Price Search, Consumption Inequality, and Expenditure Inequality over the Life Cycle *

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Abstract

In this paper, we incorporate a price search decision into a life cycle model and differentiate consumption from expenditure. Consumers with low wealth and bad income shocks search more for cheaper prices and pay less, which makes their consumption higher than in a model without search option. A plausibly calibrated version of our model predicts that the cross-sectional variance of consumption is about 17% smaller than the cross-sectional variance of expenditure throughout the life cycle. Price search has an alternative productive activity role for lower-income people to increase their consumption levels. We discuss other implications of price search over the life cycle as well.

Keywords: Consumption inequality, price search, incomplete markets, life cycle models, partial insurance.
J.E.L. Classification: D10, D91, E21.

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1 Introduction

In this paper, we study the role of price search in the age-inequality profiles of consumption and expenditure. We incorporate a price search decision into a quantitative life-cycle model and differentiate consumption from expenditure. A plausibly calibrated version of the model predicts a significant difference (about 17%) in age-inequality profiles of consumption and expenditure throughout the life cycle.

Our model economy features an incomplete markets framework. In general, the models with incomplete markets ignore the partial insurance role of price search and dispersion in prices.[1] However the empirical literature has documented significant dispersion in prices paid for identical goods.[2] For instance, Aguiar and Hurst (2007) document that, in the U.S. data, richer people pay higher prices for identical goods. Also, they report that prices paid for identical goods change over the life cycle, which is a result of a change in price search due to a change in the cost of time. Using the U.S. data, Sorensen (2000) documents dispersion in prices paid for the same medicine. Dahlbay and West (1986) report price dispersion in automobile insurance companies in Canadian data. Pratt et al. (1979) document price dispersion in several categories of goods. Baye et al. (2004) document dispersion in prices for identical goods posted in the internet. These documented facts motivate a quantitative study on the role of price search over the life cycle. Motivated by the reported facts on the dispersion in prices in the empirical literature, this paper focuses on the partial insurance role of price search in the age-inequality profiles of consumption and expenditure. We believe that filling this gap in the literature is important to understand consumption inequality over the life cycle.

We solve a life-cycle model, in which we allow agents to search for cheaper prices in addition to the consumption/saving decision. As a result of idiosyncratic income shocks, people are ex-post heterogeneous in terms of their income realizations and wealth accumulations. If agents search more for cheaper prices, they pay less and consume more; however, they enjoy less leisure due to time constraints. Optimality implies that the marginal return to and the marginal cost of price search are equalized. The marginal return to price search comes from additional consumption, and it is smaller for agents who already have high consumption. That implies that agents with low wealth and bad income shocks search more and pay less, which we interpret as partial insurance through price search. Our results show that the cross-sectional variance of consumption is roughly 17% smaller than the cross-sectional variance of expenditure throughout the life cycle.

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[1]See Heathcote et al. (2009) for a detailed survey on the partial insurance mechanisms in incomplete markets.

[2]Baye et al. (2006) provide a detailed survey on the dispersion in prices paid for identical goods.

Following the formulation of Kaplan and Violante (2008), we quantify the partial insurance through price search with insurance coefficients. The computed insurance coefficient of consumption for persistent shocks is 7.8% in the model with price search compared to the one with no price search.

Among many other studies in the quantitative life-cycle literature, this paper is closely related to Guvenen (2007), Storesletten et al. (2004), and Karahan and Ozkan (2010). Those papers study the role of income processes on the age-inequality profile of consumption. Kaplan (2010) extends a similar model with unemployment risk to better match age-inequality profiles of consumption and labor allocations over the life cycle. There is a common implicit assumption in those models that says the price of a consumption good is unique, and therefore consumption is equal to expenditure. However, as we mentioned above, there is a large empirical literature that rejects this assumption. Our paper differs from the standard life-cycle studies in the sense that it differentiates consumption from expenditure. We show that this distinction plays a quantitatively significant role in the age-inequality profile of consumption.

The paper continues as follows. In section 2, we present the model. We explain the details of the calibration in section 3. In section 4, we report the results, finally we conclude in section 5.

2 Model

We extend a standard incomplete markets model with a price search technology, which allows agents to search for cheaper prices and partially insure against bad income shocks. We do it in a life-cycle framework to study the age-inequality profiles of consumption and expenditure. The asset markets are incomplete due to uninsurable idiosyncratic income shocks. The population consists of a continuum of agents who are active for T periods and afterwards enjoy retirement until period T^*. During the active periods, the agents can choose to work or stay unemployed. The retirement is imposed exogenously at period T. Each component of the model is explained in detail below.

