Does Market Incompleteness Matter for Asset Prices?*†

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Abstract

In this paper we argue that market incompleteness resulting from limited stock market participation is important for understanding the behavior of asset prices. We build on Guvenen (2005b) and study an otherwise standard real business cycle model incorporating limited participation and heterogeneity in the elasticity of intertemporal substitution, and examine some new implications for asset prices. Furthermore, existing asset pricing models with heterogeneity almost exclusively abstract away from labor-leisure choice which is a key element in macro models. We introduce this choice into our model and investigate its implications.

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1 Introduction

The equity premium puzzle of Mehra and Prescott (1985) is perhaps one of the best known puzzles in macroeconomics and finance. The essence of the puzzle can be easily explained as follows. Assuming that the Euler equations determining the stock and bond choices hold with equality, the excess return on stocks over

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bonds (the "equity premium"), R^e, can be decomposed as:[1]

$$\frac{E(R^e)}{std(R^e)} \approx RRA \times std(\Delta c) \times corr(\Delta c, R^e) \tag{1}$$

where RRA is the relative risk aversion parameter, and Δc denotes consumption growth. The equity premium is about 6 percent in the U.S. data with a standard deviation of 15 percent, yielding a Sharpe ratio $(E(R^e)/std(R^e))$ of 0.4. A key assumption in Mehra and Prescott (1985) is the existence of a representative-agent, allowing them to substitute the volatility of per-capita consumption growth for $std(\Delta c)$, which is less than 2 percent in the postwar U.S. data. Substituting these values into the expression above and noting that the correlation is bounded above by 1.0, implies $RRA \geq 20$! This excessively high risk aversion necessary to rationalize the observed premium is the puzzle.

A number of early studies (including Mehra and Prescott) pointed to the representative agent assumption as a likely culprit. The idea is that without aggregation, the Euler equations may hold at individual level, but not necessarily at the aggregate level, suggesting that one should use individual consumption in calculating $std(\Delta c)$ which is much more volatile than aggregate consumption. However, the subsequent literature studying models with incomplete markets have quickly discovered two major difficulties associated with this approach. First, even when individuals are assumed to face substantial idiosyncratic income risk, individual consumption in these models turns out to be extremely smooth as long as agents have access to a single risk-free asset (Heaton and Lucas (1996), Krusell and Smith (1997).) This has led researchers to increasingly question the quantitative importance of market incompleteness for these questions.

The second difficulty is that even generating a high consumption volatility is not sufficient for a high equity premium. To see this, suppose that the log consumption of individual i in period t can be written as $c_t^i = c_t^A + \varepsilon_t^i$, where c^A is log aggregate consumption, and ε is an idiosyncratic shock. Clearly, individual consumption volatility can be increased by forcing a volatile process for ε. However, as long as ε is independent of the aggregate state, we have $cov(\Delta c^i, R^e) = cov(\Delta c^A, R^e)$ since $cov(\Delta\varepsilon, R^e) = 0$. Because the covariance term has not changed, it becomes clear by inspecting the expression in (1) that the increase in $std(\Delta c^i)$ will be matched one-for-one with a *decrease* in the correlation term, leaving the required RRA unchanged! Thus unless the increase in consumption volatility has a systematic component, it has no effect on the equity premium.

[1] Also assumed in the derivation is that preferences are of the CRRA form and that consumption growth is Log-normal.

Recently, some papers have introduced models with incomplete markets that circumvent both of these difficulties, and generate a high equity premium. In this paper, we extend one such model—the limited participation model introduced in Guvenen (2005b)—and study some new implications for asset prices. The basic model generates many of the empirically observed asset pricing phenomena, such as a high equity premium, a low risk-free rate, procyclical stock prices, a countercyclical expected equity premium, stock return predictability, among others. In this paper we examine some new implications of this model for the time-series behavior of asset prices and present new empirical evidence on the main mechanism of this model from the U.S. data. Furthermore, an important assumption maintained in the basic model is that labor supply is inelastic, which is common to nearly all the models in the asset pricing literature (see two exceptions: Boldrin et al (1999) and Uhlig (2004)). Another contribution of the present paper is to introduce labor-leisure choice into the model of Guvenen (2005b), and analyze its implications.

2 The Model

The model we study in this section extends the real business cycle model with limited participation studied in Guvenen (2005b) by introducing labor-leisure choice, but is otherwise the same in other respects.

