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QUANTIFYING BORROWING CONSTRAINTS AND
PRECAUTIONARY SAVINGS

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QUANTIFYING BORROWING CONSTRAINTS AND
PRECAUTIONARY SAVINGS

Makoto Nirei

ABSTRACT

This paper quantifies the effects of precautionary savings in a dynamic stochastic general equilibrium model. I show that Zeldes's estimate [14] of the excess consumption growth for low asset holders is consistent with an incomplete market model when a borrowing constraint point is set at three months' worth of average wage income. The hypotheses of no-borrowing specification and solvency-constraint specification are rejected by a test distribution derived from the stationary equilibrium distribution. At the estimated borrowing constraint, an increase in endowment shock within the range of empirical findings can cause 1.2% increase in saving rate and 10% increase in capital.

JEL classification codes: E21, C68

Key words: liquidity constraint, precautionary savings, excess consumption growth, uninsured income shock, asset distribution

QUANTIFYING BORROWING CONSTRAINTS AND PRECAUTIONARY SAVINGS

1 Introduction

This paper provides a numerical assessment on the importance of precautionary savings in explaining the excess consumption growth rate observed among the consumers with low assets. To do so, this paper also reports a confidence interval of the borrowing constraint point which is consistent with an empirical statistic for the excess consumption growth.

The analysis is built upon Aiyagari's [1] macroeconomic model of uninsured endowment shocks and Zeldes's [14] empirical finding on individual consumption growth. Zeldes reports that those who hold assets less than two months' worth of annual income exhibit 1.7% higher consumption growth rate than those who have higher assets. Zeldes interprets this excess growth as an effect of liquidity constraints. Other researchers such as Carroll [4], Deaton [6], and Kimball [11] have emphasized the importance of precautionary motive of savings in explaining the excess growth. However, the precautionary effect is often practically indistinguishable from the liquidity constraint effect in the data on individual consumption growth. Moreover, it has been recognized that the two effects work together in a dynamic consumption decision (Carroll and Kimball [5] and Huggett and Ospina [10]).

In this paper I utilize simulations of a dynamic stochastic general equilibrium model with uninsurable endowment shocks and a borrowing constraint to quantify the con-

tribution of the two effects to the consumption growth and identify the parameter range for which Zeldes's estimate of excess growth is consistent under the framework. To pursue the simulation I follow Aiyagari's method [1] to numerically calculate such equilibria when borrowing is restricted. The basic assumption of the model is that the economy follows a steady state rational expectation equilibrium.

I first estimate the borrowing constraint point which matches Zeldes's estimate. The methodological point is that the stationary equilibrium distribution is used to form a test distribution for a statistic which contains sampling errors due to the heterogeneous population. Each Monte Carlo run replicates Zeldes's estimate of the excess consumption growth rate for the low asset holders, and 500 runs constitute a test distribution for the estimate. I repeat the procedure for various values of the borrowing constraint point b , and obtain 90% confidence intervals for b in which the simulated excess growth supports Zeldes's estimate. The interval shows that Zeldes's estimate is supported by the borrowing constraint points from one month's to six months' worth of income. This means that neither specification $b = 0$ (no-borrowing) nor $b = wL/r$ (solvency constraint) used by Aiyagari and Zeldes falls on the confidence interval. The mean excess growth is exactly equal to Zeldes's estimate when the borrowing constraint point is around three months' worth of income.

Provided with the estimated borrowing constraint point, I examine the aggregate

consequence of endowment shocks. I simulate the model with the calibrated b for the minimum and maximum estimates of the endowment shock variance in the empirical micro literature cited in Aiyagari. The result shows that the capital level increases by 10% and the saving rate increases by 1.2% at the steady state equilibrium when the endowment risk is increased from the minimum to maximum. The increase in aggregate asset turns out to be carried out by the lower middle asset holders. These results imply a significant aggregate effect on savings caused by labor market fluctuations.

The paper is organized as follows. The model is presented in the following section, and the liquidity constraint and precautionary savings effects are defined and calculated. In Section 3, two specifications for b are tested and an estimate for b is shown to be robust to preference specifications. Section 4 quantifies the aggregate effects of a change in income risks. The last section concludes the paper.

2 The Model

2.1 An Aiyagari economy

I follow Aiyagari's [1] model of uninsured endowment shocks. Households maximize their utility over infinite series of consumption:

$$E \left[\sum_{t=0}^{\infty} \beta^t c_t^{1-\gamma} / (1-\gamma) \right] \tag{1}$$

with a period utility specified as exhibiting a constant relative risk aversion. A household is endowed with labor l whose growth rate follows an AR(1) process, namely:

$$\log l' = \phi \log l + \sigma \sqrt{1 - \phi^2} \epsilon \quad (2)$$

where ϵ follows the standard normal distribution and is independent over time. The prime indicates a next period variable henceforth. I assume that there is no aggregate risk in the economy. Thus there exists a steady state equilibrium where the interest rate is constant over periods. Let r denote the real interest rate, and w the wage. A household can lend and borrow, but its net asset cannot go below the borrowing constraint point $b \leq 0$. The commodity price is normalized to one. Thus their constraints are as follows:

$$(1 + r)a + wl \geq a' + c \quad (3)$$

$$a' \geq b \quad (4)$$

$$c \geq 0. \quad (5)$$

The second constraint is called a borrowing constraint or a liquidity constraint exchangeably. The utility maximization given the prices yields households' policy functions $c(a, l; w, r)$ and $a'(a, l; w, r)$.

