

# Durability of Output and Expected Stock Returns\*

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## Abstract

The demand for durable goods is more cyclical than that for nondurable goods and services. Consequently, the cash flow and stock returns of durable-good producers are exposed to higher systematic risk. Using the NIPA input-output tables, we construct portfolios of durable-good, nondurable-good, and service producers. In the cross-section, a strategy that is long on durables and short on services earns a sizable risk premium. In the time series, a strategy that is long on durables and short on the market portfolio earns a countercyclical risk premium. We develop an equilibrium asset-pricing model that explains these empirical findings.

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# 1 Introduction

The cross-section of stock returns has been a subject of considerable research in financial economics. A key finding in this literature is that variation in accounting and financial variables across stocks generates puzzlingly large variation in average returns.<sup>1</sup> In contrast, variation in measured systematic risk across stocks generates surprisingly little variation in average returns. For instance, classic studies of the capital asset pricing model (CAPM) have found no variation in average returns across portfolios of stocks sorted by the market beta (Black, Jensen, and Scholes 1972, Fama and MacBeth 1973, Fama and French 1992).

In this paper, we show that an important source of systematic risk is priced in the cross-section of stock returns. Our approach builds on the core intuition of the consumption-based CAPM, which dictates that assets with higher exposure to consumption risk command higher risk premia. Because some components of aggregate consumption are more cyclical than others, firms producing the more cyclical components must command higher risk premia. Specifically, we argue theoretically and verify empirically that firms that produce durable goods are exposed to higher systematic risk than those that produce nondurable goods and services. An appealing aspect of our approach is that we classify firms based on an easily observable and economically meaningful source of systematic risk, rather than ad hoc characteristics that have tenuous relationship with risk. While durability may not be the only aspect of a firm's output that determines its exposure to consumption risk, our empirical success provides hope for identifying other proxies for systematic risk that are tied to variation in expected returns.

To identify the durability of each firm's output, we first develop a novel industry classification using the Benchmark Input-Output Accounts. This classification essentially identifies each Standard Industrial Classification (SIC) industry by its primary contribution to final de-

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<sup>1</sup>A partial list of accounting and financial variables that are known to be related to average stock returns are market equity (Banz 1981), earnings yield (Basu 1983), book-to-market equity (Rosenberg, Reid, and Lanstein 1985, Fama and French 1992), leverage (Bhandari 1988), and past returns (Jegadeesh and Titman 1993).

mand. We then sort firms into portfolios representing the three broad categories of personal consumption expenditures (PCE): durable goods, nondurable goods, and services. Because these portfolios have cash flows that are economically tied to aggregate consumption, they can be interpreted as consumption-risk mimicking portfolios in the sense of Breeden, Gibbons, and Litzenberger (1989). Because the input-output accounts allow us to sort firms precisely along a dimension of economic interest, our portfolios are more appropriate for studying cash flows and stock returns than those based on more common (and somewhat arbitrary) industry classifications.

We use the PCE portfolios to document four new facts in the cross-section of cash flows and stock returns.

1. The durable portfolio, relative to the service or the nondurable portfolio, has cash flow that is more volatile and more correlated with aggregate consumption.
2. The durable portfolio has returns that are higher on average and more volatile. Over the period 1927–2004, a strategy that is long on durables and short on services earned an average annual rate of return of almost 4.5%.
3. The durable portfolio has cash flow that is conditionally more volatile when the durable expenditure-stock ratio, the ratio of aggregate durable expenditure to its stock, is low.
4. The durable portfolio has returns that are more predictable. A strategy that is long on durables and short on the market portfolio has countercyclical expected returns that are strongly predicted by the durable expenditure-stock ratio. Moreover, the conditional covariance of this strategy's returns with durable consumption growth is countercyclical, which suggests that this variation in expected returns is compensation for consumption risk.

The first finding is perhaps not surprising in light of the well known fact that the aggregate expenditure on durable goods is more cyclical than that on nondurable goods and services.

Although the second finding may seem like a natural implication of the first finding, we need a model of risk and return to assess whether the magnitude of the risk premium is appropriate for the amount of measured systematic risk. The third and fourth findings are less obvious implications of durability that we discovered only after developing a model that guided our search.

To shed light on our empirical findings, we develop a parsimonious model that endogenizes both household consumption and the firms' cash flows.<sup>2</sup> Specifically, we analyze a dynamic production economy with two types of firms, a nondurable-good and a durable-good producer. We assume symmetry in preferences and production technology across sectors, so that durability is the only source of firm heterogeneity. This simplifying assumption allows us to use the model as a laboratory to understand how differences in the durability of output lead to differences in expected stock returns.

The basic mechanism of our model is fairly intuitive. A proportional change in the service flow (i.e., the stock) of durables requires a much larger proportional change in the expenditure on durables. This magnification effect is analogous to that present in the relationship between capital stock and investment. As a result, the demand for durable goods is more cyclical and volatile than that for nondurable goods, which implies that the cash flow and stock returns of durable-good producers have higher risk. Because the model generates an empirically realistic magnitude of cyclical variation in durable expenditure and cash flow, it also matches the relatively high stock returns on durable-good producers.