2.1 Households

At each period, the agents have two decisions: one is the consumption/saving decision, and the other is the leisure/price search decision. The agent can enjoy more consumption by searching for cheaper prices; however, he/she enjoys less leisure in that case. They maximize life time expected value of discounted utility:

$$E \sum_{t=0}^{T^*} \beta^t u(c_t, l_t) \tag{1}$$

where, $u(\cdot)$ is period utility, β is the time discount factor, c_t and l_t are consumption and leisure of an agent at time t. He/shet has the following time constraint at period t:

$$s_t + l_t + n_t(e_t) = 1 \tag{2}$$

where, s_t and l_t are the time spent on price search and leisure for the agent at period t. Upon realization of current labor income, agents choose to work or not.[3] Employment decision is denoted with e_t, which takes value 1, if the agent chooses to work, and 0 otherwise. Therefore, labor supply is assumed to be indivisible. The variable n_t denotes the fraction of time allocated for labor supply upon choosing employment. It takes a constant value $(\bar{n})$ if the agent is employed $(e_t = 1)$, and 0 if the agent is unemployed $(e_t = 0)$ or retired $(t > T)$.

The asset markets are incomplete, where agents can borrow or save through a risk-free interest-bearing asset. Agents face the following budget constraint at time t:

$$p(s_t)c_t + a_{t+1} = y_t e_t + (1 + r)a_t \tag{3}$$

where, $p(\cdot)$ is the price of a consumption good that depends on the individual search time. Consumption and saving at the current period are denoted by c_t and a_{t+1}, respectively. Current period labor income is denoted with y_t, and the labor income process will be explained in detail later on.

2.2 Price Search Technology

We follow Aguiar and Hurst (2007) in price function, because they estimated the parameters of this form in the U.S. data, which we will calibrate accordingly in the benchmark model. It is a log linear form:

$$\log(p) = \theta_0 + \theta \log(s)$$

where θ is the return to search on prices. In the log linear form, doubling search decreases prices by $100 * \theta$ percent. Aguiar and Hurst (2007) estimate the return to search, θ, net of how much and what type of goods purchased by the shopper. They use the AC Nielsen

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[3]An alternative way of introducing unemployment to the model would be allowing for exogenous shocks as in Kaplan 2011 (He allows for an intensive margin decision as well). We choose to allow for an endogenous employment decision, because we have only external margin decision and endogenous time allocation is in the focus of this paper.

Homescan data set to estimate the parameters.[4]

2.3 Earning and Pension Processes

For the earning process, we follow the literature. At each period, the agent is assumed to receive a persistent and a transitory labor income shock. This is a standard model for labor earnings and has been estimated in several studies.[5] The log earnings follow:

$$\log(y_t) = \beta_0 + \beta_1 t + \beta_2 t^2 + z_t + \epsilon_t, \quad \text{with } \epsilon_t \sim (0, \sigma_\epsilon^2)$$

where β_0 is a scale parameter, β_1 is return to experience, t is the years of experience , z_t is the persistent income shock and ϵ_t is the transitory income shock. The persistent income shocks follow an $AR(1)$ process:

$$z_t = \rho z_{t-1} + \nu_t, \quad \text{with} \quad z_0 = 0 \text{ and } \quad \nu_t \sim N(0, \sigma_\nu^2)$$

We discuss the calibration of the earning process parameters in section 3. For the pension process, we follow Guvenen (2007), which mimics the U.S. Social Security system. After retirement, the pension of each agent is determined by the ratio of his income in the last working period to the average income in the last working period, $\frac{y_T}{\bar{y}_T}$. The pension function, $\Gamma, \left(\frac{y_T}{\bar{y}_T}\right)$ is as follows:

$$= \gamma \times \begin{cases} 0.9\frac{y_T}{\bar{y}_T}, & \text{if } \frac{y_T}{\bar{y}_T} < 0.3 \\ 0.27 + 0.32(\frac{y_T}{\bar{y}_T} - 0.3), & \text{if } 0.3 < \frac{y_T}{\bar{y}_T} < 2 \\ 0.81 + 0.15(\frac{y_T}{\bar{y}_T} - 2), & \text{if } 2 < \frac{y_T}{\bar{y}_T} < 4.1 \\ 1.1 & \text{if } 4.1 < \frac{y_T}{\bar{y}_T}. \end{cases}$$

2.4 Utility Function

We use a utility function that is quite standard in the literature and is specified as follows:

$$u(c_t, l_t) = \frac{c_t^{(1-\sigma)}}{1 - \sigma} + \phi_t \frac{l_t^{(1-\xi)}}{1 - \xi}$$

The parameter ϕ_t affects the utility enjoyed from leisure time. It could also be interpreted as the cost of the time the agent spends on price search. This parameter is calibrated to

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[4]This data set collects information on household grocery shopping which allows to distinguish different prices paid for identical goods across households. For details see Aguiar and Hurst 2007.

[5]For example: MaCurdy (1982), Storesletten (2004), Guvenen (2007).

match the life cycle profile of prices. The calibration of the utility function parameters is explained in Section 3.

