Habit Persistence, Asset Returns, and the Business Cycle

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Two modifications are introduced into the standard real-business-cycle model: habit preferences and a two-sector technology with limited intersectoral factor mobility. The model is consistent with the observed mean risk-free rate, equity premium, and Sharpe ratio on equity. In addition, its business-cycle implications represent a substantial improvement over the standard model. It accounts for persistence in output, comovement of employment across different sectors over the business cycle, the evidence of "excess sensitivity" of consumption growth to output growth, and the "inverted leading-indicator property of interest rates," that interest rates are negatively correlated with future output. (*JEL* D10, E10, E20, G12)

General-equilibrium models with complete markets and optimizing agents have enjoyed a measure of success in accounting for business-cycle fluctuations in quantities. However, these models have been notoriously unsuccessful in accounting for the joint behavior of asset prices and consumption.[1] Two failures in particular have attracted much attention: the *equity premium puzzle*, the fact that returns on the stock market exceed the return on Treasury bills by an average of six percentage points; and the *risk-free rate puzzle*, the fact that the return on Treasury bills is low on average. For the most part, the response of business-cycle researchers has been to ignore the asset-pricing implications of their models.

This is unfortunate. As emphasized by John H. Cochrane and Hansen (1992), business-cycle models assume that households equate intertemporal marginal rates of substitution in utility with intertemporal marginal rates of transformation. Under the complete-markets hypothesis, asset returns offer direct observations on these margins, and so should provide an excellent guide to the further development of business-cycle models.

This is the perspective adopted here. Recent research in the finance literature suggests that habit persistence in preferences can reconcile the consumption and asset-return facts.[2] This literature typically takes the aggregate consumption process as given. In equilibrium business-cycle models, both asset returns and allocations are endogenous. So, introducing habit persistence into these models has implications not just for asset returns, but also for consumption, output, investment, and employment. We ask whether one can construct a business-cycle model with habit persistence, which is consistent both with key asset-return facts and with key business-cycle facts. Our results suggest that the answer to this question is "yes."

Constructing a satisfactory model is not as straightforward as it might at first seem. In

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[1] Early discussions of this include Robert E. Hall (1978), Lars Peter Hansen and Kenneth J. Singleton (1982, 1983), and Rajnish Mehra and Edward C. Prescott (1985).

[2] We have in mind the early work on habit persistence of Suresh M. Sundaresan (1989) and George M. Constantinides (1990). In addition, there is Wayne E. Ferson and Constantinides (1991), Craig Burnside (1994), John Heaton (1995), Kent Daniel and David Marshall (1998), and John Y. Campbell and Cochrane (1999).

particular, if one simply introduces habit preferences into the standard real-business-cycle (RBC) model, there is *no* impact on the equity premium (see Boldrin et al., 1995; Martin Lettau and Harald Uhlig, 2000.) One way to understand this focuses on the volatility of the rate of return on equity. An important component in this is the volatility of capital gains. In the standard RBC model, this component is a constant because the supply of capital is perfectly elastic at a constant price. By enhancing the desire to smooth consumption, the introduction of habit preferences amplifies the fluctuations in the demand for capital over the business cycle. But, with capital supply perfectly elastic, this has no effect on capital gains and, hence, a negligible effect on the volatility of the return on equity. Other things the same, failure to increase the volatility of the return on equity translates into a failure to increase the equity premium. Not surprisingly, the main effect of introducing habit persistence into the standard RBC model is simply to produce a smoother consumption process.

The preceding considerations motivate the way we construct our model. In addition to habit preferences, we incorporate factor-market inflexibilities which have the effect of reducing the elasticity of capital supply.[3] We introduce these inflexibilities by replacing the standard one-sector production technology with a two-sector specification in which adjusting factors of production takes time. These features of our model are consistent with empirical evidence that factors are difficult to quickly adjust in response to shocks. The low elasticity of capital supply is consistent with the empirical evidence presented in Austan Goolsbee (1998).

We show that our model is consistent with key features of asset returns. With respect to the conventional measures of business-cycle volatility and comovement with output, it does roughly as well as the standard RBC model. Significantly, on four other dimensions our model substantially outperforms the standard model. First, the frictions in our model enhance its internal propagation of shocks, improving its ability to account for the observed persistence in output growth. Absence of internal propagation is a well-known weakness of standard RBC models (see Christiano, 1988; Timothy Cogley and James M. Nason, 1995). Second, the model accounts for the observation that employment across different sectors moves up and down together over the cycle. This is a fundamental property of business cycles that has proved surprisingly difficult to model in the standard framework.[4] Third, our model accounts for the *excess sensitivity puzzle*: instrumental variable regressions indicate that consumption growth is strongly related to income, while being relatively weakly related to interest rates (Hall, 1988; Campbell and N. Gregory Mankiw, 1989, 1991). While this is a puzzle for the standard RBC model, it is not for ours. Fourth, the model accounts for the *inverted leading-indicator property of interest rates*: high interest rates are negatively correlated with future output. This observation is often thought to reflect the operation of monetary-policy shocks. The fact that our model, which only has a technology shock, can account for it too, suggests that the role of monetary-policy shocks in the dynamics of the data may be smaller than previously thought.

The plan of the paper is as follows. Section I describes our model and how we assigned values to its parameters. Section II examines the asset-pricing and business-cycle implications of our model. Section III discusses the related literature. That literature offers other reasons, in addition to those stressed here, for taking our key model assumptions seriously. In addition, the literature offers a variety of alternative specifications that we could in principle have used to interfere with households' ability to smooth consumption and generate inelastic capital supply. In our discussion, we defend our modeling decisions against these alternatives. Section IV concludes.

I. A Two-Sector Model of the Business Cycle

This section presents our model and discusses how we selected parameter values.

[3] For discussions of the asset-pricing implications of flexibility in hours worked, see Boldrin et al. (1995) and Lettau and Uhlig (1997, 2000). These authors and Urban J. Jermann (1998) also discuss the implications of a flexible capital-accumulation technology.

[4] For a discussion of the empirical evidence on comovement and a survey of the relevant literature, see Christiano and Terry J. Fitzgerald (1998).

A. *Preferences*

The preferences of the representative agent are:

$$(1)\quad E_0 \sum_{t=0}^{\infty} \beta^t [\log(C_t - bC_{t-1}) - H_t],$$

$$0 < \beta < 1,\ b \geq 0,$$

where, $0 < C_t$ denotes time t consumption, $0 \leq H_t$ denotes time t labor, and E_0 is the conditional expectation operator.[5] When $b > 0$, household preferences are characterized by habit persistence.[6] When $b = 0$, these preferences correspond to those in a standard RBC model.[7]

The particular specification of preferences that we adopt links the household's habit to its own past consumption ("internal habit"), rather than aggregate, economywide consumption. The latter corresponds to the "catching-up-with-the-Joneses" specification studied by Andrew Abel (1990). We adopt the internal habit specification because, as emphasized in Constantinides (1990), this specification is capable of accounting for a high equity premium while not contradicting evidence which suggests that households have moderate levels of risk aversion.[8] As explained in Boldrin et al. (1997), the favorable risk-aversion implications of internal habit are not shared by the "catching-up-with-the-Joneses" specification. Throughout our analysis, we restrict the parameterization of utility so that the coefficient of relative risk aversion for wealth gambles averages roughly unity.