More importantly, the model shows that the magnification effect described above must be relatively large when the existing stock of durables is high relative to current demand. As a result, the difference in conditional risk between the cash flow of durable-good and nondurable-good producers is relatively high when the existing stock of durables is high relative to current demand. This mechanism leads to a testable implication that the durable

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<sup>2</sup>We build on a previous literature that studied a similar economic environment, but with exogenous consumption and cash flows (see Dunn and Singleton (1986), Eichenbaum and Hansen (1990), Piazzesi, Schneider, and Tuzel (2006), and Yogo (2006)).

expenditure-stock ratio predicts cross-sectional differences in the conditional moments of cash flows and stock returns, which is the basis for the third and fourth findings above.

Finally, the model provides an Euler equation as a way to test whether the durability of output is a source of consumption risk that is priced in both the cross-section and the time series of expected returns. Since the Euler equation holds regardless of specific assumptions about the nature of production, this procedure also provides a more general assessment of our model. A consumption-based model explains cross-sectional returns on our industry portfolios as well as the three Fama-French factor-mimicking portfolios. The  $R^2$  of the model is 92%, and the  $J$ -test fails to reject the model with a  $p$ -value of 22%. On the same set of portfolios, the Fama-French three-factor model has an  $R^2$  of 67% and is rejected with a  $p$ -value of 3%.

Our work is part of a recent effort to link expected returns to fundamental aspects of firm heterogeneity. One branch of the literature shows that the size and book-to-market effects arise naturally from optimal production and investment decisions.<sup>3</sup> A limitation of these earlier studies is that the underlying determinants of stock returns are often difficult to measure, and perhaps more significantly, they reflect fundamental differences between firms that are not true primitives of the economic environment.<sup>4</sup> Partly in response, Gourio (2005) and Tuzel (2005) focus on more readily identifiable sources of firm heterogeneity, such as differences in their production technology or the composition of their physical assets. This paper is in the same spirit, but we focus on heterogeneity in the characteristics of the output, rather than the inputs or technology.

The remainder of the paper proceeds as follows. In Section 2, we motivate the basic idea by documenting empirical properties of portfolios sorted by the durability of output. In Section 3, we set up a simple two-sector economy that incorporates the notion of firm heterogeneity based on the durability of output. In Section 4, we calibrate the model to

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<sup>3</sup>See, for example, Berk, Green, and Naik (1999), Kogan (2001, 2004), Gomes, Kogan, and Zhang (2003), Carlson, Fisher, and Giammarino (2004), Gala (2006), and Zhang (2006).

<sup>4</sup>Key ingredients in these models include heterogeneity in fixed costs of operation, the degree of irreversibility in capital, and the volatility of cash flow.

match aggregate quantities and examine its asset-pricing implications. In Section 5, we document cross-sectional and time-series evidence for an empirical relationship between risk and return. Section 6 concludes. A separate appendix (Gomes, Kogan, and Yogo 2006) contains the industry classification as well as a documentation of its construction.

## 2 Portfolios Sorted by the Durability of Output

Most empirical studies in asset pricing are based on portfolios constructed along fairly arbitrary dimensions. Examples include industry portfolios based on two-digit SIC codes and portfolios sorted by characteristics directly related to stock prices or returns. In this paper, we propose an alternative set of portfolios that is instead related to macroeconomic risk, carefully building a connection between consumption expenditures and firm cash flows. As a result, we believe that our new portfolios provide a much more appropriate benchmark for evaluating the performance of existing asset pricing models.

The notion of synthesizing assets that mimic macroeconomic risk is hardly new (see Shiller (1993)). However, our methodology differs from the conventional procedure that starts with a universe of assets, and then estimates portfolio weights that create maximal correlation with the economic variable of interest (e.g., Breeden, Gibbons, and Litzenberger (1989) and Lamont (2001)). Our approach does not require estimation, and more importantly, the cash flows are economically (rather than just statistically) linked to consumption risk.

### 2.1 Industry Classification

The National Income and Product Accounts (NIPA) divides PCE into the following three categories, ordered in decreasing degree of durability.

- *Durable goods* are “commodities that can be stored or inventoried and have an average service life of at least three years.” This category consists of furniture and household equipment; motor vehicles and parts; and other durable goods.

- *Nondurable goods* are “commodities that can be stored or inventoried and have an average service life of at most three years.” This category consists of clothing and shoes; food; fuel oil and coal; gasoline and oil; and other nondurable goods.
- *Services* are “commodities that cannot be stored and that are consumed at the place and time of purchase.” This category consists of household operation; housing<sup>5</sup>; medical care; net foreign travel; personal business; personal care; private education and research; recreation; religious and welfare activities; and transportation.

