.

[5]Results not reported for space considerations.

[6]We have also estimated the model using a limited information maximum likelihood estimator which is partially robust to weak instruments and found that the coefficient estimates did not change substantially in magnitude and remained statistically significant at the 5% level; see Stock, Wright and Yogo (2002) for an excellent survey of the issue.

[7]More recently, the variance of earnings shocks has received attention in microeconometric work. Specifically, Meghir and Pistaferri (2004) argue that the variance of earnings shocks is serially correlated while Storesletten, Telmer and Yaron (2004) argue that the variance of earnings shocks rises in downturns. We abstract from these more complicated specifications in this paper.

[8]The average replacement ratio in the US is estimated to be lower than 0.67, but the average replacement ratio is higher conditional on receiving the benefit.

[9]The results are very similar to the Carroll (1997) model in this column but we impose the constraint explicitly which might lead to some differences on the level of the consumption function depending on expected benefits during unemployment.

[10]Increasing the mean growth rate of earnings works like increasing impatience given the liquidity constraint and reduces individual saving, generating a big drop in average consumption from the employment to the unemployment state and increasing the volatility of individual consumption growth.

[11]In the annual frequency model, the relative smoothness ratio is closer to one. In the quarterly model this is not the case because the ratio of transitory to permanent shock variances is much higher in the quarterly than in the annual model implying higher individual saving rates and higher individual consumption smoothing, some of which survives the aggregation procedure.

[12]In some calibrations the correlation between the job destruction rate and aggregate labor income growth is non-zero. According to the true earnings process, we know that

$$cov(\delta_t, \Delta \ln Y_{it}) = \sigma_{\delta g} = \rho_{\delta g}\sigma_\delta\sigma_g$$

Matching this with the covariance between the job destruction rate and the perceived labor income process implies that the correlation between the job destruction rate and the innovation in labor income (ϵ_{it}) is given by

$$\rho_{\delta\epsilon} = \frac{\rho_{\delta g}\sigma_g}{\sigma_\epsilon}$$

[13]Consumption growth volatility actually rises relative to the benchmark case but this reflects the increase in total earnings uncertainty by the larger drop in earnings during unemployment.

Table 1

Properties of Aggregate Time Series U.S. Data

Quarterly Frequency

1959:01 - 2002:04

Time Series	s.d.	First Autoc.
ΔC_t	.44	.336*
ΔY_t	1.17	$-.082$
Δu_t	5.98	.393*
Contemporaneous Correlations		
$Corr(\Delta C_t, \Delta Y_t)$		.489*
$Corr(\Delta C_t, \Delta u_t)$		$-.422$*
$Corr(\Delta Y_t, \Delta u_t)$		$-.432$*

Notes to Table 1: Y denotes real, after tax, per capita labor income, C denotes real, per capita consumption of nondurables and services (excluding shoes and clothing) and u denotes the unemployment rate. Δ is used to denote the growth rate in a variable. Details for the construction of these variables can be found in Appendix A.* denotes statistical significance at the 5% level.

Table 2

Excess Sensitivity of Consumption Growth to

Labor Income Growth and Unemployment Growth

1959:01 - 2002:04

OLS estimates

Panel A

Dependent variable	Regressor	$Adj.R^2$
ΔC_t	ΔY_{t-1}	
	.109*	.077
	(.036)	

Panel B

Dependent variable	Regressors		$Adj.R^2$
ΔC_t	ΔY_{t-1}	Δu_{t-1}	
	.077*	$-.014$*	.102
	(.031)	(.004)	

Notes to Table 2: Y denotes real, after tax, per capita labor income, C denotes real, per capita consumption of nondurables and services (excluding shoes and clothing) and u denotes the unemployment rate. Δ is used to denote the growth rate in a variable. Details for the construction of these variables can be found in Appendix A.* denotes statistical significance at the 5% level. Standard errors for the OLS estimates are given in parentheses.