Interestingly, in addition to the asset-pricing studies discussed in the introduction, habit preferences are now being used to understand a wide range of issues in growth, monetary, and international economics. Several papers are worth noting. Christopher D. Carroll et al. (1997, 1999) use habit preferences to improve the implications of several endogenous growth models for savings and growth. Jeffrey C. Fuhrer (2000) shows that habit preferences are helpful for generating hump-shaped consumption responses to monetary shocks. Finally, Martín Uribe (2000) argues that habit preferences can account for the behavior of consumption in periods surrounding exchange-rate stabilization programs. Each of these applications, like ours, exploits the fact that habit persistence induces a desire for smooth consumption.

B. *Technology*

We adopt a two-sector specification of technology. One sector produces consumption goods and the other produces investment goods:

$$(2)\quad K_{c,t}^{\alpha}(Z_t H_{c,t})^{1-\alpha} \geq C_t,$$

$$(3)\quad K_{i,t}^{\alpha}(Z_t H_{i,t})^{1-\alpha} + (1-\delta)(K_{c,t} + K_{i,t}) \geq K_{c,t+1} + K_{i,t+1}.$$

Here, $K_{c,t}$ and $K_{i,t}$ denote the beginning of period stocks of capital in the consumption and investment sectors, respectively. Similarly, $H_{c,t}$ and $H_{i,t}$ refer to hours worked in the consumption and investment-good sectors, with $H_t = H_{c,t} + H_{i,t}$. Also $0 < \alpha < 1$ and $0 \leq \delta \leq 1$. Finally, Z_t denotes the aggregate state of technology, which is assumed to evolve as follows:

$$(4)\quad Z_t = \exp(x_t) Z_{t-1},\ x_t \sim N(\bar{x}, \sigma^2),$$

$$\forall\, t \geq 0,\ Z_{-1} \text{ given}.$$

We assume that H_t, $H_{c,t}$, and $H_{i,t}$ are determined prior to the realization of x_t. This is our way of capturing the notion that it is difficult to quickly adjust aggregate employment and its

[5] See Boldrin et al. (1999) for a discussion of the robustness of our results to alternative ways of treating leisure in the utility function. The specification we work with was originally proposed and explained in Gary D. Hansen (1985).

[6] The term, bC_{t-1}, is sometimes referred to as the household's *habit stock*. We have explored more general specifications in which the habit stock is also a function of consumption in earlier periods, and have found that this has little impact on asset prices. Christiano and Fisher (1998) explain why a model's business-cycle implications are improved by adopting the simpler formulation in (1).

[7] Habit utility functions have the distinctive feature that the present discounted value of the utility of a consumption sequence is not necessarily monotone in the consumption of any particular period. This reflects the fact that, although the period utility function is increasing in current consumption, next period's utility is decreasing in current consumption. In the simulations computed for this paper, consumption is always well inside the region of positive total marginal utility.

[8] For recent empirical evidence on risk aversion see Robert B. Barsky et al. (1997).

sectoral allocation in response to a shock. We also assume that capital, once installed in a sector, cannot be shifted to another sector. That is, we assume that $K_{c,t+1}$ and $K_{i,t+1}$ are determined as a function of date t state variables, and cannot be adjusted in response to the realization of x_{t+1}.

The notion that labor and capital cannot be instantaneously reallocated between sectors after a shock has been well documented. The search literature documents the various factors that inhibit the intersectoral movement of labor (see, for example, Christopher Phelan and Alberto Trejos [2000] and the papers they cite). A recent paper by Valerie A. Ramey and Matthew D. Shapiro (2000) documents the high costs associated with reallocating capital across sectors.

Multisector models of production have a longer tradition in macroeconomic theory than habit preferences. Still, until recently, they have not been used extensively in macroeconomics.[9] The pathbreaking contribution by John B. Long and Charles I. Plosser (1983) is an important exception. Key differences between their model and ours are that specific goods are not identified according to their function (i.e., capital or consumption), there is no capital accumulation as all goods are perishable after one period, factors are instantaneously mobile across sectors, and preferences are of the standard, time-separable form. Closer in spirit are the recent contributions by Ramey and Shapiro (1998) and Phelan and Trejos (2000). Ramey and Shapiro study a two-sector model with costly sectoral capital reallocation and show that it can match certain facts about the effects of government spending that cannot be matched with a standard one-sector model. Phelan and Trejos study a labor-matching model with two sectors of production to quantify the effects of search-and-matching costs in slowing down intersectoral labor mobility after a sector-specific shock. They provide evidence, supporting our operational assumptions, that even very small search-and-matching costs may substantially slow down intersectoral labor movements after a sectoral shift in demand.

[9] For earlier, mostly theoretical, efforts, see Boldrin (1989) and the literature mentioned therein. See also Andreas Hornstein and Jack Praschnik (1997) and Michael Horvath (2000).

C. *Equilibrium*

We find the equilibrium allocations by solving the following planning problem: maximize (1) subject to (2), (3), (4), $K_{c,t}, K_{i,t}, H_{c,t}, H_{i,t} \geq 0$, the timing assumptions mentioned after equation (4), and $C_{-1}, K_{c,0}, K_{i,0}, H_{c,0}, H_{i,0} > 0$ given. We approximate the solution to the planning problem using nonlinear methods described in Kenneth L. Judd (1998) and Christiano and Fisher (2000). It is well understood how to decentralize the allocations that solve the planner's problem by means of competitive markets, and so we do not discuss the details here.[10]

Prices and rates of return are derived from the solution to the planning problem as follows.[11] In this model, the rates of return on equity may differ between the two sectors. The rate of return on equity in the consumption sector is given by

$$(5)\quad r^c_{c,t+1} = \frac{\alpha\left[\frac{Z_{t+1}H_{c,t+1}}{K_{c,t+1}}\right]^{1-\alpha} + P_{k,t+1}}{P_{k',t}} - 1,$$

while the rate of return on equity in the investment-good sector is given by

$$(6)\quad r^i_{i,t+1} = \frac{P_{k,t+1}\alpha\left[\frac{Z_{t+1}H_{i,t+1}}{K_{i,t+1}}\right]^{1-\alpha} - P_{k,t+1}}{P_{k',t}} - 1.$$

Here, $P_{k',t} = \Lambda_{c,t}/\Lambda_{c,t}$ and $P_{k,t} = (1-\delta)P_{k',t}$.

[10] For a decentralization with one-period-lived firms, see Boldrin et al. (1995). For a decentralization based on infinite-lived firms, see Jermann (1998).

[11] To compute the rate of return on equity from the solution to the planning problem requires making an assumption about the debt-to-equity ratio. Throughout our analysis we assume that capital is 100-percent equity financed. In Boldrin et al. (1999) we consider the impact on our analysis of the assumption that debt is also used. There we show that nothing essential in our results hinges on the assumed debt-to-equity ratio.

where $\Lambda_{c,t}$ and $\Lambda_{i,t}$ denote the Lagrange multipliers on (2) and (3) in the planner's problem. Here, $P_{k',t}$ denotes the consumption-good value of a newly installed unit of capital, to be used in production at the beginning of period $t+1$. Also, $P_{k,t+1}$ is the value of that same unit of capital at the end of period $t+1$. We refer to $P_{k',t}$ as the date t price of equity and to the expression, $P_{k,t+1}/P_{k',t}$ as the capital gain during that period.