2.5   Recursive Formulations

In this section, we formulate the optimization problems of the agents in recursive form in order to solve them numerically. During the active working periods, each agent solves the following optimization problem:

$$V_t(a_t, z_t, \epsilon_t) = \max_{c_t, s_t, n_t, a_{t+1}} \{u(c_t, l_t) + \delta E[V_{t+1}(a_{t+1}, z_{t+1}, \epsilon_{t+1})|z_t, \epsilon_t]\}$$

s.t.

$$p(s_t)c_t + a_{t+1} = y_t n_t + (1 + r)a_t$$

$$s_t + l_t + n_t = 1$$

$$a_{t+1} \geq \Psi_t$$

for $t \in \{1, 2, ..., T\}$

In the above problem, c_t is consumption, s_t is the time used for price search, l_t is leisure, n_t is labor supply (chosen at the extensive margin), a_t is the accumulated asset level, a_{t+1} is saving for the next period, and y_t is earnings at period t. Agents can borrow up to a borrowing limit Ψ_t, which depends on his/her income realization one period before. The return on savings is denoted with r, and the time discount factor with β. If the agent chooses to work, his/her labor supply is equal to a fixed fraction ($\bar{n}$) of his/her total time. At his point we would like to emphasize the role of price search in the model. The agent can enjoy the same amount of consumption with different expenditure levels. He/she can spend more time to find cheaper prices which will allow him/her to enjoy a certain amount of consumption with small expenditure levels. Otherwise, he/she may prefer to enjoy more leisure and spend less time to search for cheaper prices which would make him/her to spend more for the same amount of consumption.

After retirement, agents receive a constant pension that depends on the earnings in the last period of their working life. The agent's problem becomes deterministic due to the constant pension after retirement:

Table 1: Benchmark Model Parameters

Parameter	Moment to Match	Value
	Externally Set	
r	risk-free interest rate (U.S. data)	0.04
σ	intertemporal elasticity of substitution for consumption (literature)	2
ξ	intertemporal elasticity of substitution for leisure (literature)	3
T	age of retirement (working period: 20-64)	65
T^*	age of death (retirement period: 65-85)	85
θ_1	return to price search (Aguiar and Hurst 2007)	-0.15
β_1	return to experience (Guvenen 2007)	0.009
ρ	persistence of earning shocks (Guvenen 2007)	0.988
σ_ε^2	variance of transitory earning shocks (Guvenen 2007)	0.061
σ_v^2	variance of persistent earning shocks (Guvenen 2007)	0.015
	Internally Calibrated	
β	wealth/earning ratio (U.S data)	0.97
θ_0	average price (normalized to 1)	0.76
$\{\phi_t\}$	life-cycle profile of prices (Aguiar and Hurst 2007)	figure 1

$$V_t(a_t, y) = \max_{c_t, s_t, a_{t+1}} \{u(c_t, l_t) + \delta V_{t+1}(a_{t+1}, y)\}$$

s.t.

$$p(s_t)c_t + a_{t+1} = y + (1+r)a_t$$

$$s_t + l_t = 1$$

$$a_{t+1} \geq \Psi_t$$

$$y = \Gamma(y_T)$$

for $t \in \{T+1, ..., T^*\}$ with $V_{T^*+1} = 0$

Each agent's pension is determined by $\Gamma(\cdot)$ function. The time endowment is looser for retired people, since they do not work. Note that the constant labor supply, $\bar{n}$, does not appear in the retired agent's time constraint.

3   Calibration

We calibrate the model in two stages. In the first stage, we directly use the values of some parameters that are well established in the related literature. This gives us the opportunity to understand the role of price search in the standard life cycle models. A model period is

Figure 1: Life-cycle profile of Prices: Model vs Data
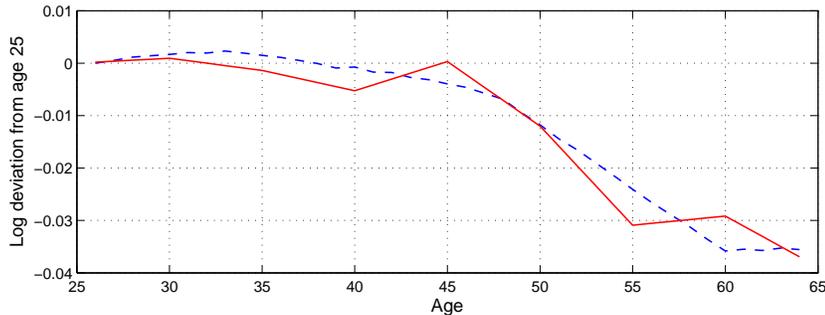
Notes: Empirical estimations for the prices paid over the life cycle are taken from Aguiar and Hurst (2007). In the model, we calculate the average price paid by each age group, and then draw the log deviation from age 25.