Table 3: IV Estimates

Panel A: Dependent Variable	IVs	Regressors		$Jstat.$
ΔC_t	1st set	ΔY_t	Δu_t	
		$.441^*$	–	.002
		(.137)	–	
		$.236^*$	$-.041^*$	.008
		(.110)	(.018)	
Panel B: Dependent Variable	IVs	Regressors		$Jstat.$
ΔC_t	2nd set	ΔY_t	Δu_t	
		$.420^*$		.020
		(.121)		
		$.231^*$	$-.039^*$	.028
		(.098)	(.016)	
Panel C: Dependent Variable	IVs	Regressors		$Jstat.$
ΔC_t	3rd set	ΔY_t	Δu_t	
		$.323^*$		.048
		(.070)		
		$.185^*$	$-.032^*$	.030
		(.082)	(.015)	

Notes to Table 3: Y denotes real, after tax, per capita labor income, C denotes real, per capita consumption of nondurables and services (excluding shoes and clothing), u denotes the unemployment rate and r is the real short term interest rate defined as the difference between the nominal three month U.S. Treaury Bill rate and inflation (constructed from the CPI). Data range: 1959:01 - 2002:04, quarterly. Δ is used to denote the growth rate in a variable. Details for the construction of these variables can be found in Appendix A. * denotes statistical significance at the 5% level and standard errors are given in parentheses. The first set of instruments is: ΔY_{t-2}, ΔY_{t-3}, Δu_{t-2}, Δu_{t-3}. The second set of instruments is the first set plus $\ln(C_{t-2}/Y_{t-2})$, $\ln(C_{t-3}/Y_{t-3})$ and the third set of instruments is the second set plus r_{t-2}, r_{t-3}.For the regressions without Δu_t the respective instrument sets do not include Δu_{t-2}, Δu_{t-3}.

Table 4

Fully Robust Inference with Weak Instruments

Test	1st set of IVs	2nd set of IVs	3rd set of IVs
A-R	8.02**	7.03**	6.97**
Critical Values (10%,5%)	(1.94, 2.37)	(1.77, 2.09)	(1.67, 1.94)
Kleibergen	16.1**	12.4*	25.6**
Critical Values (10%,5%)	(7.78, 9.49)	(10.64, 12.59)	(13.36, 15.51)
Moreira (LR)	23.5**	23.8**	39.7**
Critical Values (5%)	(4.20)	(4.73)	(4.73)

Notes to Table 4: Different tests of the null that the IVs are weak in the regressions of Table 3. * (**) denotes that H_0 is rejected at 10% (5%). Numbers in parentheses indicate the critical values of the respective statistics at the 10% and 5% level of statistical significance respectively. The first set of instruments is: ΔY_{t-2}, ΔY_{t-3}, Δu_{t-2}, Δu_{t-3}. The second set of instruments is the first set plus $\ln(C_{t-2}/Y_{t-2})$, $\ln(C_{t-3}/Y_{t-3})$ and the third set of instruments is the second set plus r_{t-2}, r_{t-3}. The critical values for the LR test are reproduced from Moreira (2003) and refer only to 5% significance. Moreira does not report any values for the case of six and eight exogenous variables but since the statistic is increasing in the number of instruments we report the threshold for 10 IVs.

Table 5: Complete Information Model

Mean Individual Statistics-Simulated Data

Comparative Statics

Variable	Deaton	Bench	$\rho = 5$	$ub = .5$	$\sigma_u = .2$	$\delta = .1$	$\rho_{\delta g} = -.7$
Mean c^e	.999	.980	.978	.973	.997	.961	.985
Mean c^u		.781	.855	.756	.819	.808	.776
Mean b^e	.134	.484	.789	.771	.649	.600	.459
Mean b^u		.130	.345	.232	.277	.219	.112
$\sigma(\Delta C_{it})$	.061	.087	.057	.098	.091	.090	.089
$\sigma(\Delta Y_{it})$	.151	.200	.201	.292	.338	.237	.201
Sensitivity	$-.028$	$-.024$	$-.007$	$-.015$	$-.010$	$-.015$	$-.026$
S.e.	.031	.033	.021	.025	.020	.028	.034
Drop in c (%)		21.2	12.6	22.3	17.8	15.9	21.1
Drop in b (%)		75.5	56.2	69.8	57.2	63.4	75.6

Notes to Table 5: λ and δ are chosen so that the mean unemployment rate is approximately 6 percent and the mean probability of finding employment after one quarter is around 80%, respectively. This generates a value for $\lambda = 8$ and $\delta = .05$. Standard errors are given in parentheses while ** denotes statistical significance at the 5% level. For the benchmark specification the discount factor (β) is set at 0.99, the risk aversion coefficient at $\rho = 2$, the real interest rate at $r = .02/4$, the replacement ratio during an unemployment spell $ub = 67\%$ of mean labor income during employment, the mean aggregate growth rate at $\mu_g = .03/4$, the standard deviation of transitory earnings shocks at $\sigma_u = 0.1$, the standard deviation of aggregate shocks at $\sigma_g = .02/\sqrt{4}$ and the standard deviation of permanent earnings shocks at $\sigma_N = .08/\sqrt{4}$. Lower case variables are normalized by the permanent component of individual labor income (c^e is normalized consumption during employment spells for instance). The last two rows refer to the drop in normalized consumption and savings that the model predicts when going from an employment to an unemployment state. The statistics are computed over 172 periods over 2000 individuals and averaged over 100 simulation draws.