We define the aggregate rate of return on equity, r^e_{t+1}, in the following way:

$$(7)\quad r^e_{t+1} = \frac{K_{c,t+1}}{K_{t+1}} r^e_{c,t+1} + \frac{K_{i,t+1}}{K_{t+1}} r^e_{i,t+1},$$

where $K_{t+1} = K_{c,t+1} + K_{i,t+1}$. Also, the risk-free rate of return, r^f_t, is computed using

$$(8)\quad r^f_t = \frac{\Lambda_{c,t}}{\beta E_t \Lambda_{c,t+1}} - 1.$$

The time subscript convention used in r^f_t and r^e_{t+1} identifies the date on which the relevant payoff becomes known. In both cases, the date at which the payoff is realized is period $t+1$. The mean equity premium is $E(r^e_{t+1} - r^f_t)$ and the Sharpe ratio, S, is defined as follows:[12]

$$(9)\quad S = \frac{E(r^e_{t+1} - r^f_t)}{\sigma_{r^e}}.$$

We measure aggregate output, Y_t, in base-year prices, because that is how the output data used in the empirical analysis are measured. We take the base year in the model to be the steady state, when the relative price of the investment and consumption good is unity:

$$Y_t = C_t + K_{t+1} - (1-\delta)K_t.$$

In closing this subsection, we note that the assumptions which differentiate our model from the standard RBC model are habit persistence and factor-market inflexibilities. When these assumptions are dropped, i.e., $b = 0$ and H_t, $H_{c,t}$, $H_{i,t}$, $K_{c,t}$, and $K_{i,t}$ are allowed to respond to the period t realization of technology, then our model reduces to the standard RBC model. In this case, the rate of return on equity simplifies to

$$(10)\quad r^e_{t+1} = \frac{\alpha\left(\frac{Z_{t+1}H_{t+1}}{K_{t+1}}\right)^{1-\alpha} + P_{k,t+1}}{P_{k',t}} - 1.$$

In this version of the model, the technology for transforming consumption goods into new capital implies that the supply of capital is perfectly elastic at $P_{k',t} = 1$.[13]

D. *Parameterization*

The time unit of the model is three months. We use the following parameter values: $\beta = 0.99999$, $\alpha = 0.36$, $\delta = 0.021$, $\bar{x} = 0.0040$, and $\sigma = 0.018$. The indicated value for the discount factor was chosen to maximize the model's ability to account for the risk-free rate. For the empirical rationale underlying the other parameter values, we refer to Christiano and Martin Eichenbaum (1992).

We now discuss how we assigned a value to the remaining model parameter, b. We did so by optimizing the model's ability to account for the mean equity premium and the mean risk-free rate. The resulting value of b is 0.73. The metric we used in our optimization procedure is $\mathcal{L}(b)$, where

$$(11)\quad \mathcal{L}(b) = [\hat{\nu}_T - f(b)]\hat{V}_T^{-1}[\hat{\nu}_T - f(b)]'.$$

Here, $\hat{\nu}_T$ is the 2×1 vector composed of the sample average of the annual observations on the risk-free rate and the equity premium reported in Stephen G. Cecchetti et al. (1993) (CLM). The 2×2 matrix $\hat{V}_T$ is CLM's estimate of the underlying sampling variance. Finally, $f(b)$ is a 2×1 vector of the model's implied average annual risk-free rate and equity premium, conditional on b and the other parameter values.[14] In the optimization procedure we

[12] Our definition of the Sharpe ratio associated with any particular asset is standard in the literature (see, e.g., Campbell et al., 1997 p. 188).

[13] In this version of our model, the technology has a one-sector formulation $Y_t = K_t^{\alpha}(Z_t H_t)^{1-\alpha}$, $C_t + I_t \le Y_t$, and $K_{t+1} = (1-\delta)K_t + I_t$, where I_t denotes time t gross investment.

[14] The annual return for a given year is computed as the sum of the rate of return over each quarter in that year. The

TABLE 1—FINANCIAL STATISTICS[a]

Statistic[b]	Data[c]	Two-sector		One-sector	
		$b = 0.73$	$b = 0$	$b = 0.9$	$b = 0$
Er_t^f	1.19 (0.81)	1.20	1.58	1.58	1.58
$E(r_{t+1}^e - r_t^f)$	6.63 (1.78)	6.63	0.02	0.001	0.001
σ_{r^f}	5.27 (0.74)	24.6	0.62	0.38	0.46
σ_{r^e}	19.4 (1.56)	18.4	0.57	0.40	0.48
$\frac{E(r_{t+1}^e - r_t^f)}{\sigma_{r^e}}$	0.34 (0.09)	0.36	0.03	0.002	0.002
σ_{P_t}	8.56 (0.85)	12.1	0.29	0	0
$\rho(Y, P_{k'})$	0.30 (0.08)	0.16	0.16	na[d]	na

[a] Results for the models are based on 500 replications of sample size 200.

[b] σ_x denotes the standard deviation of variable x, and $\rho(x, y)$ denotes the correlation between variable x and variable y. Rates of returns are annualized and in percent terms before statistics are computed.

[c] This column contains estimates (standard errors in parentheses) based on U.S. data. The sample period for the asset-return estimates is 1892–1987 and these estimates are taken from Cecchetti et al. (1993). Our empirical analogue for $P_{k'}$ is the S&P 500 composite (DRI database mnemonic FSPCOM). The output measure and the procedure for estimating σ_{P_t} and $\rho(Y, P_{k'})$ is described in Table 3, note c.

[d] This abbreviates "not applicable."

allowed for $b \in [0, 0.9]$ subject to the requirement that $C_t \leq bC_{t-1}$ and $\Lambda_{c,t} \leq 0$ are never observed in the Monte Carlo simulations used to evaluate f. Let

$$J = \mathcal{L}(\hat{b}_T), \tag{12}$$

where $\hat{b}_T$ minimizes $\mathcal{L}(b)$. Under the null hypothesis that the model is true, and ignoring sampling uncertainty in the other parameters, J has a Chi-square distribution with 1 degree of freedom. Since J is in practice either very small or very large, we do not report its value or its p-value in the analysis below.

II. Implications of the Model

We show that our model is consistent with key features of asset returns. In addition, it dominates the standard RBC model with respect to the business cycle.