The Firm.—There is a single firm producing a consumption good using capital (K_t) and labor (L_t) inputs with a Cobb-Douglas technology, $Y_t = Z_t K_t^{\theta} L_t^{1-\theta}$. The logarithm of the technology level evolves as an AR(1) process:

$$\log(Z_{t+1}) = \rho \log(Z_t) + \varepsilon_{t+1}, \quad \varepsilon \sim N\left(0, \sigma_{\varepsilon}^2\right).$$

The firm is equity financed, and a share in the firm entitles its owner to the entire stream of future dividends given by $D_t = Z_t K_t^{\theta} L_t^{1-\theta} - W_t L_t - I_t$, where W is the wage rate and I is investment. The firm does not issue new shares and the number of shares outstanding is normalized to one for convenience, so that P_t^s is also the (ex-dividend) stock price. The firm maximizes the present discounted value of the dividend stream to its owners:

$$P_t^s = \underset{\{I_{t+j}, L_{t+j}\}}{Max} E_t \left[\sum_{j=1}^{\infty} \beta^j \frac{\Lambda_{t+j}}{\Lambda_t} \left(Z_t K_t^{\theta} L_t^{1-\theta} - W_t L_t - I_t \right) \right] \quad (2)$$

$$s.t. \quad K_{t+1} = (1-\delta) K_t + \Phi\left(\frac{I_t}{K_t}\right) K_t, \quad (3)$$

where $\beta^j (\Lambda_{t+j}/\Lambda_t)$ is stockholders' discount rate (marginal rate of substitution between t and $t+j$). The function $\Phi(\cdot)$ is assumed to be concave in investment, which captures the difficulty of quickly changing the level of capital installed in the firm. Finally, workers are paid their marginal product: $W_t = (1-\theta) Z_t (K_t/L_t)^{\theta}$.

Households.—The economy is populated by two types of agents who live forever. The population is constant, and is normalized to unity. Let $1-\mu \in (0,1)$ denote the measure of the first type of agents. Both agents derive utility from consumption and, in some specifications, also from leisure. Individuals have time-separable utility functions: $E_t \left[\sum_{j=0}^{\infty} \beta^j U^i (c_{t+j}, 1-l_{t+j})\right]$, for $i = h$, n, where the superscripts h and n denote stock*h*olders and *n*on-stockholders respectively. We consider two cases. First, we assume that agents have CRRA utility functions and do not derive utility from leisure: $U^i(c) = c^{1-\alpha^i}/\left(1-\alpha^i\right)$. In the second case, we assume that preferences are Cobb-Douglas in consumption and leisure: $\left(c^{\nu}(1-l)^{1-\nu}\right)^{1-\alpha^i}/\left(1-\alpha^i\right)$, where ν is assumed to be the same across the two groups.

In addition to the firm's shares, there is also a one-period riskless household bond traded in this economy. The difference between the two groups is that the "stockholders" can trade both assets whereas "non-stockholders" are restricted from participating in the stock (capital) market.[2]

Let Υ denote the aggregate state vector (K, B, Z), where B is the aggregate bond holdings of non-stockholders. The problem of a stockholder is:

$$
\begin{aligned}
V^h(\omega; \Upsilon) &= \max_{c,l,b',\ s'} \left\{ U^h(c, 1-l) + \beta E\left[V^h\left(\omega'; \Upsilon'\right) \mid Z\right]\right\} \\
& \quad s.t. \\
c + P^B(\Upsilon)\, b' + P^s(\Upsilon)\, s' &\leq \omega + W(K,Z)\, l \\
\omega' &= b' + s'\left(P^s\left(\Upsilon'\right) + D\left(\Upsilon'\right)\right) \\
K' &= \Gamma_K(\Upsilon), \qquad B' = \Gamma_B(\Upsilon) \\
b' &\geq \underline{B}^h,
\end{aligned}
$$

where ω denotes financial wealth; b' and s' are individual bond and stock holdings; the endogenous functions Γ_K and Γ_B denote the (equilibrium) laws of motion for the wealth distribution; and P^B is the equilibrium bond pricing function. The problem of a non-stockholder can be written as above with $s' \equiv 0$, and the superscript h replaced with n. Finally, the description of a recursive competitive equilibrium is standard and is omitted for brevity (see Guvenen (2005b)).

[2] It is possible to think of the participation structure assumed here as an endogenous outcome of a model where there is a one-time fixed cost of entering the stock market. see Guvenen (2005b) for further discussion.