The supply side of the economy is expressed by a representative firm which takes

prices as given. I assume a Cobb-Douglas production technology:

$$Y = AK^\theta L^{1-\theta} \quad (6)$$

where K , L , and Y are the aggregate capital, labor, and product, respectively. The capital is depreciated at rate δ . The stationary competitive price has to satisfy $w = (1 - \theta)Y/L$ and $r = \theta Y/K - \delta$.

Let $f(a, l)$ denote the joint density function of asset and endowment across households and let $p(l'; l)$ denote the conditional density for the labor endowment process. Market clearing conditions require $L = 1$ (labor supply is normalized to one), $K = \int \int a f(a, l) da dl$, and $Y = \int \int (c(a, l; w, r) + a'(a, l; w, r) - (1 - \delta)a) da dl$. A stationary distribution $f(a, l)$ must satisfy the functional equation: $f(a, l) = \int \int f(a', l') p(l'; l) da' dl'$. The stationary equilibrium is the price (w, r) , the aggregate allocation (K, L, Y) , the policy functions $(c(a, l), a'(a, l))$, and the distribution $f(a, l)$ that solve the household's problem and satisfy the production function, the competitive price conditions, the market clearing conditions, and the stationarity condition.

The Euler equation must hold for an optimal consumption path. Define λ_1 as a Lagrange multiplier for the liquidity constraint (4). Then the Euler equation is:

$$\lambda_1 = c^{-\gamma} - E[c'^{-\gamma} | a, l](1 + r)\beta. \quad (7)$$

Following Zeldes [14] and Dynan [7], the *liquidity constraint effect* λ and the *precau-*

tionary effect μ are defined as follows.

$$\begin{aligned}\lambda &= \log \left(1 + \lambda_1 / (\mathbb{E}[c'^{-\gamma} | a, l](1+r)\beta) \right) / \gamma \\ &= - \left(\log \mathbb{E}[(c'/c)^{-\gamma} | a, l] + \log((1+r)\beta) \right) / \gamma\end{aligned}\quad (8)$$

$$\mu = \text{Var} [\log (c'/c) | a, l] \gamma / 2 \quad (9)$$

Then, by following Deaton [6], an approximation for the Euler equation is obtained:

$$\log (c'/c) = \log((1+r)\beta)/\gamma + \lambda + \mu + e. \quad (10)$$

$\mathbb{E}[e|a, l] = 0$ holds if c' follows a log-normal distribution, as Deaton argues. This is the case in my model when the elasticity of consumption to current endowment, i.e. $\partial \log c(a, l) / \partial \log l$, is constant. This is because the random term in the conditional consumption growth ($\log(c'/c) | a, l$) is concentrated in the second variable of the consumption policy function $c' = c(a'(a, l), l^\phi + e^{\sigma\sqrt{1-\phi^2}\epsilon})$ and ϵ is assumed to be normally distributed. With this constant elasticity holding, the first three terms in the right hand side of (10) give an unbiased estimate for the consumption growth.

Finally, let us define the *unexplained growth* $\tilde{\mu}$ as the mean of the residual of the Euler equation regression: the mean consumption growth less the fundamental growth $\log((1+r)\beta)/\gamma$ and the liquidity effect λ , namely,

$$\tilde{\mu} = \mathbb{E} [\log (c'/c) | a, l] - \log((1+r)\beta)/\gamma - \lambda(a, l). \quad (11)$$

Then we obtain:

$$\log(c'/c) = \log((1+r)\beta)/\gamma + \lambda + \tilde{\mu} + \tilde{\epsilon} \quad (12)$$

where $E[\tilde{\epsilon}|a, l] = 0$ holds regardless of the consumption function form. The unexplained growth $\tilde{\mu}$ coincides with the precautionary effect μ when the elasticity of consumption to endowment is constant. I call $\lambda + \tilde{\mu}$ an *excess growth*, since it represents the surplus consumption growth of consumers to that of consumers with maximum asset.

To summarize, the Euler equations show that the excess growth $\lambda + \tilde{\mu}$ is decomposed into two factors: the liquidity constraint effect λ and the precautionary effect μ . The precautionary effect μ is an approximation of the unexplained growth $\tilde{\mu}$, that is, $\lambda + \mu$ is an unbiased estimator of the excess growth $\lambda + \tilde{\mu}$ if the consumption function $c(a, l)$ has a constant elasticity with respect to l .