Our empirical analysis requires a link from industries, identified at the four-digit SIC code, to the various components of PCE. Because such a link is not readily available, we create our own using NIPA’s Benchmark Input-Output Accounts (Bureau of Economic Analysis 1994). The input-output accounts identify how much output each industry contributes to the four broad categories of final demand: PCE, gross private investment, government expenditures, and net exports of goods and services. Within PCE, the input-output accounts also identify how much output each industry contributes to the three categories of durability. Based on this data, we assign each industry to the category of final demand to which it has the highest value added: PCE on durable goods, PCE on nondurable goods, PCE on services, investment, government expenditures, and net exports. Gomes, Kogan, and Yogo (2006) contains further details on the construction of the industry classification.

## 2.2 Construction of the Portfolios

The universe of stocks is ordinary common equity traded in NYSE, AMEX, or Nasdaq, which are recorded in the Center for Research in Securities Prices (CRSP) Monthly Stock Database. In June of each year  $t$ , we sort the universe of stocks into five industry portfolios

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<sup>5</sup>According to the input-output accounts, SIC 7000 (hotels and other lodging places) is the only industry that has direct output to housing services. Expenditure on owner-occupied housing is accounted as part of residential fixed investment, rather than PCE. In the publicly available files, the input-output accounts do not have a breakdown of fixed investment into residential and nonresidential. Therefore, owner-occupied housing will remain outside the scope of our analysis of durable goods.

based on their SIC code: services, nondurable goods, durable goods, investment, and other industries. Other industries include the wholesale, retail, and financial sectors as well as industries whose primary output is to government expenditures or net exports. The stock must have a non-missing SIC code in order to be included in a portfolio. We first search for a match at the four-, then at the three-, and finally at the two-digit SIC. Once the portfolios are formed, we track their value-weighted returns from July of year  $t$  through June of year  $t + 1$ . We compute annual portfolio returns by compounding monthly returns.

We compute dividends for each stock based on the difference of holding period returns with and without dividends. Since 1971, we augment dividends with equity repurchase (Item 115) from Compustat’s statement of cash flows (Boudoukh, Michaely, Richardson, and Roberts 2007). We assume that the repurchases occur at the end of each fiscal year. Monthly dividends for each portfolio are simply the sum of dividends across all stocks in the portfolio. We compute annual dividends in December of each year by accumulating monthly dividends, assuming that intermediate (January through November) dividends are reinvested in the portfolio until the end of the calendar year. We compute dividend growth and the dividend yield for each portfolio based on a “buy and hold” investment strategy starting in 1927.

Since 1951, we compute other properties for each portfolio using the subset of firms for which the relevant data are available from Compustat. Book-to-market equity is book equity at the end of fiscal year  $t$  divided by the market equity in December of year  $t$ . Liabilities-to-market equity is liabilities (Item 181) at the end of fiscal year  $t$  divided by the market equity in December of year  $t$ . We construct book equity data as a merge of Compustat and historical data from Moody’s Manuals, available through Kenneth French’s webpage. We follow the procedure described in Davis, Fama, and French (2000) for the computation of book equity. Operating income is sales (Item 12) minus the cost of goods sold (Item 41). We compute the annual growth rate of sales and operating income in each year  $t$  based on the subset of firms that are in the portfolio in years  $t - 1$  and  $t$ .

## 2.3 Portfolio Properties

Table 1 reports some basic properties of the five industry portfolios. We focus our attention on the first three portfolios, which represent PCE. To get a sense of the size of the portfolios, we report the average number of firms and the average share of total market equity that each portfolio represents. In the full sample period, services represent 15%, nondurables represent 35%, and durables represent 16% of total market equity. On average, the service portfolio has the highest, and the nondurable portfolio has the lowest dividend yield.

For the sample period 1951–2004, we also report log book-to-market equity and log liabilities-to-market equity. On average, the service portfolio has the highest, and the nondurable portfolio has the lowest book-to-market equity. Similarly, the service portfolio has the highest, and the nondurable portfolio has the lowest liabilities-to-market equity. These patterns suggest that durability is not a property that is directly related to the book-to-market and leverage effects in expected stock returns.

## 2.4 Link to Aggregate Consumption

If our procedure successfully identifies durable-good producers, the total sales of firms in the durable portfolio should be empirically related to the aggregate expenditure on durable goods. In Figure 1, we plot the annual growth rate of sales for the service, the nondurable, and the durable portfolio. The dashed line in all three panels, shown for the purposes of comparison, is the growth rate of real durable expenditure from NIPA. As shown in Panel C, the correlation between sales of the durable portfolio and durable expenditure is almost perfect, except in the last ten years.<sup>6</sup> This evidence suggests that our industry classification based on the input-output tables successfully identifies durable-good producers.