Table 1: Baseline Parameterization

Quarterly Model		
Parameter		Value
β	Time discount rate	0.99
$1/\alpha^h$	EIS of stockholders	0.5, 0.25
$1/\alpha^n$	EIS of non-stockholders	0.1
μ	Participation rate	0.2
$1-\nu$	Exponent of leisure in utility function	0.64
ρ	Persistence of aggregate shock	0.95
σ_ε	Standard deviation of shock	0.02
θ	Capital share	0.3
ξ	Adjustment cost coefficient	0.23
δ	Depreciation rate	0.02
$\underline{B}^h$	Borrowing limit of stockholders	$16\overline{W}$
$\underline{B}^n$	Borrowing limit non-stockholders	$8\overline{W}$

Notes: The baseline model assumes CRRA utility functions for both agents implying that the relative risk aversion parameter is 2 or 4 for stockholders and 10 for non-stockholders. Borrowing limits are indexed to the average wage rate, $\overline{W}$.

3 Quantitative Analysis

Baseline Parameterization.—The model is calibrated following the real business cycle tradition to replicate the long-run macroeconomic facts of the U.S. economy. Table 1 summarizes our baseline parameterization. Many of the parameter choices are standard and we refer the reader to Guvenen (2005b) which contains more detailed discussion about how they were chosen. Here we only briefly discuss the choice of parameters that are more specific to the present model.

The curvature parameter α is calibrated mainly based on the implied EIS. Based on the extensive empirical evidence indicating that stockholders have higher EIS than non-stockholders (discussed in Guvenen (2005a)) we set $EIS^n = 1/\alpha^n = 0.1$, and $EIS^h = 1/\alpha^h = 0.5$. Although with CRRA utility, this parameterization also implies heterogeneity in risk aversion, the latter heterogeneity plays no essential role in our results as we show in Guvenen (2005b). Following Cooley and Prescott (1995) we set the share of leisure in the utility function, $1-\nu$, to 0.64. The borrowing constraints are set to $\underline{B}^h = 16 \times E(W)$, and $\underline{B}^n = 8 \times E(W)$, and they rarely bind in our simulations. The participation rate in the stock market, μ, is set to 20 percent. Finally, the functional form for

Table 2: The First Two Moments of Asset Returns

	US Data	RBC model	Limited Participation Model		
			Inelastic Labor		Elastic Labor
			$\alpha^h = 2$	$\alpha^h = 4$	$\alpha^h = 4$
$E(R^s - R^f)$	6.17	.004	3.43	6.11	2.21
$\sigma(R^s - R^f)$	19.4	0.27	17.2	22.4	14.5
$\frac{E(R^s-R^f)}{\sigma(R^s-R^f)}$	**0.32**	**0.014**	**0.20**	**0.27**	**0.15**
$E(R^f)$	1.91	4.16	1.98	0.61	2.86
$\sigma(R^f)$	5.44	0.18	5.62	7.31	5.48
$E(P^s/D)$	22.1	–	25.7	29.4	25.8
$\sigma(\log(P^s/D))$	26.3	–	20.1	30.5	12.4

Notes: The mean and standard deviation of variables are reported in annualized percentages. The data covers 1890−1991, and is explained in more detail in Guvenen (2005b).

Φ is specified as $a_1 \left(I_t/K_t\right)^{1-1/\xi} + a_2$, where a_1 and a_2 are constants chosen such that the steady state level of capital is invariant to ξ. The curvature parameter ξ determines the severity of adjustment costs and is set equal to $\xi = 0.23$.

3.1 Results: Inelastic Labor Supply Case

We begin by discussing the results of the model with *inelastic* labor supply ($\nu = 1$). Table 2 displays the results. The equity premium is 6.2 percent in the century-long U.S. data with a standard deviation of 19.4 percent yielding a Sharpe ratio of 0.32. In the baseline model the equity premium is 3.4 percent when the risk aversion is 2, and 6.1 percent when the risk aversion is 4. The standard deviation of excess returns is 17.2 percent in the baseline case, which is reasonably close to its empirical counterpart (19.4 percent), but increasing the risk aversion to 4 raises the standard deviation to 22.4 percent, making it somewhat too volatile. The Sharpe ratio is 0.20 in the baseline model and rises to 0.27 when the risk aversion is 4. The price of risk can be increased further by choosing a larger α^h, and the resulting excessive volatility can be reduced by relaxing the adjustment costs (higher ξ) as shown in Guvenen (2005b).