A. *Asset Prices*

The asset-pricing implications of our model are reported in Table 1 under the heading "Two-sector, $b = 0.73$." Significantly, the model almost exactly replicates the mean risk-free rate and equity premium (which it was optimized to match) and the Sharpe ratio (which it was not optimized to match). Interestingly, the model does reasonably well on the correlation of equity prices with output and on the volatility of equity prices. Unfortunately, the latter success in part reflects the model's counterfactually high prediction for the volatility of the risk-free rate. That models like ours do poorly on risk-free rate volatility is well known and in particular is consistent with the findings in Heaton (1995). However, it is not clear how fundamental this problem truly is for the approach to asset pricing adopted in this paper. There are results in the literature which suggest that it is not. For example, Campbell and Cochrane (1999) adopt a more elaborate representation of habit prefer-

mapping, f, was executed by computing the average of the mean risk-free rate and mean equity premium across 500 artificial data sets, each of length 200 quarters.

ences, which has the implication that the risk-free rate is constant. Similarly, the risk-free rate in Constantinides (1990) is also constant. Finally, Abel (1999) presents a model with habit persistence in preferences which also implies a realistic amount of volatility in the risk-free rate.[15]

We now discuss how our habit-persistence and factor-inflexibility assumptions contribute to these results. Without these features (in which case, the model reduces to a standard RBC model) the equity premium and Sharpe ratio are essentially zero (see the column marked "One-sector, $b = 0$"). Even when habit persistence is introduced into that version of our model ("One-sector, $b = 0.9$"), there is still no equity premium or Sharpe ratio. Why is it that with factor-market inflexibilities, a rise in b raises the equity premium and Sharpe ratio, but without these inflexibilities, a rise in b has no effect?

To gain insight into this question, it is useful to rewrite the Sharpe ratio as follows:

$$E(r^e_{t+1} - r^f_t) = S\sigma_{r^e}. \tag{13}$$

This expression indicates that changes in the equity premium can be understood in terms of S and σ_{r^e}. Intuition appears to be an unreliable guide regarding the impact of b on S.[16] But, it is possible to gain intuition about the impact of b on σ_{r^e}. Table 1 indicates that σ_{r^e} does not rise with b unless there are factor-market inflexibilities. The reason is that in the absence of these inflexibilities, there is no variation in the capital-gains component of r^e_{t+1}. This in turn reflects that, as noted above, the supply of capital is perfectly elastic in this version of the model. As a result, variation in the return to equity is driven entirely by variation in the marginal product of capital, which is known to be quite small in standard models (e.g., Christiano, 1987). In practice, no amount of variation in the demand for capital, induced, say, by a high b, can raise σ_{r^e} because it has no impact on capital gains. This same reasoning suggests that with inelasticity in capital supply induced, say, by our factor-market inflexibilities, variation in demand has a very substantial impact on σ_{r^e}. This is why it is that when these inflexibilities are present, an increase in b raises σ_{r^e}.

We investigated whether our model's good asset-market implications depend on the presence of all our factor-market inflexibilities. In Boldrin et al. (1999) (BCF) we report evidence that all are needed. For example, we considered the case in which $H_{t,t}$ and $H_{c,t}$ are a function of the current-period shock, but H_t, $K_{t,t}$, and $K_{c,t}$ are not (below, we refer to this as the *mobile labor model*.) In this case, increasing b to its upper bound has virtually no impact on the equity premium or the Sharpe ratio.

B. *Standard Business-Cycle Statistics*

We now consider the implications of the model for the set of standard business-cycle statistics reported in Table 2. The results in Panel A show that, in terms of conventional measures of volatility and comovement with output, our model performs about as well as the standard RBC model (see "One-sector, $b = 0$"). The exception is that our model overstates slightly the empirical magnitude of the relative volatility of consumption. We found that intersectoral rigidities are important here. For example, in the mobile labor model the relative volatility of consumption is 0.32.

Panel B displays the persistence properties of our model. It represents essentially no change over the standard RBC model when persistence in consumption alone is considered. Each implies that consumption is a near-random walk, whereas consumption growth is positively autocorrelated in the data. Our model represents a substantial improvement over the standard model with respect to the autocorrelation in output growth. This is practically zero in the standard model, 0.34 in the data, and 0.36 in our model.

[15] One difference between Abel's (1999) specification of habit preferences and ours is that he adopts a higher level of risk aversion. In our context, this is also a strategy for reducing the volatility of the risk-free rate. This strategy works by reducing the value of b needed to account for the mean risk-free rate and equity premium. We found that a smaller value of b also reduces the volatility of the risk-free rate. A difficulty with this strategy is that increasing the curvature in the utility of consumption tends to make employment countercyclical (see the discussion in Section III, subsection B). This implication of high risk aversion is not evident in Abel's (1999) work because he holds labor constant.

[16] See Boldrin et al. (1999) for a detailed elaboration.

TABLE 2—STANDARD BUSINESS-CYCLE STATISTICS[a]

Statistic[b]	Data[c]	Two-sector		One-sector	
		$b = 0.73$	$b = 0$	$b = 0.9$	$b = 0$
		Panel A—Volatility and Comovement with Output			
σ_Y	1.89 (0.21)	1.97	1.96	1.79	2.11
σ_C/σ_Y	0.40 (0.04)	0.69	0.62	0.30	0.53
σ_I/σ_Y	2.39 (0.06)	1.67	1.83	2.58	1.86
σ_H/σ_Y	0.80 (0.05)	0.51	0.50	0.27	0.48
$\rho(Y, C)$	0.76 (0.05)	0.95	0.92	0.48	0.99
$\rho(Y, I)$	0.96 (0.01)	0.97	0.97	0.98	0.99
$\rho(Y, H)$	0.78 (0.05)	0.86	0.86	0.99	0.99
		Panel B—Persistence			
$\rho(\Delta Y_t)$	0.34 (0.07)	0.36	0.36	0.02	0.002
$\rho(\Delta C_t)$	0.24 (0.09)	−0.05	−0.22	0.90	0.05

[a] Results for the models are based on 500 replications of sample size 200.

[b] σ_x denotes the standard deviation of variable x. $\rho(x, y)$ denotes the correlation between x and variable y, where x and y are logged and HP filtered prior to analysis, and $\rho(\Delta x)$ denotes the autocorrelation of $\log x_t - \log x_{t-1}$. The statistic σ_Y is reported in percent terms.

[c] This column contains estimates (standard errors in parentheses) based on an updated version of the Christiano (1988) database compiled by Fisher (1997) covering the sample period 1964.1–1988.2. The standard errors are based on the GMM procedure described in Christiano and Eichenbaum (1992). For estimation of the relevant zero-frequency spectral density, a Bartlett window truncated at lag four was used.

To understand the persistence properties of the model, it is helpful to study Figure 1. This displays the response of Y, C, I, and H to a positive, one-standard-deviation shock to technology, x_t, in period 0 (see "Two-sector model"; the responses of two other models are displayed there too, but these are discussed later). The strong, positive autocorrelation in output is in part due to the delay in the response of hours worked (see Figure 1B). This has the effect of making the period 1 response of output substantially larger than the period 0 response (see Figure 1A).

C. *Other Business-Cycle Phenomena*

Here, we expand the set of business-cycle statistics and find that our model emerges as clearly superior to the standard one. The new set of business-cycle statistics that we consider includes measures of: (i) the tendency for employment in different economic sectors to move up and down together over the business cycle; (ii) the tendency for the predictable part of consumption growth to be relatively strongly associated with the predictable part of income growth and weakly associated with the real interest rate; and (iii) the tendency for high real interest rates to be associated with low future output and high past output.