Table 2 reports the same evidence in a more systematic way. Panel A reports descriptive statistics for the annual growth rate of sales for the PCE portfolios. In addition, the table

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<sup>6</sup>We suspect that foreign firms, producing motor vehicles and appliances in the U.S., have become an important part of durable expenditure in the recent period.

reports the correlation between sales growth and the growth rate of real service consumption, nondurable consumption, and durable expenditure. (Appendix A contains a detailed description of the consumption data.) The durable portfolio has sales that are more volatile than those of the service or the nondurable portfolio with a standard deviation of 8%. The sales of the durable portfolio have correlation of 0.81 with durable expenditure, confirming the visual impression in Figure 1. The sales of both the service and the nondurable portfolio have relatively low correlation with nondurable and service consumption. An explanation for this low correlation is that a large part of nondurable and service consumption is produced by private firms, nonprofit firms, and households that are not part of the CRSP database.

There is a potential accounting problem in aggregating sales across firms. Conceptually, aggregate consumption in NIPA is the sum of value added across firms, which is sales minus the cost of intermediate inputs. Therefore, the sum of sales across firms can lead to double accounting of the cost of intermediate inputs. We therefore compute the operating income for each firm, defined as sales minus the cost of goods sold. Unfortunately, the cost of goods sold in Compustat includes wages and salaries in addition to the cost of intermediate inputs. However, this adjustment would eliminate double accounting and potentially give us a better correspondence between the output of Compustat firms and aggregate consumption.

Panel B reports descriptive statistics for the annual growth rate of operating income for the PCE portfolios. The standard deviation of operating-income growth for the durable portfolio is 13%, compared to 6% for the service and the nondurable portfolio. These differences mirror the large differences in the volatility of real aggregate quantities. In the full sample, the standard deviation of nondurable and service consumption growth is 2%, compared to 13% for durable expenditure growth (see Table 7). In comparison to sales, the operating income of the service and the nondurable firms have much higher correlation with nondurable and service consumption. The correlation between the operating income of the service portfolio and service consumption is 0.25, and the correlation between the operating income of the nondurable portfolio and nondurable consumption is 0.31. The correlation

between the operating income of the durable portfolio and durable expenditure is 0.79.

The fundamental economic mechanism in this paper is that durable-good producers have demand that is more cyclical than that of nondurable-good producers. Table 2 provides strong empirical support for this mechanism, consistent with previous findings by Petersen and Strongin (1996). In the Census of Manufacturing for the period 1958–1986, they find that durable manufacturers are three times more cyclical than nondurable manufacturers, as measured by the elasticity of output (i.e., value added) to gross national product. Moreover, they find that this difference in cyclicity is driven by demand, rather than factors that affect supply (e.g., factor intensities, industry concentration, and unionization).

## 2.5 Stock Returns

Table 3 reports descriptive statistics for excess returns (over the three-month T-bill) on the five industry portfolios. In the period 1927–2004, both the average and the standard deviation of returns rise in the durability of output. Excess returns on the service portfolio has mean of 5.99% and a standard deviation of 18.70%. Excess returns on the durable portfolio has mean of 10.40% and a standard deviation of 29.27%. In ten-year sub-samples, durables generally have higher average returns than both services and nondurables. Interestingly, the largest spread in average returns occurred in the period 1927–1934, during the Great Depression. The spread between durables and nondurables is almost 8%, and the spread between nondurables and services is over 6%.

## 2.6 Predictability of Returns

Panel A of Table 4 examines evidence for the predictability of excess returns on the PCE portfolios. Our main predictor variable is durable expenditure as a fraction of its stock, which captures the strength of demand for durable goods over the business cycle. As shown in Panel A of Figure 2, the durable expenditure-stock ratio is strongly procyclical, peaking during expansions as identified by the National Bureau of Economic Research (NBER).

We report results for the full sample 1930–2004 and the postwar sample 1951–2004. The postwar sample is commonly used in empirical work due to apparent non-stationarity in durable expenditure during and immediately after the war (e.g., Ogaki and Reinhart (1998) and Yogo (2006)). We focus our discussion on the postwar sample because the results are qualitatively similar for the full sample.

In an univariate regression, the durable expenditure-stock ratio predicts excess returns on the service portfolio with a coefficient of  $-0.75$ , the nondurable portfolio with a coefficient of  $-0.14$ , and the durable portfolio with a coefficient of  $-1.11$ . The negative coefficient across the portfolios implies that the durable expenditure-stock ratio predicts the common countercyclical component of expected returns. This finding is similar to a previous finding that the ratio of investment to the capital stock predicts aggregate stock returns (Cochrane 1991). Of more interest than the common sign is the relative magnitude of the coefficient across the portfolios. The coefficient is the most negative for the durable portfolio, implying that it has the largest amount of countercyclical variation in expected returns.

In order to assess the strength of the evidence for return predictability, Table 4 also examines a bivariate regression that includes each portfolio’s own dividend yield. The coefficient for the durable expenditure-stock ratio is hardly changed from the univariate regression. The dividend yield predicts excess returns with a positive coefficient as expected, but adds little predictive power over the durable expenditure-stock ratio in terms of the  $R^2$ .