set to one year, and each agent starts working at age 20 and retires at 65.[6] Each agent starts working life with an asset level set at 0. We set $r = 0.04$, which which is roughly equal to return on risk-free investment in the U.S. The value of the relative risk-aversion parameter for consumption, σ, is set to a very standard value in the literature, 2.[7] In the literature, the value of parameter ξ, which pins down intertemporal elasticity of substitution for leisure, is usually set greater than the value of σ, therefore we set the value of ξ to 3.[8] The parameters of income process - β_0, β_1, β_2, ρ, σ_ε^2 and σ_v^2 - are borrowed from Guvenen (2009), which provides one of the most recent estimations of income processes.[9]

In the second stage, we calibrate parameters β, θ_0, ϕ_t to match chosen moments in the data. The value of β is set to 0.97 which gives an average wealth to yearly earning ratio of 3. We allow the value of ϕ to change over the life cycle. We do that in order to match the empirical life cycle profile of average prices paid. We target the log deviation of average prices from age 25 over the life cycle. We normalize the average price paid in the whole population to 1 by calibrating θ_0. For a given set of parameters we compute the policy functions and simulate a population of $N = 10000$ individuals. We repeat this process until we match the chosen moments. The benchmark parameters are reported in Table 1. Figure 1 compares the model-generated prices with the empirical counterpart.

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[6]We assume high school graduates start working at age 18 and college graduates at age 22. We take the average of the two ages, because we don't distinguish between education levels in the model.

[7]This number is very standard in both real business cycle literature and heterogeneous agents literature. An acceptable range for the value of σ is usually takes from 1 to 10.

[8]Storesletten et al. 2004, Chang and Kim 2007, Kaplan 2011

[9]Guvenen (2009) estimates two different types of income processes, namely Restricted Income Process and Heterogeneous Income Process. We pick the first one, because it matches our model's empirical target (age-inequality profile of expenditures) well.

Figure 2: Cross Sectional Variance: Consumption vs Expenditure
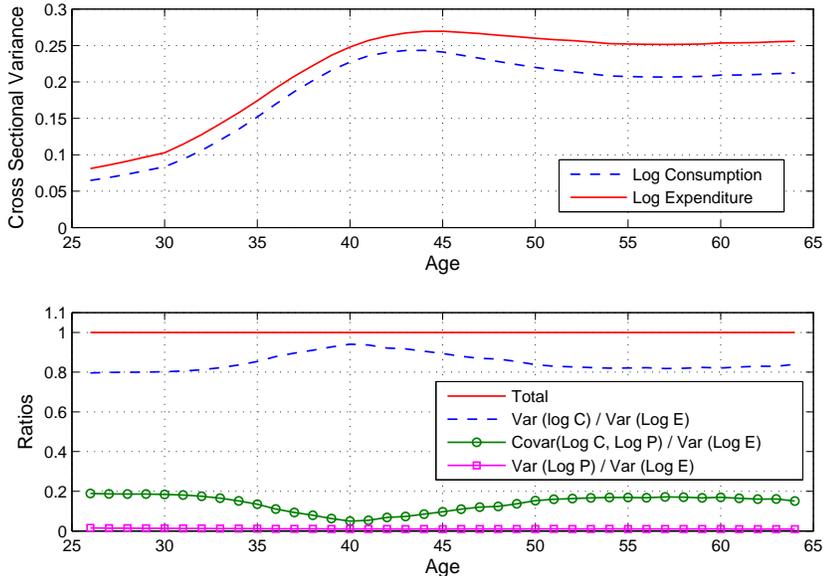
Note: In the simulated population, we take the variance of log consumption and log expenditure for each
age group separately and plot. The lower panel shows the ratio of its components over expenditure
inequality.

4   Results

4.1   Age-Inequality Profiles of Consumption and Expenditure

In the earlier studies, consumption was assumed to be equal to expenditure, which implied
exactly equal age-inequality profiles for consumption and expenditure. In this paper, we
differentiate consumption from expenditure by introducing price search into the model. Our
model predicts a higher expenditure inequality than consumption inequality throughout
the life cycle. The cross-sectional variance of log expenditure starts from 0.08 at age 25,
increases up to 0.27 at age 45, and stays flat around 0.25 after then. However, the cross
sectional variance of log consumption is about 0.06 at age 25, increases up to 0.24 at age
44, decreases to 0.20 at age 55, and stays flat around 0.20 after then. The Upper panel of
Figure 2 illustrates the age-inequality profiles of consumption and expenditure together.