1. *Comovement of Employment.*—A key feature of business cycles, emphasized at least since the time of Arthur Burns and W. C. Mitchell (1946 p. 3), is that employment in a broad set of sectors moves up and down together during recessions and expansions. Our model is consistent with this phenomenon: the correlation between output and $H_{t,t}$ is 0.70 and between output and $H_{t,t}$ is 0.86 (see Table 3, Panel A),

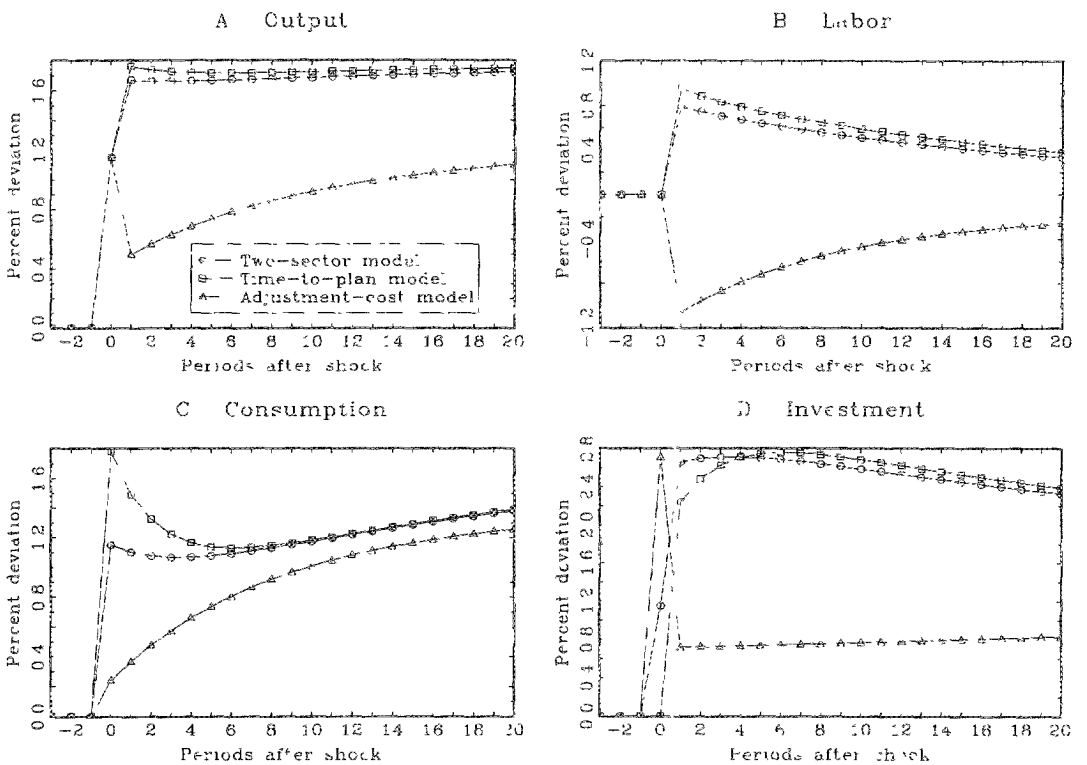

FIGURE 1. IMPULSE-RESPONSE FUNCTIONS IMPLIED BY VARIOUS MODELS

and hours worked in each sector responds positively to an unexpected increase in technology.

To understand these findings, consider Figure 2. This exhibits the dynamic responses of sectoral employment to a technology shock in our model (see "Two-sector model") and in the version of our model that we have called the mobile labor model ("Mobile labor model"). Recall that in this version of our model, labor is intersectorally mobile, but the total amount of labor, H_t, is still chosen before observing the date t realization of technology. Note that in the mobile labor model $H_{c,t}$ drops and $H_{i,t}$ rises after a positive shock to technology. The reason is that with the positive technology shock, there is a sharp rise in the demand for investment goods, which causes labor to leave the consumption sector for the investment sector. In our model, labor cannot be reallocated between sectors in the same quarter during which the shock takes place. As a consequence, there is a relatively strong rise in consumption output in the period of a shock. The presence of habit persistence in consumption then implies that the value of consumption goods is high in subsequent periods. This explains why labor does not leave the consumption sector in the periods after a positive technology shock in our model. Table 3, Panel A, confirms that both habit persistence and intersectoral-factor immobilities are important for comovement of employment.

2. *Excess Sensitivity of Consumption to Income* —We now turn to the statistical evidence which Campbell and Mankiw (1989, 1991) (CM) argue is a puzzle from the perspective of equilibrium business-cycle models. They estimate a linear expression relating the predictable component of consumption growth to the predictable component of income growth and to the interest rate. Applying instrumental variables techniques, they find that the estimated coefficient on income, λ, is about $\frac{1}{2}$, while the coefficient on the interest rate, θ, is close to zero.

TABLE 3—OTHER BUSINESS-CYCLE STATISTICS[a]

Statistic[b]	Data[c]	Two-sector		One-sector	
		$b = 0.73$	$b = 0$	$b = 0.9$	$b = 0$
Panel A—Employment Comovement					
$\rho(Y, H_C)$	0.72 (0.08)	0.70	na[d]	−0.93	na
$\rho(Y, H_K)$	0.86 (0.04)	0.86	0.86	0.96	0.99
Panel B—Excess Sensitivity of Consumption to Income $\Delta C_t = \mu + \lambda \Delta Y_t + \theta r^f_{t-1} + \varepsilon_t$					
λ	0.47 (0.15)	1.01	0.93	0.18	0.52
θ	0.089 (0.11)	0.05	1.25	2.58	0.92
Panel C—Inverted Leading-Indicator Phenomenon					
$\rho(r^f_{t-2}, Y_t)$	−0.35 (0.11)	−0.30	−0.20	0.54	0.51
$\rho(r^f_t, Y_t)$	0.00 (0.10)	−0.15	0.01	0.98	0.99
$\rho(r^f_{t+2}, Y_t)$	0.16 (0.10)	0.33	0.41	0.35	0.38

[a] Results for the models are based on 500 replications of sample size 200.

[b] σ_x denotes the standard deviation of variable x, and $\rho(x, y)$ denotes the correlation between x and variable y, where x and y are logged and HP filtered prior to analysis.

[c] The "Data" column for Panels A and C contains estimates (standard errors in parentheses) based on the sample period 1964:1–1988:2. See note [c], Table 2, for a description of the output data and the estimation procedure used. The sectoral hours and interest-rate data are from DRI Basic Economics Database. For the consumption sector we used two alternative measures: an index of hours worked in the service sector (DRI series LWHPX) and an index of hours worked in the nondurable manufacturing sector (LWHNX). The estimate for the consumption-sector hours-worked correlation is based on LWHPX. The analogous point estimate (standard error) based on LWHNX is 0.83 (0.05). The estimate for the investment-sector hours-worked correlation is based on hours worked in the durable manufacturing sector (LWHDX). The real interest rate at date t for the statistics in Panel C is measured as the nominal federal funds rate (FYFF) at date t less the realized inflation rate between dates t and $t + 1$. The price for calculating the inflation rate is the deflator on nondurable and services consumption, (GCN + GCS)/(GCNQF + GCSQF), where the mnemonics are taken from the DRI database. Estimates for λ and θ in Panel B are taken from Campbell and Mankiw (1989). The model and data instrumental variables estimates for λ and θ in Panel B are based on the instrument list $\{\Delta c_{t-2}, \Delta c_{t-3}, \Delta c_{t-4}, r^f_{t-3}, r^f_{t-4}, r^f_{t-5}\}$, where $\Delta x_t = \ln x_t - \ln x_{t-1}$.