In Panel B, we examine whether there is cyclical variation in the volatility of returns. Rather than a structural estimation of risk and return, which we implement in Section 5, we report here a simple regression of absolute excess returns onto the lagged predictor variables. In an univariate regression, the durable expenditure-stock ratio predicts absolute excess returns on the service portfolio with a coefficient of  $0.12$ , the nondurable portfolio with a coefficient of  $0.16$ , and the durable portfolio with a coefficient of  $-0.18$ . While these coefficients are not statistically significant in the postwar sample, the empirical pattern suggests that the volatility of returns on the durable portfolio is more countercyclical than

that of the service or the nondurable portfolio.

## 2.7 Predictability of Cash-Flow Volatility

Differences in the conditional risk of the PCE portfolios are difficult to isolate based on returns data alone. This difficulty could arise from the fact that returns are driven by both news about aggregate discount rates and news about industry-specific cash flows. In Table 5, we therefore examine evidence for the predictability of cash-flow volatility. The basic idea is that the conditional risk on the PCE portfolios should be predictable because their returns are predictable. We use the same predictor variables as those used for predicting returns in Table 4.

As reported in Panel A, the durable expenditure-stock ratio predicts absolute sales growth for the service portfolio with a coefficient of 0.14, the nondurable portfolio with a coefficient of 0.25, and the durable portfolio with a coefficient of  $-0.20$ . This empirical pattern suggests that the volatility of cash-flow growth for the durable portfolio is more countercyclical than that for the service or the nondurable portfolio. The evidence is robust to including the dividend yield as an additional regressor, and to using operating income instead of sales as the measure of cash flow.

In Panel C, we examine evidence for the predictability of the volatility of five-year dividend growth. We motivate five-year dividend growth as a way to empirically implement the cash-flow news component of a standard return decomposition (Campbell 1991). The durable expenditure-stock ratio predicts absolute dividend growth for the service portfolio with a coefficient of 0.15, the nondurable portfolio with a coefficient of  $-1.17$ , and the durable portfolio with a coefficient of  $-1.46$ . This evidence suggests that the cash flow of the durable portfolio is exposed to higher systematic risk than that of the service or the nondurable portfolio during recessions, when durable expenditure is low relative to its stock.

### 3 Asset-Pricing Model

The last section established two key facts about the cash flow and returns of durable-good producers in comparison to those of nondurable-good producers. First, the cash flow of durable-good producers is more volatile and more correlated with aggregate consumption. This unconditional cash-flow risk appears to explain the fact that durable-good producers have higher average returns than nondurable-good producers. Second, the cash flow of durable-good producers is more volatile when the durable expenditure-stock ratio is low. This conditional cash-flow risk appears to explain the fact that durable-good producers have expected returns that are more time varying than those of nondurable-good producers.

In this section, we construct an equilibrium asset-pricing model as an organizing framework for our empirical findings. We begin with a representative household model as in Yogo (2006), then endogenize the production of nondurable and durable consumption goods. Our analysis highlights the role of durability as an economic mechanism that generates differences in firm output and cash-flow risk, abstracting from other sources of heterogeneity. The model delivers most of our key empirical findings in a simple and parsimonious setting. It also provides the necessary theoretical structure to guide our formal econometric tests in Section 5.

#### 3.1 Representative Household

There is an infinitely lived representative household in an economy with a complete set of financial markets. In each period  $t$ , the household purchases  $C_t$  units of a nondurable consumption good and  $E_t$  units of a durable consumption good. The nondurable good is taken to be the numeraire, so that  $P_t$  denotes the price of the durable good in units of the nondurable good. The nondurable good is entirely consumed in the period of purchase, whereas the durable good provides service flows for more than one period. The household's

stock of the durable good  $D_t$  is related to its expenditure by the law of motion

$$D_t = (1 - \delta)D_{t-1} + E_t, \quad (1)$$

where  $\delta \in (0, 1]$  is the depreciation rate.

The household's utility flow in each period is given by the Cobb-Douglas function

$$u(C, D) = C^{1-\alpha}D^\alpha, \quad (2)$$

where  $\alpha \in (0, 1)$  is the utility weight on the durable good.<sup>7</sup> As is well known, Cobb-Douglas utility implies a unit elasticity of substitution between the two goods. Implicit in this specification is the assumption that the service flow from the durable good is a constant proportion of its stock. We therefore use the words “stock” and “consumption” interchangeably in reference to the durable good.

The household maximizes the discounted value of future utility flows, defined through the Epstein-Zin (1991) recursive function

$$U_t = \{(1 - \beta)u(C_t, D_t)^{1-1/\sigma} + \beta(\mathbf{E}_t[U_{t+1}^{1-\gamma}])^{1/\kappa}\}^{1/(1-1/\sigma)}. \quad (3)$$

The parameter  $\beta \in (0, 1)$  is the household's subjective discount factor. The parameter  $\sigma \geq 0$  is its elasticity of intertemporal substitution (EIS),  $\gamma > 0$  is its relative risk aversion, and  $\kappa = (1 - \gamma)/(1 - 1/\sigma)$ .