2.2 Liquidity constraint and precautionary savings effects

In this section a steady state equilibrium is numerically calculated when consumers cannot have a net debt position at all, i.e. $b = 0$. I employ Aiyagari's specification for parameters as follows. The production and preference parameters are set as $\beta = 0.96$, $\gamma = 3$, $A = 1$, $\theta = 0.36$, and $\delta = 0.08$. The parameters for endowment shock follow Aiyagari's benchmark case: $\sigma = 0.4$ and $\phi = 0.6$. These values for σ and ϕ fall on the upper bound of the empirical findings cited in Aiyagari. The endowment process

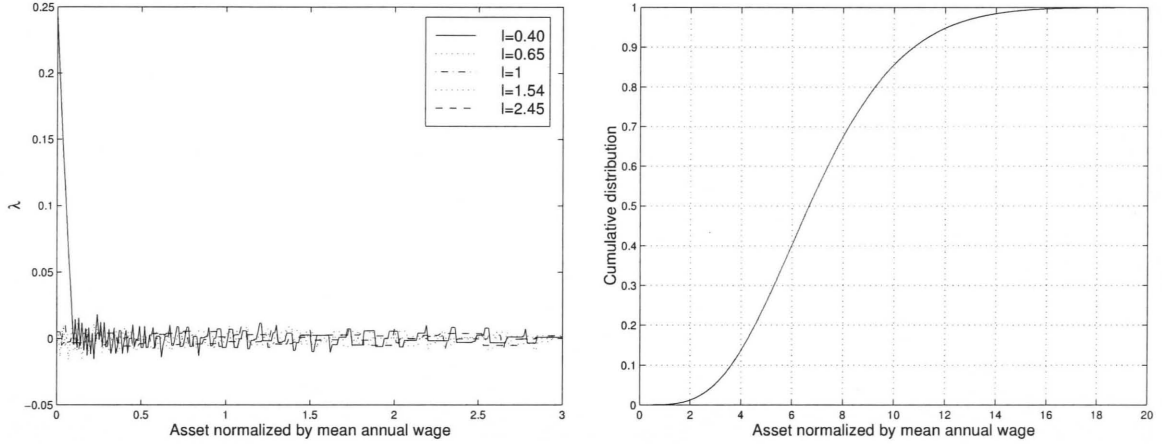


Figure 1: Liquidity constraint effect λ (left) and stationary distribution of asset (right)

is approximated by a five-state Markov transition matrix by a quadrature method of Tauchen and Hussey [13]. Then I numerically obtain the value functions, policy functions, prices w and r , and the stationary asset distribution.

Figure 1 shows the liquidity constraint effect λ as a function of asset and labor state. The asset is normalized by the mean annual wage $wE[l]$ in all the plots henceforth. The liquidity constraint is shown to be binding for the consumers with the worst labor shock and the lowest asset holding less than about two months' worth of mean annual wage income. In the present model, the binding region is largely determined by the endowment shock size σ . The binding region for $\sigma = 0.4$ corresponds well to the wealth split used by Zeldes where the constrained group is defined by asset holdings less than two months' worth of income. The right panel shows the stationary distribution of

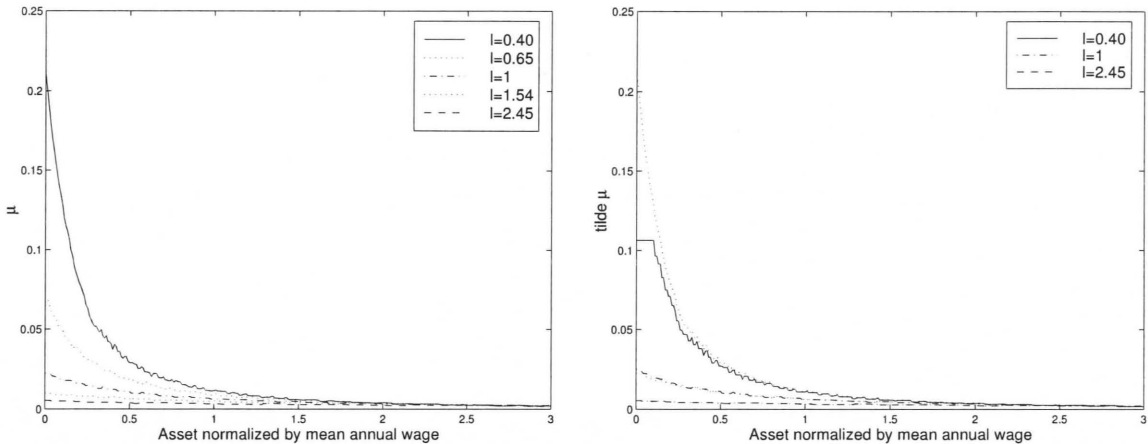


Figure 2: Precautionary effect μ (left) and unexplained growth $\tilde{\mu}$ (right)

asset. The plot captures the right-skewed distribution of asset correctly, but it is too much concentrated in the middle range compared to empirical distributions.