In order to understand the gap between the consumption variance and the expenditure
variance throughout the life cycle, we decompose the expenditure variance:

$$e \quad = \quad p \times c \tag{4}$$

$$var(\log e) \quad = \quad var(\log c) + var(\log p) + 2cov(\log c, \log p) \tag{5}$$

We calculate each component of $var(\log e)$ from the model-generated data. The cross sectional variance of log consumption is smaller than that of expenditure throughout the life cycle as illustrated in Figure 2. The ratio of consumption inequality over expenditure inequality is about 80% at age 25, increases up to 92% at 40, decreases to 82% at age 55 and stays flat after then. The rest of the variance in expenditure is composed of covariance between consumption and prices, and variance in prices.

The reasons behind the hum-shaped profile in the lower panel of Figure 2 are the life-cycle profile of average wealth and the way we calibrate the set of parameters $\{\phi_t\}$.[10] These two factors affect the ratio of consumption inequality/expenditure inequality in opposite directions. On the one hand, average wealth is increasing until mid life, therefore agents tend to reject employment opportunities more frequently (wealthy agents prefer rejecting low paying offers and stay unemployed). This makes the unemployment rate higher among wealthier, that is looser time constraints for a greater fraction of the wealthier and the population. Once wealthier agents choose to stay unemployed, they have more time to search for lower prices and increase their consumption further, which leads to a greater inequality in consumption. This factor tends to close the gap between consumption inequality and expenditure inequality.

On the other hand, the value of parameter ϕ_t is decreasing over the life cycle in order to match the life cycle profile of prices. Lower values of ϕ_t reduces the value of leisure, therefore agents tend to accept employment opportunities more frequently, which reduces the rate of unemployment. Therefore, the fraction of agents who have looser time constraints decrease. This factor tends to widen the gap between consumption inequality and expenditure inequality. The net effect of these two factors determine the shape of the consumption inequality over expenditure inequality ratio.

We visit the optimality condition for price search to understand the positive covariance between consumption and prices:

$$-\frac{u_1(c_t, l_t)}{p(s)}p'(s_t)c_t = u_2(c_t, l_t) \tag{6}$$

Plugging the utility and price functions into equation 6, we get the following equation, which gives the relationship between search and consumption:

$$\frac{c_t^{1-\sigma}}{s_t}\theta_1 = \frac{\phi_t}{1 - s_t}$$

The first-order condition for price search implies a diminishing marginal return with con-

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[10]Recall that $\{\phi_t\}$ are calibrated to match the life-cycle profile of prices.

Figure 3: Labor Income and Prices: Model vs Data

Average Price Paid by Income Quintiles
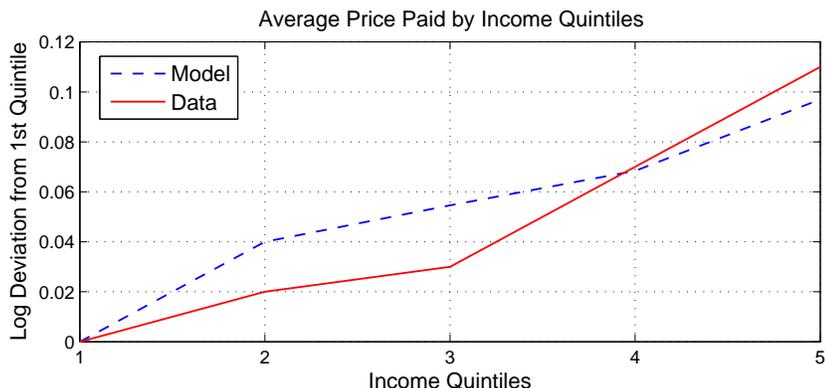
Notes: Empirical relationship between the level of earnings and prices is calculated using the data set of Aguiar and Hurst (2007). In the model, we divided population into quintiles in terms of labor income, calculate average price paid by each quintile, and draw the log deviations from age 25.

Table 2: Insurance Coefficients

	w/ Price Search		w/out Price Search	
	Expenditure	Consumption	Expenditure	Consumption
Transitory	.95	.96	.94	.94
Persistent	.51	.55	.50	.50

Notes: The insurance coefficients are calculated using the formula of Blundell et al. (2008). The coefficients are calculated for the entire population. See text for details.

sumption. Wealthier people who consume at high levels have less incentive to increase their consumption by sacrificing leisure. Note that the cost of price search is forgone utility from leisure. Agents with higher income and wealth spend more time on non-search activities instead of searching prices to increase their consumption. Agents with lower income and wealth spend more time on price search to increase their consumption levels. Therefore, price search has a productive activity role for lower-income and lower-wealth people to increase consumption levels.