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<sup>7</sup>We use homothetic preferences to ensure that the difference in the volatility of expenditure is a consequence of durability alone, rather than income elasticity. See Bils and Klenow (1998) and Pakoš (2004) for a model with nonhomothetic preferences.

## 3.2 Technology

Let  $X_t$  be the aggregate productivity at time  $t$ , which evolves as a geometric random walk with drift. Specifically, we assume that

$$X_{t+1} = X_t \exp\{\mu + z_{t+1} + \epsilon_{t+1}\}, \quad (4)$$

$$z_{t+1} = \phi z_t + \nu_{t+1}, \quad (5)$$

where  $\epsilon_t \sim \mathbf{N}(0, \sigma_\epsilon^2)$  and  $\nu_t \sim \mathbf{N}(0, \sigma_\nu^2)$  are independently and identically distributed shocks. The variable  $z_t$  captures the persistent (i.e., business-cycle) component of aggregate productivity, which evolves as a first-order autoregression.

## 3.3 Firms and Production

In each period  $t$ , the household inelastically supplies one unit of a perfectly divisible composite input (e.g., Solow’s mythical “shmoo”). The variable  $L_t \in [0, 1]$  denotes the share of input allocated to the production of the nondurable good in period  $t$ . The nondurable firm has the production function

$$C_t = X_t L_t^\theta, \quad (6)$$

where  $\theta \in (0, 1)$  measures the degree of returns of scale.

Similarly, the production function of the durable firm is given by

$$E_t = X_t^\lambda (1 - L_t)^\theta, \quad (7)$$

where  $\lambda \geq 1$  determines the relative productivity of the durable firm. The relative price of durable goods has steadily fallen, and the quantity of durable goods relative to that of nondurable goods and services has steadily risen in the postwar period (see Yogo (2006,

Figure 1)). These facts suggest that the productivity of the durable sector has grown faster than that of the nondurable sector, which can be modeled through the parametrization  $\lambda > 1$ .

Finally, we assume that the firms must pay a fixed cost of operation each period. The fixed cost creates operating leverage and drives a wedge between the volatility of household expenditure and the volatility of firm profits. The fixed cost for the nondurable firm is  $f_C X_t$ , and the fixed cost for the durable firm is  $f_E X_t$ .

The nondurable firm chooses the amount of input each period to maximize its profit

$$\Pi_{Ct} = C_t - Y_t L_t - f_C X_t, \quad (8)$$

where  $Y_t$  denotes the rental rate of the input. Similarly, the profit of the durable firm is given by

$$\Pi_{Et} = P_t E_t - Y_t(1 - L_t) - f_E X_t. \quad (9)$$

Since the firms distribute their profits back to the household, these equations imply the aggregate budget constraint

$$C_t + P_t E_t = \Pi_{Ct} + \Pi_{Et} + Y_t + (f_C + f_E) X_t. \quad (10)$$

The last term appears under the (inconsequential) assumption that the fixed costs are paid directly to the household.

### 3.4 Competitive Equilibrium

We solve for optimal allocations through the central planner's problem. We first substitute out  $L_t$  in equations (6) and (7) to write the production-possibilities frontier as

$$C(E_t, X_t) = X_t \left[ 1 - \left( \frac{E_t}{X_t^\lambda} \right)^{1/\theta} \right]^\theta. \quad (11)$$

The Bellman equation for the problem is

$$\begin{aligned} J_t = J(D_{t-1}, X_t) &= \max_{E_t} \{ (1 - \beta)u(C(E_t, X_t), D_t)^{1-1/\sigma} \\ &\quad + \beta(\mathbf{E}_t[J(D_t, X_{t+1})^{1-\gamma}]^{1/\kappa})^{1/(1-1/\sigma)}. \end{aligned} \quad (12)$$

Equations (1) and (4) define the law of motion for the state variables. The policy variable is the optimal level of durable expenditure. We solve for the policy function through numerical methods as described in Appendix B.

#### 3.4.1 Equilibrium Condition for the Household

Let  $R_{Wt}$  be the gross rate of return on aggregate wealth in period  $t$ , which is defined more precisely below. Define the household's intertemporal marginal rate of substitution (IMRS) as

$$M_{t+1} = \left[ \beta \left( \frac{C_{t+1}}{C_t} \right)^{-1/\sigma} \left( \frac{(D_{t+1}/C_{t+1})^\alpha}{(D_t/C_t)^\alpha} \right)^{1-1/\sigma} R_{W,t+1}^{1-1/\kappa} \right]^\kappa. \quad (13)$$

The household's first-order conditions imply that

$$\frac{\alpha}{1-\alpha} \left( \frac{D_t}{C_t} \right)^{-1} = P_t - (1-\delta)\mathbf{E}_t[M_{t+1}P_{t+1}] = Q_t. \quad (14)$$

Intuitively, the marginal rate of substitution between the durable and the nondurable good must equal the user cost of the service flow for the durable good, denoted by  $Q_t$ . The

user cost is equal to the purchase price today minus the present discounted value of the depreciated stock tomorrow.