Figure 2 plots the precautionary effect $\mu(a, l) = \text{Var}[\log(c'/c)|a, l]\gamma/2$. In the left panel, we observe that the precautionary effect converges to the minimal level about 0.1% as the asset increases. In the right panel, the unexplained growth rate $\tilde{\mu}$ is plotted for three labor states. The plots of $\tilde{\mu}$ are compared with the precautionary effects μ which are shown in dotted lines. The precautionary effect μ tracks the unexplained growth $\tilde{\mu}$ well except for the lowest asset group with the worst labor shock. The divergence between μ and $\tilde{\mu}$ occurs exactly at the asset/labor states for which the consumers are liquidity-constrained. The unexplained growth $\tilde{\mu}$ is constant in the liquidity-constrained region because the Lagrange multiplier absorbs the effects.

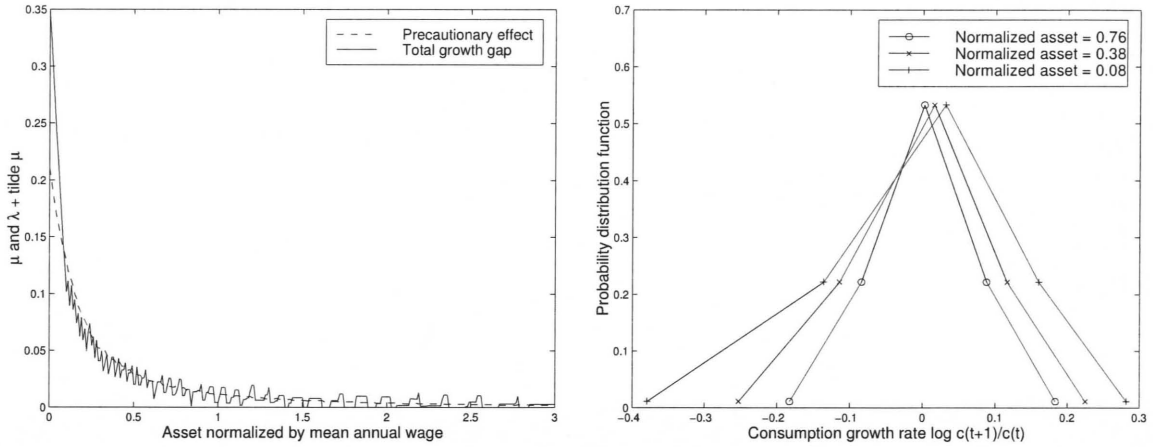


Figure 3: Precautionary effect μ and excess growth $\lambda + \tilde{\mu}$ for the lowest l (left) and probability distributions of consumption growth rates (right)

The left panel in Figure 3 compares the precautionary effect μ with the excess growth $\lambda + \tilde{\mu}$ for the lowest endowment state. The precautionary effect explains most of the excess growth for the high asset consumers. The precautionary effect is significantly smaller than the excess growth for the liquidity constrained group because of the liquidity constraint effect λ . Interestingly, μ exceeds $\lambda + \tilde{\mu}$ for the asset near the liquidity constrained group (around 0.2–0.5). This discrepancy occurs because of the skewness of the consumption growth distribution in this region. The right panel in Figure 3 shows the growth rate distribution for different asset levels. The distribution is skewed to the left not only for the liquidity constrained asset level but also for the level above it (the middle distribution in the figure).

To summarize, the growth rate contains λ only for the consumers with assets less than two months' worth and with the worst endowment shock. It contributes at most 20% growth of consumption of the constrained consumers, but the fraction of those consumers is small. The precautionary effect μ is prominent for a wider range of assets holders. It contributes at least 1% growth of consumption for the consumers with assets less than three years' worth. The maximum contribution is about 20%. Hence, in this model, the precautionary effect dominates the liquidity constraint effect for most of the asset levels.

It is well noticed that the liquidity constraint effect is dominated by the precautionary effect for infinitely-living households in a stationary equilibrium at which few consumers are bound by the borrowing constraint. It is also known that Zeldes's estimator can pick up the precautionary savings effect when the conditional variance of forecast error correlates with wealth or disposable income [14, page 319]. The task of disentangling the liquidity constraint and precautionary savings effects empirically has been pursued elsewhere. In this paper I focus on the combined effect $\lambda + \mu$ or the excess growth $\lambda + \tilde{\mu}$ to match Zeldes's estimate.