[d] This abbreviates "not applicable." The correlation is not defined in these cases since hours worked producing consumption goods is constant. See Christiano and Fisher (1998) for further discussion.

Appealing to standard optimizing models, CM argue that household maximization implies the coefficient on income should be zero and the coefficient on the interest rate should be large. In these models, the level of consumption is determined by household wealth and its growth rate is determined solely by the rate of interest. The coefficient on the interest rate is the reciprocal of the coefficient of relative risk aversion. This coefficient should be substantially above zero on the assumption that risk aversion is small.

CM interpret the evidence as indicating that the representative agent optimizing framework should be abandoned as a way of thinking about fluctuations. Our results suggest another interpretation. We show that the modifications introduced into the standard RBC model to help it account for asset prices also have the effect of raising the implied estimated value of λ and reducing the implied estimated value of θ. Thus, an alternative interpretation of CM's findings is that they provide corroborating evidence in favor of these modifications.[17]

Our two-sector model's ability to generate a

[17] Marianne Baxter and Jermann (1999) document that a model with home production can also account for the excess sensitivity puzzle.

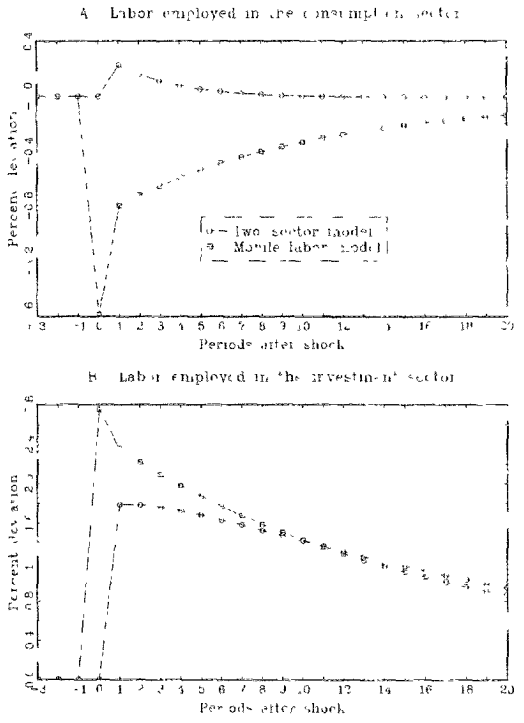

FIGURE 2. COMOVEMENT OF EMPLOYMENT ACROSS SECTORS

high value for λ reflects that, under habit persistence, the intertemporal Euler equation relates consumption growth to lagged consumption growth, as well as to expectations of future consumption growth. In this case, the apparent excess sensitivity to income reflects income's statistical role as a proxy for these variables. The model's ability to generate a low value of θ is perhaps not surprising in view of the fact that, at our estimated value for b, intertemporal substitution in consumption is low. Because agents in our model also have low risk aversion, our framework provides a formal basis for Hall's (1988) suggestion that the weak empirical relation between consumption growth and the interest rate should be interpreted as reflecting low intertemporal substitution in consumption and not necessarily high risk aversion.

The statistical relation that is a primary focus of CM's analysis is:

$$(14) \quad \Delta C_t = \mu + \lambda \Delta Y_t + \theta r^f_{t-1} + \varepsilon_t,$$

where, $\Delta u_t \equiv \log(u_t) - \log(u_{t-1})$. CM estimate μ, λ, and θ by the following two-step instrumental variables procedure: in the first step they replace the left- and right-hand side variables in (14) by their fitted values, after regression on a set of instruments; in the second step they run an ordinary least-squares regression on this modified version of (14) to estimate μ, λ, and θ. The first column of Table 3, Panel B, displays a typical set of results reported by CM for these parameter values (see Campbell and Mankiw, 1989 Table 5, row 3).

Table 3, Panel B, also summarizes our models' implications for the CM regression. We report the mean, in samples of typical size, of instrumental variables regressions in which the instrument list is $\{\Delta C_{t-2}, \Delta C_{t-3}, \Delta C_{t-4}, r^f_{t-3}, r^f_{t-4}, r^f_{t-5}\}$. This instrument list was chosen because it is representative of the type used in the literature. In principle our results could reflect small sample distortions which can occur in instrumental variables estimators when the instruments are not very informative for the right-hand variables. BCF investigate the potential for poor instrument quality to affect inference in small sample regressions. We point out below where this bias affects the qualitative assessment of the results presented in Table 3, Panel B.

Consider first the results for θ. Consistent with CM's observations, the standard RBC model (see "One-sector, $b = 0$") implies this parameter is roughly unity (the reciprocal of risk aversion in that model). This is more than two standard deviations away from the corresponding empirical estimate, and warrants rejecting the standard RBC model. However, the implied value for θ in our two-sector model (see "Two-sector, $b = 0.73$") is close to the corresponding empirical value. This reflects that in this model, the coefficient of relative risk aversion (which is unity) and the degree of intertemporal substitution are not connected as they are in the standard RBC model. Note that both habit persistence and the two-sector technology are important to achieve a low value of θ (see "Two-sector model, $b = 0$" and "One-sector model, $b = 0.9$").

Now consider the results for λ. Note that the standard RBC model's implication for the small sample mean of this variable is consistent with the corresponding empirical value. However, Christiano (1989) shows that this reflects the

model's counterfactual implications for instrument quality. Minor perturbations which improve these implications simultaneously drive the small sample results for λ towards zero. The analysis of small sample bias in BCF is consistent with this finding. On this basis, we agree with CM that the empirical results for λ also warrant rejecting the standard RBC model. Turning to our two-sector model, the results indicate that, empirically, consumption is *not* excessively sensitive to income. Ironically, according to this model the real puzzle is not that measured consumption is excessively sensitive to current income. It is instead that consumption is insufficiently sensitive. BCF show that this finding is not due to a small sample bias.

3. *Inverted Leading-Indicator Phenomenon.*—Real (and nominal) interest rates appear to covary positively with past (detrended) levels of output and negatively with future levels (see Riccardo Fiorito and Tryphon Kollintzas, 1994). This can be seen in Table 3, Panel C, which displays the dynamic correlations between the inflation-adjusted federal funds rate and detrended output. V. V. Chari et al. (1995) and Robert King and Mark Watson (1996) have emphasized that these are important observations for models to be consistent with. They represent a key factor underlying the belief of some researchers that monetary-policy shocks play an important role in the dynamics of the business cycle. One reason for this belief is that the monetary-policy shock interpretation seems straightforward. Another reason, which appears to receive support in the results of King and Watson (1996), reflects the view that RBC models are incapable of accounting for the negative association between interest rates and future output. Our results based on the standard RBC model are consistent with this view. However, our two-sector model is not. It is consistent with the inverted leading-indicator phenomenon. This suggests that the dynamic economic behavior attributed to monetary disturbances may, at least in part, also reflect the effects of real disturbances propagated via mechanisms like those captured by our two-sector model.