The average risk-free rate is 2.0 percent when $\alpha^h = 2$, and 0.6 percent when $\alpha^h = 4$ compared to 1.9 percent in the data. However, a well-documented feature of the interest rate—which turns out to be more challenging to explain—is its low volatility. The standard deviation is 5.4 percent for the real ex-post interest rate and 2.7 percent in the post-war period. The corresponding figure is 5.6 percent in

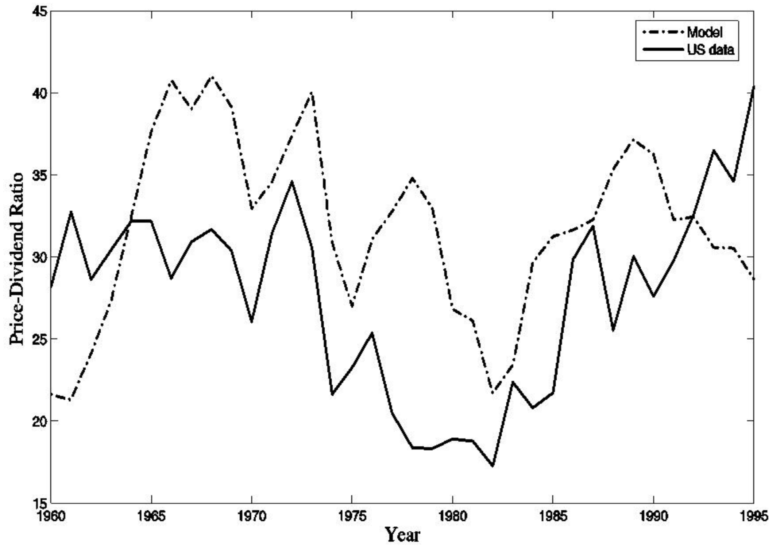

Figure 1: The Time-series Behavior of the Price-Dividend Ratio in the U.S. data and in the Baseline Model, 1960-1995.

our model when $\alpha^h = 2$, and 7.3 percent when $\alpha^h = 4$. Although these numbers are still somewhat higher than in the data, this statistic has proved difficult to generate for many models, so these results represent a step in the right direction. Finally, the mean and the standard deviation of the price-dividend ratio in the baseline model are broadly consistent with the data.

Time-series Behavior.—Although it is common in the asset pricing literature to compare the statistical properties of models to their empirical counterparts, a less common but interesting exercise is to compare the *historical* path of stock prices to the one implied by the model. Figure 1 presents such an exercise: the dashed line plots the (annual) price-dividend ratio in the U.S. data from 1960 to 1995, and the solid line shows the counterpart obtained by our baseline model. The simulated path is generated by setting the model's P/D ratio in 1965 to its long-run average in the US data (22.1), and then calculate the P/D ratio in subsequent years by feeding into the model the historical path of the Solow residuals from the U.S data.[3] Especially over the period 1965 to 1990, the model

[3]The time period was dictated by the availability of data: the price-dividend ratio series (described in Guvenen (2005b)) is available until 1995, and the Solow residuals—obtained from Christian Zimmerman's website at University of Connecticut—is available from 1960 onward.

provides a rather striking account of the stock price movements in the U.S. data, tracking closely the directions and the rough magnitudes of their movements.

3.2 How Does Limited Participation Generate a High Equity Premium?

There are *two distinct* mechanisms that can generate a high equity premium in limited participation models. The earlier models (Saito (1995) and Basak and Cuoco (1998)) have emphasized the role of limited participation as a channel to *leverage* stockholders' portfolio. The argument is as follows. First, non-stockholders are assumed to have a strong demand for savings, which is ensured in these models by assuming that their only income is derived from financial wealth that they are endowed with at time zero. Therefore, unless they invest this wealth they will have zero consumption in future dates. But since the only avenue for savings is the bond market, this is only possible if stockholders are willing to borrow. As a result, in equilibrium the interest rate adjusts such that stockholders borrow the entire wealth owned by non-stockholders and make interest payments every period, which sustains the consumption of the latter group. Consequently, stockholders' consumption becomes more volatile than their underlying endowment stream due to this leverage, which leads them to demand a high equity premium.