3 Quantifying Borrowing Constraint Point

3.1 Test for specifications on borrowing constraint

In this section, I test specifications for the borrowing constraint point b by Monte Carlo simulations. I replicate the procedure of Zeldes's estimation for the growth bias of the low asset consumers and give a test distribution for the estimate. A state (a, l, l') is randomly drawn from a stationary distribution for low and high asset groups, and a corresponding consumption growth rate is calculated. By mimicking Zeldes's samples, 2731 samples of the consumption growth rates are drawn from the low asset group and 1583 from the high asset group, then the estimators such as average λ and μ are computed. The splitting point for the low and high groups is set at two months' worth of mean annual wage income. I test two specifications: $b = 0$ and $b = -lw/r$. The former specification that allows no-borrowing is used by Zeldes as well as Aiyagari's [1] benchmark simulation. The latter specification is called a *natural* debt limit [1, 12] and implies a solvency constraint. Under these null hypotheses, the estimation procedure is iterated for 500 times, and the result is plotted to give a test distribution for the estimators.

The above testing procedure is methodologically an extension of the calibration procedure. In the calibration, the mean equilibrium excess growth rates are calculated

by using the stationary distribution for various b , and a value of b is determined so that the equilibrium excess growth rate matches with an empirical estimate. To derive a testing distribution, sets of households are randomly drawn from the stationary distribution, and a sample average excess growth rate is calculated for each set. This testing procedure exploits the fact that the equilibrium model predicts both the stationary distribution and the policy function. In other words, the stationary equilibrium not only provides the *population* excess growth but also the *distribution* of the excess growth. This method is particularly useful in our case where the underlying heterogeneity significantly contributes to the behavioral difference *within* the sample groups (the constrained and unconstrained groups). As seen in the previous section, the precautionary effect differs among the households in each group. Thus the distribution of the sampling error in the estimate of the excess growth rate depends on the policy function and the stationary distribution of asset and endowment.

The left panel in Figure 4 shows the mean differences in λ , μ , $\lambda + \mu$, and $\lambda + \tilde{\mu}$ between low and high asset groups. The difference in λ accounts for 0.26% higher growth rate of consumption on average. The difference in μ accounts for 2.5%. The difference in excess growth $\lambda + \tilde{\mu}$ is distributed around 2.8%. The support of the distribution of the excess growth difference is above Zeldes's estimation 1.7% which is shown by a vertical line. Thus the hypothesis $b = 0$ is rejected.

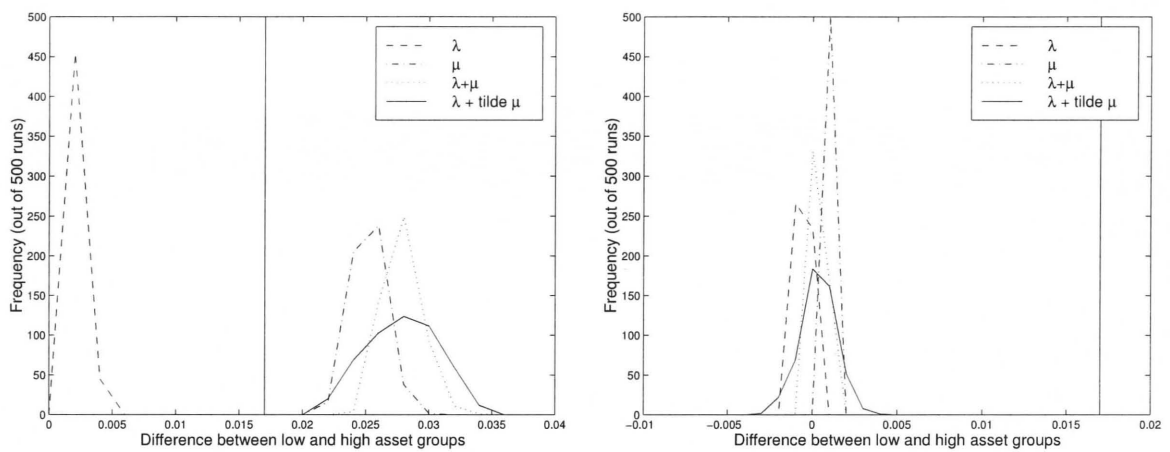


Figure 4: Distributions of estimated differences in liquidity constraint and precautionary effects between the low and high asset holders for the no-borrowing case ($b = 0$, left) and for the solvency constraint case ($b = -11.7$, right). The vertical line shows Zeldes's estimate.

The position of the histogram of $\lambda + \mu$ matches the average excess growth $\lambda + \tilde{\mu}$ reasonably well. This is a convenient property, since both λ and μ can be calculated only from the conditional consumption growth with appropriate assumptions on parameters. Let us note, however, that the distribution of $\lambda + \mu$ has a smaller variance than that of excess growth. This implies that the standard error of $\lambda + \mu$ is conservative to be used as an estimated standard error for the excess growth.

The right panel in Figure 4 shows the same plots for $b = -11.7$, which corresponds to the natural debt limit or solvency constraint $b = -w\underline{l}/r$. By this constraint, a household is required to be able to pay at least the interest of its debt at any event. Note that the solvency constraint point b is determined endogenously by the stationary equilibrium prices, and my simulations show that the prices w and r and the constraint b are consistent when $b = -11.7$. As seen in the graph, the simulated distributions of the liquidity constraint and the precautionary effects are far below 1.7%. Therefore the hypothesis $b = -w\underline{l}/r$ is rejected. Zeldes's estimate implies a severer borrowing constraint than the solvency constraint.