Table 6: Complete Information Model

Mean Aggregate Statistics-Simulated Data

Comparative Statics

Variable	Deaton	Bench	$\rho = 5$	$ub = .5$	$\sigma_u = .2$	$\delta = .1$	$\rho_{\delta g} = -.7$
Mean ΔC_t	.008	.009	.009	.009	.009	.009	.009
$\sigma(\Delta C_t)$	.011	.011	.011	.011	.011	.011	.001
Mean ΔY_t	.008	.009	.009	.009	.009	.009	.009
$\sigma(\Delta Y_t)$	.012	.013	.013	.015	.015	.013	.013
$\sigma(\Delta C_t)/\sigma(\Delta Y_t)$	.917	.843	.814	.742	.726	.821	.827
$Corr(\Delta C_t, \Delta Y_t)$	.965	.942	.924	.903	.863	.926	.941
$Corr(\Delta C_t, \Delta U_t)$		$-.360$	$-.365$	$-.508$	$-.301$	$-.395$	$-.450$
$Corr(\Delta Y_t, \Delta U_t)$		$-.217$	$-.146$	$-.231$	$-.191$	$-.201$	$-.308$
Sensitivity (ΔY_{t-1})	.044	.040	.041	.032	.043	.052	.173**
S.E. (ΔY_{t-1})	(.070)	(.069)	(.067)	(.066)	(.058)	(.068)	(.069)
Sensitivity (ΔU_{t-1})		.000	.000	.000	.000	.000	.010**
S.E. (ΔU_{t-1})		(.003)	(.003)	(.003)	(.003)	(.060)	(.003)
Unemployment (%)		6.0	5.8	5.5	6.0	11.4	5.9
Prob Find Empl (%)		80.2	83.5	87.0	80.4	79.2	80.2

Notes to Table 6: See notes to Table 5. The sensitivity rows report the coefficients from a regression using the simulated data of consumption growth on lagged labor income and unemployment growth respectively. S.E. are the standard errors from these regressions. Prob Find Empl reports the probability of finding employment after one quarter.

Table 7: Complete Information Model

Mean Individual Statistics-Simulated Data

Utility cost for search

Comparative Statics

Variable	Bench	$\rho = 5$	$ub = .5$	$\sigma_u = .2$	$\delta = .1$	$\mu_g = .06/4$
Mean c^e	.980	.974	.970	.978	.958	.983
Mean c^u	.977	1.07	1.00	1.00	1.00	.899
Mean b^e	.459	.808	.764	.652	.597	.304
Mean b^u	.119	.373	.234	.287	.226	.035
Drop in c (%)	0.34	-10.3	-3.59	-2.87	-4.48	8.49
Drop in b (%)	73.9	53.7	69.3	55.9	62.1	88.4

Notes to Table 7: All parameters are the same as the ones used in table 5. The only difference between the two tables arises from the search cost being incurred as a utility rather than a monetary cost in table 7.

Table 8: Incomplete Information Model

Mean Individual Statistics-Simulated Data

Comparative Statics

Variable	Deaton	Benchmark	$\rho = 5$	$ub = .5$	$\sigma_u = .2$	$\delta = .1$	$\rho_{\delta g} = -0.7$
Mean c^e	1.00	.990	.991	.990	1.01	.973	.992
Mean c^u		.873	.962	.973	.924	.908	.875
Mean b^e	.100	.490	.976	.872	.688	.668	.493
Mean b^u		.279	.908	.979	.556	.505	.281
$\sigma(\Delta C_{it})$	.082	.184	.145	.247	.195	.212	.183
$\sigma(\Delta Y_{it})$	.151	.201	.201	.292	.338	.237	.201
Sensitivity	$-.04$	$-.178^*$	$-.156^*$	$-.229^*$	$-.067$	$-.226^*$	$-.176^*$
S.e.	.04	.068	.061	.062	.044	.066	.068
Drop in c (%)		12.0	2.92	1.63	8.93	6.7	11.8
Drop in b (%)		42.9	6.91	-12.3	19.3	24.5	42.9