Despite its simple appeal this mechanism has one main drawback: to generate a large equity premium, the borrowing by stockholders (which in turn is equal to the wealth owned by non-stockholders) must be a substantial fraction of the aggregate wealth stock. This contrasts sharply with the wealth distribution in the U.S. where almost all of the capital stock is owned by stockholders with only about 10 percent held by non-stockholders.

In contrast, Guvenen (2005b) emphasizes a different channel. In particular, the *major effect* in his model also works through the bond market, but is a combination of three factors, which reinforce each other. *First,* non-stockholders' main source of income is from wages. As a result of this risky income stream they have a strong *precautionary* motive for wealth accumulation. *Second,* non-stockholders have a lower EIS than stockholders. Therefore, non-stockholders have a much stronger desire for smooth consumption compared to stockholders. The combination of these two effects imply that non-stockholders need the bond market much more than stockholders. However, and *third*, the bond market is not a very effective device for consumption smoothing in the face of *aggregate* risk, because it merely reallocates the risk rather than reducing it, as would be the case if shocks were idiosyncratic. In equilibrium, non-stockholders' desire for smooth consumption is satisfied via trade in the bond market, at the expense of higher volatility in stockholders' consumption. Moreover, since these large fluctuations in stockholders' consumption are procyclical, they are reluctant to own the shares of the aggregate firm that performs well in booms and poorly in recessions. As a result, they demand a high equity premium.

The main difference of this second mechanism from the earlier ones is that the average wealth of non-stockholders need not be large. For example, in the baseline model with $\alpha^h = 2$, non-stockholders hold only 13 percent of aggregate wealth (and 9 percent when $\alpha^h = 4$). As shown in Guvenen (2005a) these figures are consistent with the wealth distribution between these groups observed in the U.S. data. Instead what matters for the equity premium in this paper is the *timing* of trade in the bond market: the fact that stockholders are *lending* during recessions and *borrowing* during expansions makes their consumption growth co-vary more with the aggregate state (See Guvenen (2005b) for a detailed discussion of this point). In fact, if the bond market was shut down, the variance of stockholders' (non-stockholders') consumption growth would be only 22 percent (330 percent) of what it is in the baseline model.

Finally it should be noted that the amount of funds flowing between the two groups is rather modest compared to the scale of the economy: for example, the average absolute value of trade, $E(|a_h|)$, is only 1.1 percent of annual output in this economy. Taking the U.S. gross domestic product in 2005 (slightly less than \$12 trillion) as a benchmark, this would imply a net flow of \$130 billion a year between stockholders and non-stockholders. Notice that this number is a tiny fraction of the wealth stock in the U.S. economy, which exceeds the gross domestic product by roughly a factor of 2.5.[4]

3.2.1 Empirical Evidence on the Mechanism

In a recent paper, Malloy, Moskowitz and Vissing-Jorgensen (2005) provide empirical evidence supporting this prediction of the model. In particular they regress the consumption growth of each group on aggregate labor income growth, which is reported in the first row of Table 3.[5] The slope coefficient, b, in this regression measures how responsive each group's consumption is to aggregate labor income shocks. A one-percent innovation to aggregate labor income results in a 1.26 percent increase in the consumption growth of asset holders, and a 1.94 percent increase in the consumption growth of the top-third asset holders. In

[4]Nevertheless, these modest flows are large enough (about 5 percent of stockholders' annual consumption) to increase their consumption volatility significantly.

[5]More precisely, the measure they use is "long-run consumption growth," which is a discounted sum of quarterly consumption growth rates over 12 periods. Moreover, these tables report the results for "assetholders," which include all stockholders plus those who hold savings bonds. The authors note that the results with only stockholders included are very similar.

Table 3: THE RESPONSE OF STOCKHOLDERS' AND NON-STOCKHOLDERS' CONSUMPTION GROWTH TO AGGREGATE LABOR INCOME SHOCKS

	Assetholders	Top third assetholders	Non-assetholders
	$\sum_{s=0}^{11} \beta^s \left(c^i_{t+s+1} - c^i_{t+s}\right) = a + b \sum_{s=0}^{11} \beta^s \left(y_{t+s+1} - y_{t+s}\right) + e_t$		
$\widehat{b}$ (US data)	1.26	1.94	0.49
	(9.46)	(6.77)	(2.74)
$\widehat{b}$ (Model)	1.67	1.67	0.65
	(0.00)	(0.00)	(0.00)

Notes: y denotes log aggregate labor income, and c^i denotes the log consumption of groups defined according to their asset holdings. The regression results for the U.S. data are taken from Malloy et al. (2005) Table 6, panel A, and "assetholders" are defined as stockholders who also hold savings bonds. The model counterpart is obtained by running the same regression on the simulated data from the baseline model in Guvenen (2005b) with a relative risk aversion of 4.

contrast, the response of the non-assetholders' consumption is much weaker, at 0.49 percent. The same equation can be estimated using simulated data from our baseline model (with $\alpha^h = 4$), which is reported in the next row. The results are quite similar, with stockholders' consumption responding roughly three times more strongly than that of non-stockholders.