Figure 3 compares the model with data in terms of average prices paid by income quintiles. In the model, average price paid by the highest earning quintile is 10% higher than that of the lowest earning quintile. The corresponding number is 11% in the data.[11]

4.2 Measuring the Partial Insurance Role of Price Search

In this section, we compute the amount of partial insurance gained through price search.[12] In order to quantify the partial insurance role of price search, we solved the model twice; once with price search and once without price search. We target the same average wealth over income ratio in the two cases.[13]

Using the formula of Blundell et al. (2008), we calculate the insurance coefficients as follows:

$$\phi^\epsilon = 1 - \frac{cov(\Delta c_{it}, \epsilon_{it})}{var(\epsilon_{it})} \tag{7}$$

where insurance coefficient of shock ϵ is denoted with ϕ^ϵ. In the complete markets framework, $\phi^\epsilon = 1$ due to the fact that idiosyncratic shocks do not affect consumption, that is $cov(\Delta c_{it}, \epsilon_{it}) = 0$. In an autarky environment, consumption is one-to-one mapped to idiosyncratic shocks, therefore $\phi^\epsilon = 0$. Under incomplete markets, one would expect insurance coefficients between 0 and 1.

Using U.S. micro-level consumption data, Blundell et al. (2008) estimate insurance coefficients as 0.36 and 0.95 for permanent and transitory shocks, respectively.[14] Kaplan and the Violante (2010) generate almost the same coefficients in a simulated economy using a life cycle model with incomplete asset markets and idiosyncratic income shocks where agents face natural borrowing limits.

Using equation (7), we compute the insurance coefficients for the entire population in our benchmark economy. In the case of no price search, the computed insurance coefficients are 0.51 (persistent shock) and 0.95 (transitory shock) for both consumption and expenditure.[15] Once we impose price search into the model, the corresponding insurance coefficients for consumption increase to 0.55 and 0.96, respectively.[16] The corresponding coefficients for expenditure do not change significantly. The wealth/earning ratio is held constant in the two cases in order to control for the additional insurance through savings. In the model with price search, the consumption insurance coefficients of persistent and transitory shocks are improved by 0.04 (7.8%) and 0.01 (1.1%), respectively. The coefficients are reported in

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[11]We borrowed the data set (A.C. Nielsen Homescan data) of Aguiar and Hurst (2007) for this analysis.

[12]We would like to thank the editor for initiating this section, which highlights the main mechanism of the paper in a formal way.

[13]In this exercise, we use inelastic labor supply to have comparable results with Kaplan and Violante 2010.

[14]They use the Panel Study of Income Dynamics (PSID) and Consumer Expenditure Survey (CEX) data. See Blundell et al. 2008 for details.

[15]Note that consumption is equal to expenditure by definition in this case.

[16]The insurance coefficients of our model are greater than those of Kaplan and Violante 2010 due to the fact that we use persistent shocks and they use permanent shocks while modeling earnings.

Figure 4: Household Composition: Data
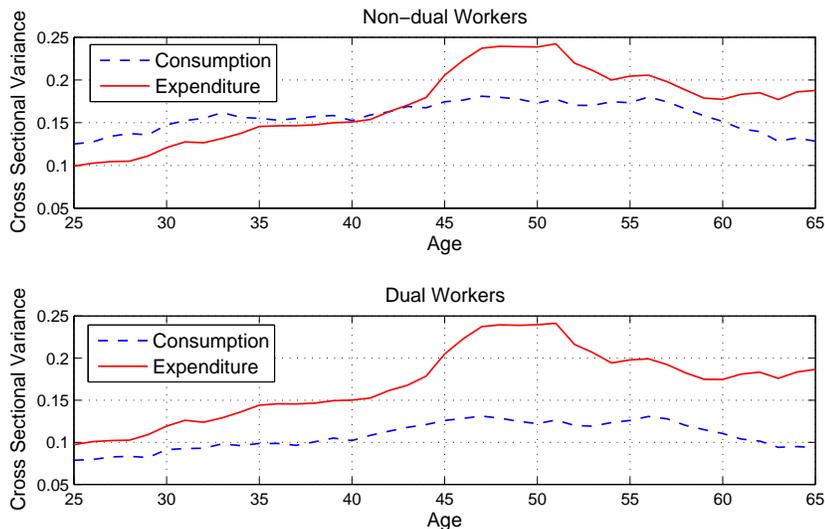
Notes: The upper and lower panels depict the age-inequality profiles of consumption and expenditure for non-dual worker households and dual worker households, respectively. The consumption variance is calculated using the effective consumption index of Aguiar and Hurst (2007). The expenditure variance is calculated using the market expenditures in the same data set.

Table 2.

4.3 The Role of Family Composition

In this section, we study the partial insurance role of price search under different family compositions.[17] One can argue that married households in which the second earner does not work would have more time to shop and search for lower prices. For these households, one would expect that the increase in consumption inequality over the life cycle would be close to the one measured for expenditures. Instead, if you focus on single households or married households where both spouses work, you would expect a bigger gap between the age-inequality profiles of consumption and expenditure.