Notes to Table 8: λ and δ are chosen so that the mean unemployment rate is approximately 6 percent and the mean probability of finding employment after one quarter is around 80%, respectively. This generates a value for $\lambda = 8$ and $\delta = .05$. Standard errors are given in parentheses while ** denotes statistical significance at the 5% level. For the benchmark specification the discount factor (β) is set at 0.99, the risk aversion coefficient at $\rho = 2$, the real interest rate at $r = .02/4$, the replacement ratio during an unemployment spell $ub = 67\%$ of mean labor income during employment, the mean aggregate growth rate at $\mu_g = .03/4$, the standard deviation of transitory earnings shocks at $\sigma_u = 0.1$, the standard deviation of aggregate shocks at $\sigma_g = .02/\sqrt{4}$ and the standard deviation of permanent earnings shocks at $\sigma_N = .08/\sqrt{4}$. Lower case variables are normalized by the permanent component of individual labor income (c^e is normalized consumption during employment spells for instance). The last two rows refer to the drop in normalized consumption and savings that the model predicts when going from an employment to an unemployment state. The statistics are computed over 172 periods over 2000 individuals and averaged over 100 simulation draws.

Table 9: Incomplete Information Model

Mean Aggregate Statistics-Simulated Data

Comparative Statics

Variable	Deaton	Bench	$\rho = 5$	$ub = .5$	$\sigma_u = .2$	$\delta = .1$	$\rho_{\delta g} = -0.7$
Mean ΔC_t	.009	.009	.009	.009	.009	.009	.009
$\sigma(\Delta C_t)$	.007	.008	.007	.009	.008	.008	.009
Mean ΔY_t	.009	.009	.009	.009	.009	.009	.009
$\sigma(\Delta Y_t)$	.012	.013	.013	.015	.015	.013	.014
$\sigma(\Delta C_t)/\sigma(\Delta Y_t)$	.585	.607	.549	.634	.500	.582	.642
$Corr(\Delta C_t, \Delta Y_t)$	.846	.787	.772	.817	.645	.784	.777
$Corr(\Delta C_t, \Delta U_t)$		$-.355$	$-.354$	$-.502$	$-.297$	$-.385$	$-.444$
$Corr(\Delta Y_t, \Delta U_t)$		$-.608$	$-.603$	$-.726$	$-.638$	$-.627$	$-.689$
Sensitivity (ΔY_{t-1})	.247*	.169*	.161*	.130*	.092*	.194*	.434*
S.E. (ΔY_{t-1})	.041	.048	.043	.054	.039	.046	.043
Sensitivity (ΔU_{t-1})		.007*	.007*	.010*	.006*	.016*	.014*
S.E. (ΔU_{t-1})		.002	.002	.003	.002	.005	.002
Unemployment rate (%)		5.9	5.8	5.6	5.9	11.2	5.8
Prob find Empl (%)		81.3	82.4	86.3	80.8	79.8	81.3

Notes to Table 9: See notes to Table 8. The sensitivity rows report the coefficients from a regression using the simulated data of consumption growth on lagged labor income and unemployment growth respectively. S.E. are the standard errors from these regressions. Prob Find Empl reports the probability of finding employment after one quarter.