The Monte Carlo simulations show that neither specification $b = 0$ nor $b = -w\underline{l}/r$ is consistent with Zeldes's estimate under an Aiyagari economy. The specification $b = 0$ is too strict and $b = -w\underline{l}/r$ too slack. The next section will show that such a b exists between the two extremes that Zeldes's estimate is consistent under the Aiyagari

model.

3.2 Confidence interval of borrowing constraint point

In this section, the same Monte Carlo simulations are executed for various values of the borrowing constraint b , and the 90% confidence interval of b which supports Zeldes's estimate is reported. Again I concentrate on the combined effects of liquidity constraints and precautionary effects $\lambda + \mu$.

Figure 5 shows the means and 90% confidence intervals of the difference in excess growth between the low and high asset groups. The left panels show the cases for $\gamma = 2, 3, 4$. The right panels show the cases for $\beta = 0.94, 0.96, 0.98$. The benchmark case, $\gamma = 3$ and $\beta = 0.96$, is shown in the middle row (the two panels are identical but shown for comparison with other plots).

The real lines show the mean growth difference between low and high asset groups for various b . The plot shows that the mean difference in excess growth is increasing in b . This is because, as b increases, the low asset group becomes closer to the constraint point on average, and hence the average effects of liquidity constraints and precautionary savings become larger. It is seen that, in the benchmark parameter set, Zeldes's estimate 1.7% corresponds to about $b = -0.25$, which is a net debt worth three months' wage.

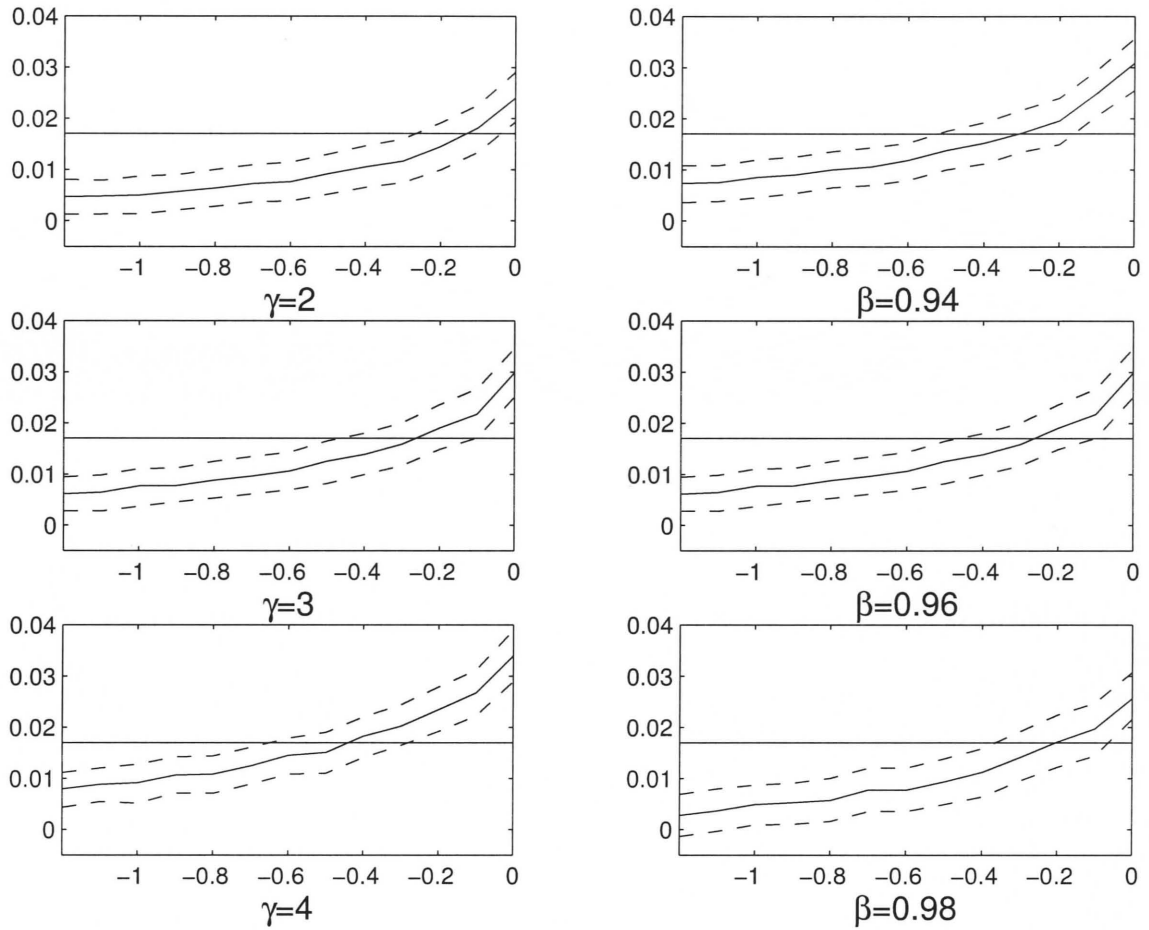


Figure 5: Mean and 90% confidence interval of growth difference as functions of liquidity constraint point b . The mean is calculated by the stationary distribution and the interval is obtained by 500 Monte Carlo runs.