### 3.4.2 Equilibrium Conditions for the Firms

The firms' first-order conditions imply that the competitive rental rate for the input is equal to its marginal product,

$$Y_t = \theta X_t^{1/\theta} C_t^{1-1/\theta} = \theta P_t X_t^{\lambda/\theta} E_t^{1-1/\theta}. \quad (15)$$

Rearranging this equation, the supply of the durable good, relative to that of the nondurable good, is

$$P_t = X_t^{(1-\lambda)/\theta} \left( \frac{E_t}{C_t} \right)^{1/\theta-1}. \quad (16)$$

In equilibrium, the firm profits are given by

$$\Pi_{Ct} = (1 - \theta)C_t - f_C X_t, \quad (17)$$

$$\Pi_{Et} = (1 - \theta)P_t E_t - f_E X_t. \quad (18)$$

Each firm's profit is proportional to the corresponding consumption expenditure, up to the fixed cost of operation. The profit of the durable firm, relative to that of the nondurable firm, is

$$\frac{\Pi_{Et}}{\Pi_{Ct}} = \frac{(1 - \theta)P_t E_t - f_E X_t}{(1 - \theta)C_t - f_C X_t}. \quad (19)$$

The key economic mechanism in the model is captured by equations (14) and (19). On the one hand, equation (14) shows that the household smoothes the ratio of the *stock* of durables to nondurable consumption. On the other hand, equation (19) shows that the

profit of the durable firm, relative to that of the nondurable firm, is proportional to the ratio of the *expenditure* on durables to nondurable consumption. Consequently, the profits of the durable firm are more volatile than those of the nondurable firm because a proportional change in the durable stock requires a much larger proportional change in its expenditure.

### 3.5 Equilibrium Asset Prices

Let  $V_{Ct}$  be the value of a claim to the profits of the nondurable firm, or the present discounted value of the stream  $\{\Pi_{C,t+s}\}_{s=1}^{\infty}$ . The one-period return on the claim is

$$R_{C,t+1} = \frac{V_{C,t+1} + \Pi_{C,t+1}}{V_{Ct}}. \quad (20)$$

In analogous notation, the one-period return on a claim to the profits of the durable firm is

$$R_{E,t+1} = \frac{V_{E,t+1} + \Pi_{E,t+1}}{V_{Et}}. \quad (21)$$

Let  $V_{Mt}$  be the value of a claim to total consumption expenditure, or the present discounted value of the stream  $\{C_{t+s} + P_{t+s}E_{t+s}\}_{s=1}^{\infty}$ . The one-period return on the claim is

$$R_{M,t+1} = \frac{V_{M,t+1} + C_{t+1} + P_{t+1}E_{t+1}}{V_{Mt}}. \quad (22)$$

The one-period return on the “wealth portfolio” that enters the IMRS (13) is then given by

$$R_{W,t+1} = \left(1 - \frac{Q_t D_t}{V_{Mt} + P_t D_t}\right)^{-1} \left(\frac{V_{M,t+1} + P_{t+1} D_{t+1} + C_{t+1}}{V_{Mt} + P_t D_t}\right). \quad (23)$$

If the durable good fully depreciates each period (i.e.,  $\delta = 1$ ), the durable stock does not enter the wealth portfolio. In this special case, the wealth portfolio collapses to the claim on total consumption expenditure (i.e.,  $R_{Wt} = R_{Mt}$ ).

The absence of arbitrage implies that the one-period return on any asset  $i$  satisfies

$$\mathbf{E}_t[M_{t+1}R_{i,t+1}] = 1, \quad (24)$$

where the IMRS is given by equation (13). In particular, the one-period riskfree interest rate satisfies

$$R_{f,t+1} = \frac{1}{\mathbf{E}_t[M_{t+1}]}. \quad (25)$$

We use the solution to the planner's problem and numerical methods to compute asset prices as described in Appendix B.

### 3.6 Discussion of the Model

Our model is designed to focus on durability as the sole economic mechanism that drives cross-sectional differences in profits and expected returns. For emphasis, we state this point formally as a proposition.

**Proposition 1.** *Suppose that the fixed costs of operation are given by*

$$f_C = (1 - \alpha)f, \quad (26)$$

$$f_E = \alpha f, \quad (27)$$

where  $f \in [0, 1)$  is a constant. In the special case  $\delta = 1$ , the profit of the durable firm is a constant proportion of that of the nondurable firm. Consequently, the two firms have identical rates of return (i.e.,  $R_{Ct} = R_{Et}$ ).