Consider first the standard RBC model. Note from Table 3, Panel C, how the correlation between the interest rate and output is positive at all leads and lags. Mechanically, the positive correlation between the interest rate and current and future output reflects that a positive shock to technology drives up the rate of interest and also drives up current and future output. The reason for the rise in the interest rate is that the shock gives rise to a gradual upward response in consumption. The implications of this with the time-separable utility function are straightforward: the current increase in consumption drives the current marginal utility of consumption down, but the larger future rise drives future marginal utility down even more. The interest rate rises in response to the positive technology shock because it is the ratio of these two marginal utilities. A related way of seeing this is as follows. With the time-separable, log-utility function, households prefer a constant level of consumption over time. The positive technology shock drives up future consumption more than present consumption, and for this to be an equilibrium, households must be discouraged from using asset markets to reallocate consumption from the future to the present. It is precisely the rise in the rate of interest which has this effect.

Significantly, the two-sector model is consistent with the inverted leading-indicator phenomenon. This is because the rate of interest falls in the period of a positive technology shock in that model. To see why, notice that consumption is relatively high in the period of the shock, compared to its value in subsequent periods (see Figure 1). The reasoning above suggests that this should lead to a fall in the rate of interest, assuming habit persistence does not play too great a role. Consistent with this assumption, when b is set to zero in the two-sector model, this model remains consistent with the inverted leading-indicator phenomenon (see "Two-sector, $b = 0$"). We conclude that our model's ability to account for the inverted leading-indicator phenomenon reflects the factor-market inflexibilities and not habit persistence.

III. Comparison to Alternative One-Sector Models

The literature offers one-sector alternatives to the two-sector modeling approach that we have

adopted in this paper. This section discusses two of these alternatives and concludes that they can do as well as our two-sector model in accounting for asset-market facts. Nevertheless, our approach is to be preferred because the alternatives do less well on the business-cycle facts.

The alternatives to our two-sector technology we consider can in principle also generate inelastic capital supply and interfere with consumption smoothing. Each alternative works with a version of our model in which the sectoral allocation of factors of production is permitted to respond in the current period to a technology shock. With this change, our two-sector technology reduces to the standard one-sector specification. We continue to maintain the assumption that aggregate hours worked must be decided prior to the realization of the technology shock, and we continue to work with the utility function, (1), and with our Cobb-Douglas production function. In each case, we estimate the value of the habit parameter, b, using the method used for our two-sector model. To save space, the details of our findings are not reported here, but can be found in BCF.

A. *Time-to-Plan*

The *time-to-plan model* is obtained by requiring that investment be decided before the realization of the current-period shock. Under this assumption, the quantity of new capital is perfectly inelastic in the immediate aftermath of a shock. This assumption has been studied by Christiano and Richard M. Todd (1996) and Mark Gertler and Simon Gilchrist (1999).

The timing of investment in this model necessitates the following change in the formulas for $P_{k',t}$ and $P_{k,t+1}$: $P_{k',t} = \Lambda_{k',t}/\Lambda_{c,t}$, $P_{k,t+1} = (1-\delta)\Lambda_{k',t}/\Lambda_{c,t}$, where $\Lambda_{k',t}$ is the Lagrange multiplier on the capital-accumulation technology in the planner's problem. In the standard RBC model, $\Lambda_{k',t} = \Lambda_{c,t}$ always. This equality does not hold under the time-to-plan assumption since it only requires $E_{t-1}\Lambda_{k',t} = E_{t-1}\Lambda_{c,t}$. The estimated value of b for this model is 0.66.

This model's asset-return implications are similar to those of our two-sector model. Its implications for business cycles are similar to those of the standard RBC model, except for consumption. It substantially overstates the relative volatility of consumption, by much more than our two-sector model does. In addition, this model implies that consumption growth is counterfactually strongly negatively autocorrelated. We view these as significant shortcomings of the time-to-plan model and they lead us to conclude that it does less well on standard business-cycle statistics than the standard RBC model.

To understand these results it is helpful to compare the impulse-response functions for this model with those of our two-sector model in Figure 1 (see "Time-to-plan model"). The key difference lies in the response of C. In the time-to-plan model, consumption responds very strongly in the period of the technology shock and then drops sharply, eventually following the path of our two-sector model. This overshooting property accounts for the negative autocorrelation in consumption growth implied by the model. That the initial jump in consumption exceeds what it is in our two-sector model accounts for the relatively high volatility in consumption in the time-to-plan model.

It is also interesting to examine the predictions of the time-to-plan model for comovement, excess sensitivity of consumption, and the leading-indicator phenomenon. The implications for the Campbell-Mankiw regression, (14), and for the leading-indicator phenomenon are similar to those for our two-sector model. In the former case, this reflects the properties of the utility function and that the instruments in the first-stage regression are relatively good. The time-to-plan model's success with the inverted leading-indicator phenomenon reflects that the rate of interest falls in the period of a positive technology shock. This occurs for the same basic reason as it does in our two-sector model.

Technically, the time-to-plan model is also capable of accounting for employment comovement. However, it is a Pyrrhic victory. To explain this, note that, as in standard one-sector models, there is a two-sector interpretation of the time-to-plan model. Under that interpretation, we can compute $H_{c,t}$ and $H_{i,t}$. When we do this, we find that the response of both variables to a positive technology shock is generally

positive.[18] This is why this model implies that both $H_{t,t}$ and $H_{t,t}$ are procyclical. But, ultimately we find the time-to-plan model's explanation of comovement unconvincing. This is because under the two-sector interpretation of the time-to-plan model, the assumption that aggregate hours worked must be decided prior to the realization of the technology shock is implausible. The type of considerations which motivate the assumption that aggregate labor is difficult to adjust flexibly in response to shocks seem to suggest that it is difficult to flexibly shift labor across economic sectors too. Yet, the time-to-plan model allows such movements to occur freely. Of course, the two-sector interpretation of the time-to-plan model is not the only one possible. Another interpretation is simply that the aggregate production function produces a homogeneous, intermediate output good, which is split linearly into consumption and investment by final-goods firms. However, it is not clear that this interpretation provides the basis for an interesting explanation of comovement.

B. *Adjustment Costs*

The *adjustment-cost model* posits that there is curvature in the trade-off between C_t and K_{t+1}. We obtain this model by replacing the capital-accumulation technology with the specification used in Jermann (1998):

$$K_{t+1} = (1 - \delta)K_t + \phi(I_t/K_t)K_t,$$

where

$$\phi(I_t/K_t) = \frac{a_1}{1 - 1/\xi}\left(\frac{I_t}{K_t}\right)^{1 - 1/\xi} + a_2$$

and a_1, a_2 are chosen so that the balanced growth path is invariant to ξ. Our results for this model are based on $\xi = 0.23$, which is the value used by Jermann (1998). This value is also near the lower bound of the range of estimates reported in the empirical literature on Tobin's q (see Christiano and Fisher, 1998.) As a result, it minimizes the supply elasticity of capital—hence, maximizes the models' ability to account for asset returns—while still lying in the range of empirical plausibility. Conditional on this value for ξ, we assigned values to the other parameters using the method in our two-sector model. The estimated value of b is at its upper bound.[19]

This model has similar implications for asset pricing as our two-sector model and the time-to-plan model, except that it understates the equity premium by a little over two percentage points. The discrepancy is not very important, however, because the gap can be closed by a modest increase in curvature above the log specification in (1). Overall, we find that the adjustment-cost model does roughly as well on asset prices as the other two models.