The dashed lines show confidence intervals of b . The confidence interval is obtained from 500 iterations of a Monte Carlo run which simulates Zeldes's estimation procedure. The 500 estimates of the consumption growth difference are sorted in ascending order, and the 25th and 476th estimates are taken as boundaries of the confidence interval of the excess growth difference for a particular b . I define the 90% confidence interval of b as the region which contains Zeldes's point estimate of the growth difference (1.7%) between the 25th and 476th estimates. This conversion of the confidence interval from the excess growth to the borrowing constraint is secured by the monotonic increasing property of the growth difference with respect to b observed in Figure 5. The middle panels of Figure 5 show that the confidence interval b for a benchmark case is (-0.5, -0.2). It is a range of net debts worth from two to six months' wage.

The confidence interval is fairly robust to parameter specifications. The panels in the top and bottom rows in Figure 5 show the confidence intervals for various γ and β . The intervals always reside within the range (-0.7, -0.1). Hence for various parameter settings, Zeldes's estimate is consistent with an Aiyagari model with a mild liquidity constraint less than one year's worth of income. Let us note that b decreases in γ and increases in β . This result is natural, since the precautionary effect strengthens when consumers are more risk averse or less patient.

Finally, Figure 6 shows the mean excess growth for various b . The excess growth is

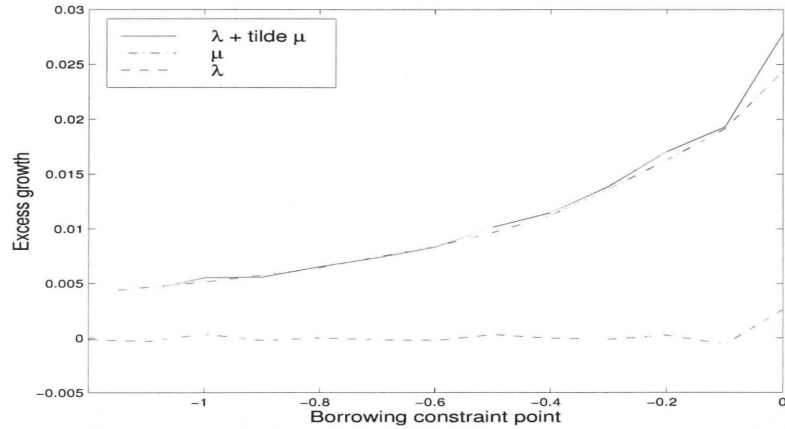


Figure 6: Decomposition of excess growth $\lambda + \tilde{\mu}$ into effects of liquidity constraint λ and precautionary savings μ

sensitive to b , and it decreases from 2.8% to 0.5% as b decreases from 0 to -1 (i.e., an annual wage worth). The plot also shows the decomposition of the excess growth into λ and μ for various b . The liquidity effect is visible only when $b = 0$. This is because the liquidity-constrained group quickly becomes a minority among the consumers with less than two months' worth asset as the borrowing constraint is relaxed. For the range $b \leq -0.1$, the precautionary effect mostly explains the excess growth, and μ matches well with the unexplained growth $\tilde{\mu}$.

4 Aggregate Effects of Income Risk

In this section I quantify the effects of income risks on aggregate savings and capital accumulation. I fix the borrowing constraint point at $b = -0.25$, for which the excess growth is consistent with Zeldes's estimation. In a benchmark case, the standard deviation of the innovation in log of endowment is set at $\sigma = 0.4$. The equilibrium interest rate r is 3.37%, and the average net saving rate is 3.09%. Naturally, the interest is greater than the Aiyagari's benchmark case 2.78% where b was set to zero. Yet it is still significantly smaller than the Aiyagari's full insurance case 4.17%. Hence the precautionary savings decrease the equilibrium interest significantly when the borrowing constraint is set to be compatible with Zeldes's estimate.

The saving rate as a function of (a, l) is plotted in the left panel in Figure 7. It is clear that the low asset holders increase their saving rates as the prospect of liquidity constraint binding in future becomes higher. Let us note that the saving rates vary more across the endowment states than across the asset levels. For the asset holders with two to six years' worth of wage, the consumption is fully financed by dissaving when the worst endowment shock hits (the saving rate is -1). The dissaving amount is forced to be reduced for the consumers with asset less than two years' worth and with the worst shock because of the current and future borrowing constraints. This corresponds to the large μ in this state range.