Monetary cost - Complete information model

Figure 1: Normalized consumption

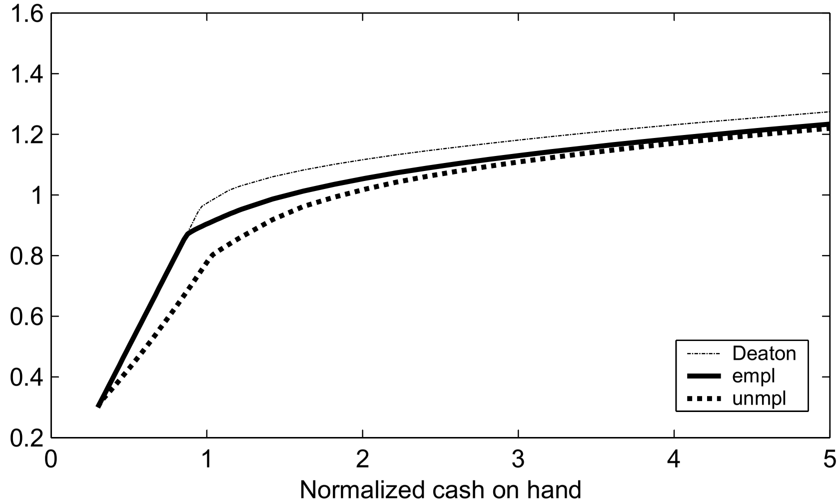


Figure 2: Probability of finding employment

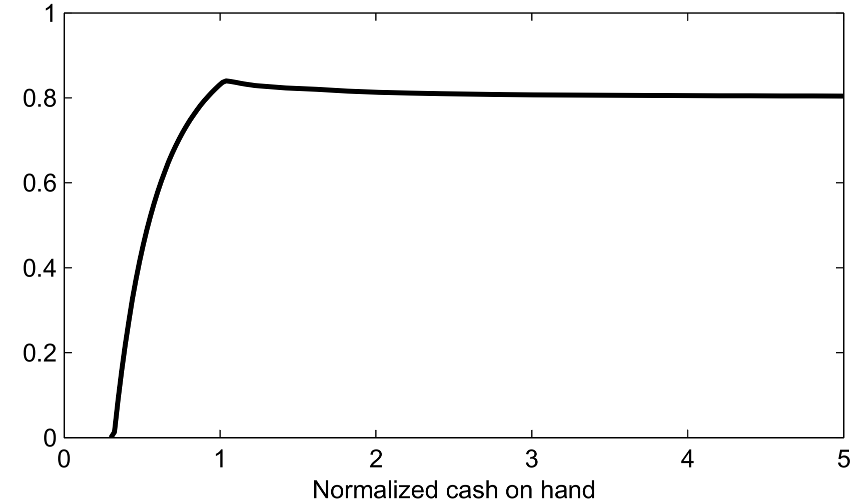


Figure 3: Probability of finding employment

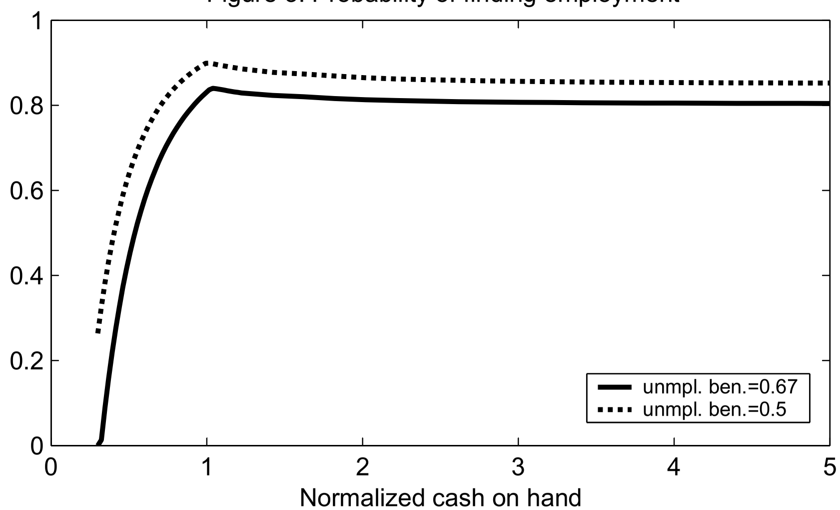
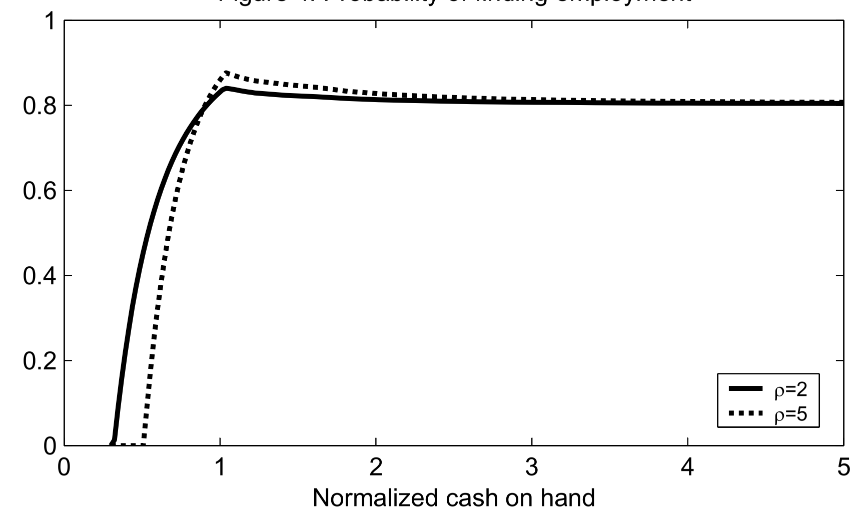