We test the above conjecture in data and then make a comparison with model's implications. Upper panel of Figure 4 draws the empirical age-inequality profiles of consumption and expenditure for married household where second earner does not work. The lower panel draws that for the single or dual worker households. The gap between expenditure inequality and consumption inequality is smaller for household where second earner does not work.

We solve the model with looser time constraints to mimic the behavior of married house-

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[17]We would like to thank the editor for initiating this section.

Figure 5: Household Composition: Model
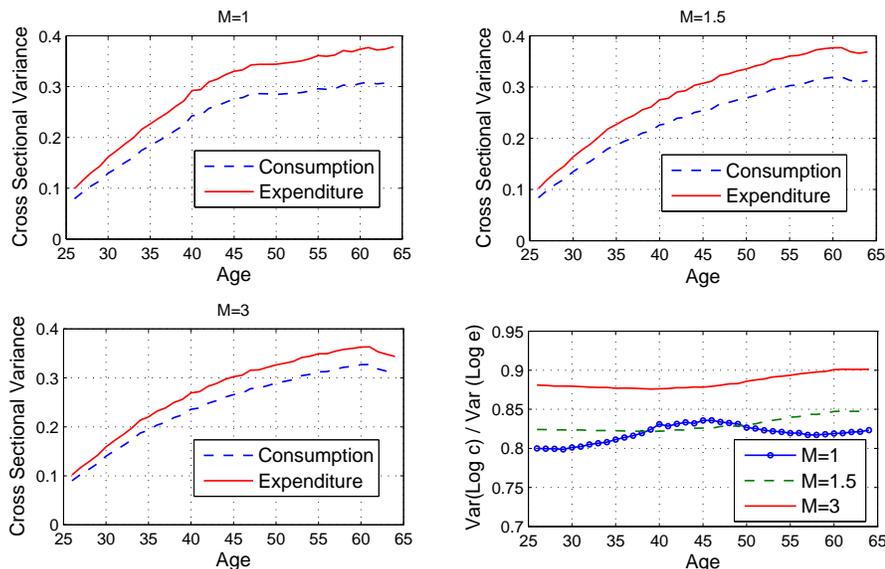
Notes: The model is solved under various time constraints to mimic search behavior of different family compositions.

holds in which the second earner does not work.[18] Figure 5 shows the age-inequality profiles of consumption and expenditure for different values of total available time (M). The gap between the expenditure inequality and consumption inequality gets smaller as we loosen the time constraint of households which is consistent with data as shown in Figure 4.

4.4   The Role of Risk Aversion

In this section, we study the effect of risk aversion on search behavior and the age-inequality profiles of consumption and expenditure. We do so by solving the model for $\sigma = 2$ and $\sigma = 3$. The average wealth to earning ratio is held constant in the two cases so that we make a plausible comparison. Figure 6 shows the ratio of the cross-sectional variance of log consumption over that of expenditure for risk aversion parameter values of 2 and 3. As a result of the increase in risk-aversion parameter, the agents prefer a smoother consumption profile. Therefore, they adjust the price search time (this can be seen in the middle panel which shows that variance of search increases when σ is increased) to keep the consumption level smooth. That makes the age-inequality profile of consumption flatter compared to the lower risk-aversion case. A flatter age-inequality profile of consumption increases the gap

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[18]Instead, one could extend the model with household compositions. The focus of this paper is partial insurance through price search, and it depends on the time constraint of households. We abstract from the problem of allocation within household. Therefore, we have chosen to modify the time constraints instead of extending the model with household compositions.