In terms of its business-cycle implications, though, this model represents a substantial step backward. To see this, note from Figure 1 (see "Adjustment-cost model") that labor responds countercyclically to a shock. This reflects that adjustment costs on investment in effect operate like a tax on labor. We noted above that the asset-pricing implications of the model are improved if curvature in utility were to be increased modestly. We found, however, that this change causes employment to be even more countercyclical. In contrast with our two-sector model and with the time-to-plan model, where the difficulties in adjusting investment only extend for one period, in the adjustment-cost model such difficulties last for many periods. This is why the drop in hours worked in response to a positive technology shock is persistent over time.

[18] The explanation mirrors the explanation of comovement in the two-sector model. In the period of the shock, $H_{t,t}$ actually drops temporarily because of the predetermined nature of I_t. Since H_t is also predetermined, this means that $H_{t,t}$ surges in the period that a positive shock occurs. In subsequent periods there is a strong motive to increase $H_{t,t}$, as the demand for investment goods rises in response to an increase in the return to capital. But, $H_{t,t}$ rises then too because the value of the output of the consumption sector is high in the periods after the shock. As in the two-sector model, this reflects the interaction between habit persistence in preferences and the surge in consumption that occurs in the period of the shock.

[19] Jermann (1998) also reports a high value of b. His value, 0.83, is somewhat lower than ours for two reasons: he has higher curvature in utility and he assumes hours worked is constant. The former amplifies the fluctuations in the demand for capital by directly increasing the preference for smooth consumption. The latter amplifies the fluctuations in the demand for capital indirectly, by eliminating fluctuations in labor as a way to smooth consumption.

The adjustment-cost model also has counterfactual implications for output. As may be inferred from Figure 1, the volatility of output is counterfactually low, and its autocorrelation is strongly *negative*. These properties of the model reflect the nature of the hours-worked response in the model.

We conclude that when standard business-cycle statistics are considered, the adjustment-cost model represents a substantial step in the wrong direction by comparison with the standard RBC model. The root of the problem with the adjustment-cost model lies in the persistently negative response of hours worked to a positive technology shock. This in turn reflects the persistence of the friction introduced with the adjustment-cost formulation. The relative success of our two-sector model appears to reflect the intuitively appealing notion that, in order to reduce capital's short-run supply elasticity, rigidities work best when their effects are transient.

Finally, consider the implications of the adjustment-cost model for the other business-cycle statistics listed in Table 3. This model also has a two-sector interpretation, and under this interpretation it has implications for $H_{c,t}$ and $H_{i,t}$. When we compute the response of these variables to a positive technology shock, however, we find that $H_{c,t}$ drops persistently and $H_{i,t}$ rises persistently, after a technology shock. As a result, when we compute the correlation of these variables with output we find that $H_{c,t}$ is countercyclical and $H_{i,t}$ is procyclical. Thus, even if we ignore the implausibility of the assumption that aggregate hours worked must be decided prior to the technology shock, under the two-sector interpretation of the adjustment-cost model, we find that the model is completely inconsistent with comovement. The implications of the adjustment-cost model for the Campbell and Mankiw regression, (14), are ambiguous. Small sample distortions due to poor instruments make interpreting these results difficult.

The adjustment-cost model is qualitatively consistent with the inverted leading-indicator phenomenon. According to Figure 1, the time pattern of consumption after a positive technology shock is very different from what it is in the time-to-plan and preferred two-sector models: it shows a gradual rise. As explained before, with time-separable preferences this pattern would imply a *rise* in the rate of interest. But, the relatively high value of b in the adjustment-cost model produces the opposite, with the interest rate falling in the period of a shock. Despite the gradual nature of the equilibrium consumption response, households with habit persistence prefer that response to be even more gradual. The fall in the rate of interest is required to discourage them from attempting to use loan markets to achieve this, by reallocating consumption from the present to the future.

Quantitatively, the adjustment-cost model does not do as well as the time-to-plan and two-sector models in accounting for the inverted leading-indicator phenomenon. Still, we think that model conveys an important lesson. We suspect that the relatively unsmooth consumption response implied by the time-to-plan and preferred two-sector models is counterfactual, although we are not aware of data which shows this. The adjustment-cost model results suggest that this unattractive feature of these models is not critical to their good performance on the inverted leading-indicator phenomenon and the asset-return facts. They give us hope that modifications which produce smoother consumption responses can be introduced while not destroying their good empirical performance on these other dimensions.

IV. Summary and Conclusion

We explored two modifications on the standard RBC model: the adoption of habit persistence in preferences and the assumption that the sectoral and aggregate allocation of capital and labor are determined before the current-period realization of uncertainty. These changes add just one unknown parameter to the model, a measure of persistence in consumption habit. We found that the modifications not only dramatically improve on the standard RBC model's asset-pricing implications, they also substantially improve upon that model's implications for business cycles.

We now briefly discuss two limitations of our model. First, we find (in results not reported here) that our two-sector model implies a high correlation between consumption growth and the rate of return on equity—higher than in the data. This is a long-standing problem for the

type of equilibrium model used here, to which our approach, at least for the time being, has nothing new to add.

Second, a key ingredient in our success in obtaining an equity premium is that, in addition to habit preferences, we introduced features of technology that prevent households from intertemporally smoothing consumption as much as they would like to. At the same time, our model has left out an important real-world device for doing this: inventories. Are our results robust to the introduction of inventories? Determining the answer with confidence is beyond the scope of this paper. However, there are at least three reasons for optimism. First, inventories are not a perfect smoothing device, since services and nondurables are a substantial part of consumption, and these cannot be stored or are poorly stored. Second, the adjustment-cost model described in this paper offers households slightly more flexible smoothing opportunities than does our two-sector model. Nevertheless, that model is also consistent with key features of asset returns. This suggests that the inflexibilities in the two-sector model can be softened (possibly, by introducing inventories) without sacrificing too much on asset returns. Finally, any modeling approach (based, say, on the Campbell and Cochrane [1999] specification of preferences) which solves the excess volatility problem with the risk-free rate would simultaneously make inventories unattractive as a smoothing device. For example, if the risk-free rate were always greater than unity, then inventories would never be held for smoothing reasons. This is true under the (plausible) assumption that inventories generate a gross rate of return no greater than unity.

In sum, we believe our model makes progress on the task of integrating the analysis of asset returns and business cycles. Still, the model has shortcomings and a final verdict depends on whether these shortcomings turn out to be signals that there is something fundamentally wrong with the model, or whether minor perturbations can overcome them. Assessing this is a task for future research.

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