Figure 4: Probability of finding employment



Monetary cost - Incomplete information model

Figure 5: Normalized consumption of employed

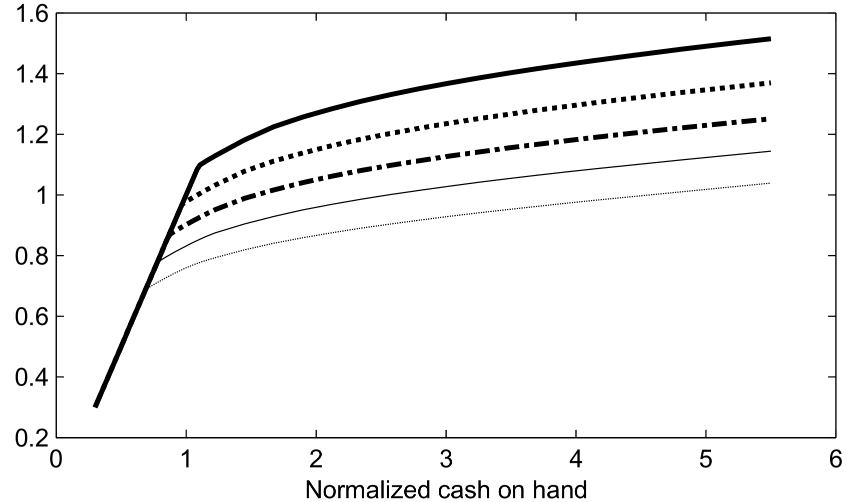
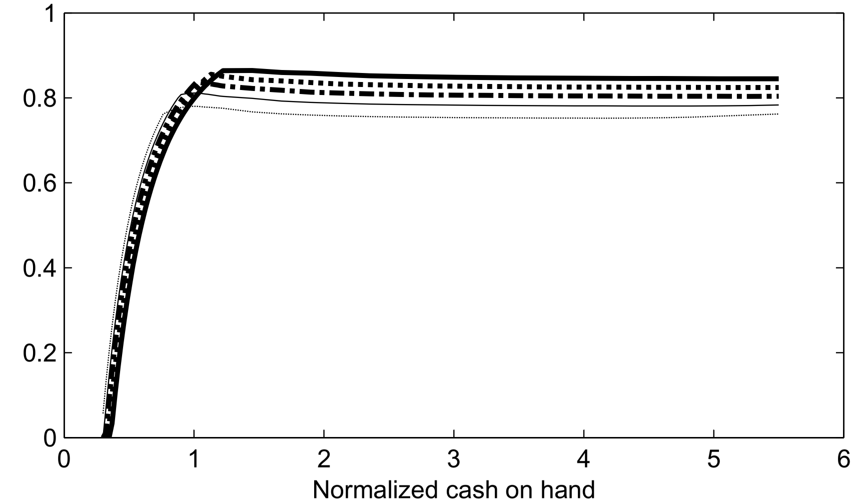


Figure 6: Probability of finding employment



Fogure 7: Probability of finding employment

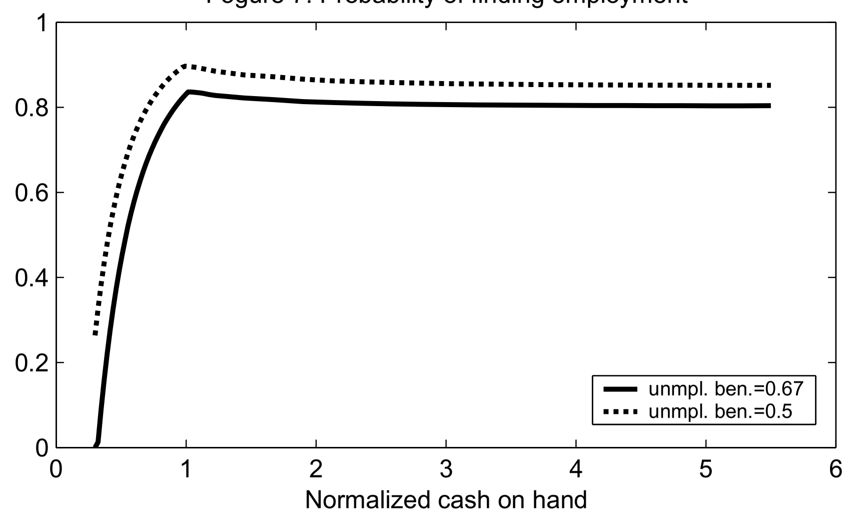


Figure 8: Probability of finding employment