3.3 Results: Elastic Labor Supply Case

In a recent paper Uhlig (2004) introduces labor-leisure choice into the limited participation model studied in Guvenen (2005b).[6] In particular, he only considers the special case where leisure and consumption are separable, and preferences with respect to leisure are perfectly elastic. He finds that this extension reduces the Sharpe ratio significantly, from 0.17 to 0.04. It is easy to see why this happens: non-stockholders now have the option of working longer hours during recessions in order to smooth consumption fluctuations rather than having to rely entirely on the bond market. More importantly, because preferences are

[6]As Uhlig acknowledges, his baseline version without endogeneous labor is not identical to Guvenen's (2005b) model either. Moreover, unlike Guvenen, he also relies on log-linear approximations to solve the model whose accuracy remains to be explored. As a result, there are discrepancies between the numerical results even between the versions of the models that are identically calibrated.

linear in leisure, the resulting countercyclical variation in hours does not affect utility (as long as *average* leisure does not change) making this a rather efficient way to smooth consumption.[7] Consequently, stockholders' consumption volatility does not rise as much, resulting in a low Sharpe ratio. A similar difficulty with preserving successful asset pricing implications with elastic labor supply was previously illustrated by Boldrin et al. (1999, Table 2) in a representative agent framework. These authors found that introducing a labor-leisure choice (with, again, perfectly elastic leisure) into a model with habit formation in preferences caused a *30-fold reduction* in the equity premium from 4.47 percent to 0.15 percent, and in the Sharpe ratio from 0.27 to 0.03.

The exercise we conduct in this section differs from Uhlig's analysis in two ways. First, we consider a Cobb-Douglas utility function in consumption and leisure (instead of perfectly elastic labor supply). Second, we do not rely on log-linear approximations which may not provide sufficient accuracy in this highly non-linear model. Instead we solve the model using numerical methods with high accuracy as described in Guvenen (2005b).[8] Column 6 in Table 2 reports the results: the equity premium falls from 6.1 percent to 2.2 percent. However, because the volatility of the premium is also lower, the Sharpe ratio falls by less, from 0.27 to 0.15. Thus, while the Sharpe ratio falls by about 45 percent, it is significantly higher than the comparable models with leisure mentioned above.

It is worth noting though that the lower risk premium does not result from the mechanism suspected above: non-stockholders' labor supply is in fact procyclical (correlation with output: 0.96), so they work *more* during expansions and *less* during recessions, because of the substitution effect of a pro-cyclical wage process. On the other hand, stockholders' labor supply is counter-cyclical (correlation: -0.91) mainly because of the substantial procyclical wealth effect from their stock holdings. This in turn dampens the fluctuations in their marginal utility, reducing the risk premium.

An encouraging finding is that *total* labor hours are mildly procyclical (correlation with output 0.15), in contrast to the strongly countercyclical movements found in both Uhlig's (2004) and Boldrin et al.'s (1999) models. This is due to the existence of non-stockholders who supply a large fraction of aggregate labor hours and whose labor hours are procyclical as explained above. Another finding is that the dynamics of asset prices (the predictability of stock returns, the autocorrelation patterns of returns, etc.) remain mostly unaffected by labor-leisure

[7]Notice however that adjusting the labor supply is not totally costless: since the agent works more hours during recessions—when wages are low—the average labor hours necessary to earn a certain amount of income is higher than it has to be when hours are procyclical.

[8]The Fortran 90 code that solves this model is available at http://www.econ.rochester.edu/guvenen/Research.htm

choice, and are similar to those reported in Guvenen (2005b). These additional results are reported in an appendix available for download at the same address given in the previous footnote.

There is clearly much more that can be examined in this framework with labor-leisure choice. Experimenting with more flexible functional forms for the utility function (that allow a better calibration of labor supply elasticities), and investigating the role of frictions as in Boldrin et al. (1999) to generate a larger equity premium in this case are left for future work.

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