Figure 6: Effect of Risk Aversion
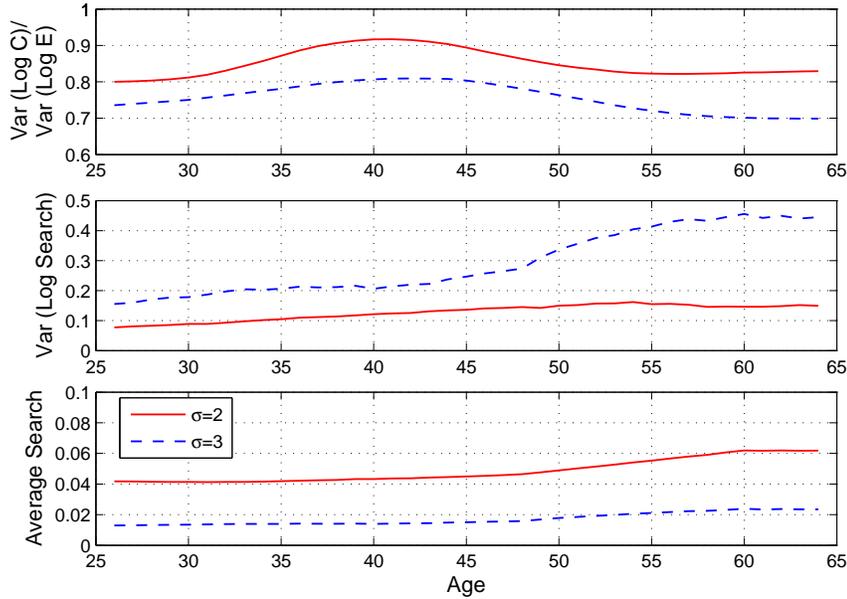
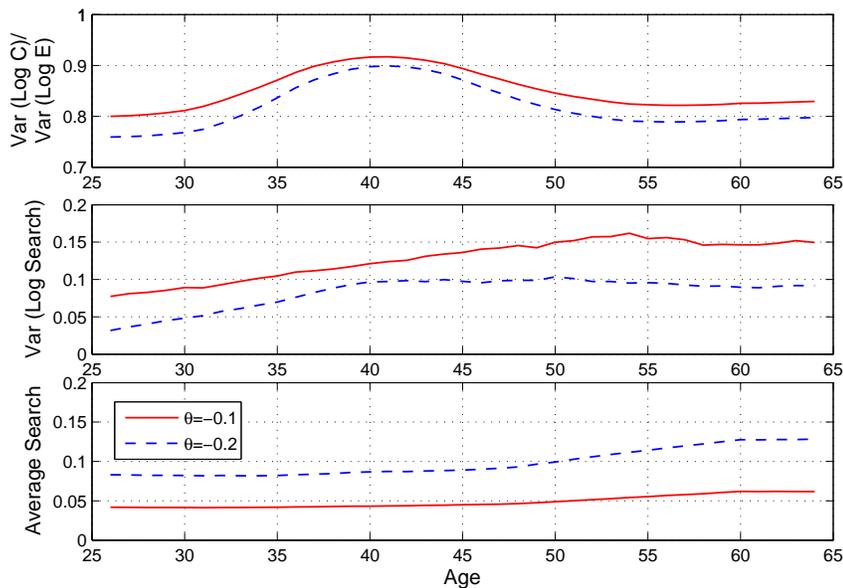between the age-inequality profiles of consumption and expenditure as illustrated in Figure 6.

The lower panel of Figure 6 shows that an increase in risk aversion decreases average price search. This happens due to the fact that marginal return of current consumption decreases in response to an increase in σ. Therefore, agents prefer to increase leisure and decrease price search as illustrated in the figure.

4.5 The Role of Search Technology

We solve the model with two values of the parameter θ to determine its role in the quantitative results. In the benchmark model, we use a value of -0.1, which is the estimated value in Aguiar and Hurst (2007) for the U.S. data. We also solve the model with a value of -0.2. This exercise shows the implications of a technological innovation in price search, such as internet.

As illustrated in Figure 7, the gap between the age-inequality profiles of consumption and expenditure increases as a result of an increase in price search technology. The higher return to price search provides more partial insurance, therefore consumption inequality decreases. For the same reason, average search increases as shown in the lower panel of the figure. The increase in search time of the wealthier is greater than that of the poorer in response to an improvement in search technology. As a consequence, the variance of search is decreased.

Figure 7: Effect of Price Search Technology

5   Discussion and Conclusion

In this paper, we study the role of price search on the age-inequality profiles of consumption
and expenditure. We introduce a price search decision into a life-cycle model, differen-
tiate consumption from expenditure, and study the joint behavior of shopping strategies,
individual prices, and consumption/saving decisions. The model predicts an increasing age-
inequality profile for search, prices, consumption, and expenditure. Our quantitative study
- using an estimated income process and price search functions from the literature - predicts
that consumption inequality is significantly different from expenditure inequality when agents
can search for prices. A plausibly calibrated version of our model predicts that the cross-
sectional variance of consumption is about 17% smaller than the cross-sectional variance of
expenditure throughout the life cycle. In the earlier studies,[19] consumption inequality was
implicitly assumed to be the same as expenditure inequality.

Although we focused on age-inequality profiles, the model can be extended to further
explain empirical observations. For instance, Aguiar and Hurst (2009) document different
patterns in different expenditure categories. Price search could be helpful in explaining the
different patterns because some categories might be more sensitive to price search. The
life-cycle search profile may have different implications for the expenditure patterns of dif-
ferent categories due to their different sensitivities. Carroll and Summers (1989) document

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[19]For example; Storesletten et al. (2004), Krueger and Perri (2006), Guvenen (2007).

different expenditure patterns for different education groups. Again, price search together with income processes could be helpful to explain the expenditure patterns. Different price search technologies or time cost profiles for different education or occupation groups could be helpful in explaining the different expenditure patterns. In this paper we used average cost of time (the coefficient of leisure in the utility function) over the life cycle. It is likely that the variance of the opportunity cost of time changes over the life cycle to varying degrees for different education and occupation groups. Potentially it will have important implications on inequality in general.

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