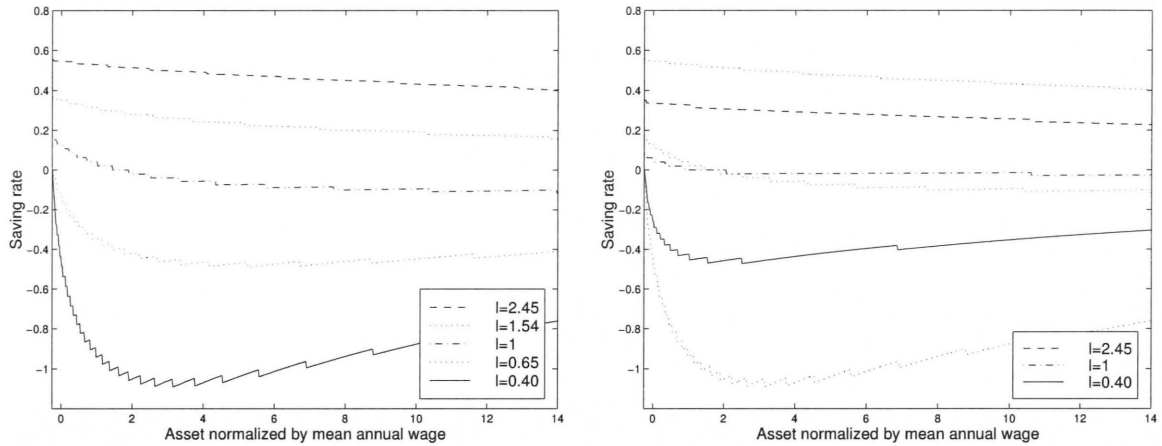


Figure 7: Saving rates when $\sigma = 0.4$ (left) and $\sigma = 0.2$ (right)

Now let us see how the aggregate savings change as the riskiness of endowment process σ varies. I take $\sigma = 0.2$ which is the lower bound among the empirical findings cited in Aiyagari, and compare the steady state to the benchmark case $\sigma = 0.4$ which is about the upper bound. The endowment state vector is altered for different σ in the quadrature approximation, but the percentile of each state in the stationary distribution is kept unchanged.

The right panel in Figure 7 shows the saving rate functions for three endowment states for $\sigma = 0.2$ (the dotted lines show their counterparts for $\sigma = 0.4$). It is clear that the dispersion of the saving rates across the endowment states is much decreased for the smaller σ . The saving pattern across asset levels is not changed very much. These imply that the smaller σ causes the smaller variance in consumption growth and thus

σ	K	w	r (%)	saving rate (%)
0.2	5.57	1.19	4.00	1.89
0.4	6.05	1.22	3.37	3.09

Table 1: Aggregate equilibria for different endowment shocks

smaller precautionary savings for a wide range of asset.

The aggregate equilibria for different σ are reported in Table 1. The result is consistent with precautionary savings models. The riskier the income process is, the larger the steady state capital accumulation and the saving rate are. The interest rate becomes lower as the endowment becomes riskier since the precautionary motives generate larger supply of savings.

Finally, Figure 8 shows the stationary distribution of asset for different endowment shocks. The asset level is normalized by the mean annual wage of the case $\sigma = 0.4$ so that two distributions compare in the same unit. The plot shows that the increased asset holding occurs across a wide range of asset levels. The consumers up to the 90th percentile shift their asset position up, and the magnitude of the shift is largest in the lower middle asset holders. The change in aggregate savings can be attributed to the change in savings of consumers in this range. This implies that the precautionary motive can be quantitatively an important factor to transmit the

5 Conclusion

In this paper I quantify the effects of precautionary savings on the consumption growth rate difference between the low and high asset holders, as well as on the aggregate savings, in the framework of a steady state dynamic general equilibrium model.

I test specifications for the borrowing constraint point b by a test distribution for Zeldes's estimate of the excess growth. The test distribution is generated by Monte Carlo simulations under various borrowing constraint points. The test rejects the no-borrowing hypothesis $b = 0$ as well as the solvency constraint hypothesis $b = -wE[l]/r$. Instead, a mild borrowing constraint at three months' worth of wage income is shown to be consistent with Zeldes's estimate. Using the same Monte Carlo simulations, I form 90% confidence intervals of b under various parameter sets. The confidence interval for the benchmark case is the asset range from two to six months' worth of wage income. The intervals fall in the range of less than one year worth net debt for all the parameter sets I examined.

Under the borrowing constraint consistent with Zeldes's estimate, the aggregate saving is shown to be considerably affected by the riskiness of the labor endowment process. When the riskiness is changed from the minimum to the maximum in the range of empirical findings, the aggregate saving rate increases by 1.2% and the aggregate capital increases by 10% at the steady state. The stationary asset distribution is

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shifted upward in the wide range of the lower middle asset holders. This suggests that a persistent change in labor market, such as that in the recent Japanese economy, might affect the aggregate consumption propensity in a quantitatively significant manner.

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