*Proof.* When  $\delta = 1$ , the household's first-order condition (14) simplifies to

$$\frac{\alpha}{1 - \alpha} \left( \frac{E_t}{C_t} \right)^{-1} = P_t.$$

Substituting this expression in equation (19),

$$\frac{\Pi_{Et}}{\Pi_{Ct}} = \frac{\alpha}{1 - \alpha}.$$

□

The proposition immediately implies that, in the general case  $\delta < 1$ , any differences in the firms' profits and returns arise from durability alone. The result might initially be surprising because the productivity of the durable firm is more cyclical than that of the nondurable firm when  $\lambda > 1$ . The reason is that the profit of the durable firm also depends on the relative price of durables, which is endogenously determined through optimal resource allocation.

Because durability is the only source of asymmetry between the firms, our model provides a laboratory for assessing the importance of durability as a mechanism for generating cross-sectional differences in cash flows and returns. The ability to analyze durability in the absence of asymmetries in preferences or technologies is an advantage of the production approach. In contrast, the endowment model requires exogenous assumptions about the firms' cash flows. Of course, the ability to pinpoint the empirical properties of cash flows is an advantage of the endowment approach, which makes it especially suitable for matching the standard asset-pricing facts. We refer to Pakoš (2004), Piazzesi, Schneider, and Tuzel (2006), and Yogo (2006) for an analysis of the endowment model.

## 4 Quantitative Implications of the Model

### 4.1 Choice of Parameters

Panel A of Table 7 reports the four macroeconomic quantities that we target in the calibration. These quantities are

- the log growth rate of real nondurable consumption,  $\log(C_t/C_{t-1})$ ;

- the log growth rate of real durable expenditure,  $\log(E_t/E_{t-1})$ ;
- the ratio of durable expenditure to its stock,  $E_t/D_t$ ;
- the ratio of durable expenditure to nondurable consumption,  $P_t E_t/C_t$ .

By matching the first two moments and the autocorrelation for these quantities, we ensure realistic implications for aggregate consumption and the relative price. We compute the population moments by simulating the model at annual frequency for 500,000 years.

For the purposes of calibration, “nondurable consumption” in the model is matched to nondurable and service consumption in the data. Similarly, the “nondurable firm” in the model is matched to the combination of the nondurable and the service portfolio in the data. We report the empirical moments for two sample periods, 1930–2004 and 1951–2004. Both nondurable consumption and durable expenditure are somewhat more volatile in the longer sample, but otherwise, the empirical moments are quite similar across the samples. We calibrate to the longer sample because it is a somewhat easier target from the perspective of explaining asset prices.

As with most general equilibrium models, especially those with production, our model fails to match the high volatility of stock returns and the magnitude of time variation in the equity premium. The ingredients necessary to resolve the classic asset-pricing puzzles within the consumption-based framework are now well known (see Campbell and Cochrane (1999) and Bansal and Yaron (2004)). We abstract from these issues to highlight the basic intuition for our findings and to focus on the cross-sectional asset-pricing facts discussed in Section 2.

Table 6 reports the parameters in our benchmark calibration. We set the depreciation rate to 22%, which matches the value reported by the Bureau of Economic Analysis (BEA) for consumer durables. We set the growth rate of technology to 2% in order to match the growth rate of real nondurable consumption. We set the relative productivity of the durable sector to  $\lambda = 1.8$  in order to match the growth rate of real durable expenditure. We set the

degree of returns to scale to  $\theta = 0.7$  and perform sensitivity analysis around that value.

Following Bansal and Yaron (2004) we model productivity growth as having a persistent component with an autoregressive parameter  $\phi = 0.78$ . We choose the standard deviation of the shocks so that  $\log(X_{t+1}/X_t)$  has the moments

$$\begin{aligned} \text{SD} &= \left( \sigma_\epsilon^2 + \frac{\sigma_\nu^2}{1 - \phi^2} \right)^{1/2} = 3\%, \\ \text{Autocorrel} &= \frac{\phi}{1 + \sigma_\epsilon^2(1 - \phi^2)/\sigma_\nu^2} = 0.4. \end{aligned}$$

To generate a nontrivial equity premium, we choose a fairly high risk aversion of  $\gamma = 10$ . At the same time, we choose a fairly high EIS of  $\sigma = 2$ , which helps keep both the mean and the volatility of the riskfree rate low. An EIS greater than one also implies that the substitution effect dominates the income effect, so that asset prices rise in response to a positive productivity shock. This helps magnify both the equity premium and the volatility of asset returns. Finally, the intratemporal first-order condition (14) requires that  $\alpha = 0.12$  to pin down the level of durable expenditure relative to nondurable consumption.

## 4.2 Calibration to Aggregate Consumption

Panel A of Table 7 shows that our choice of parameters leads to a realistic match of the targeted quantities. We match the mean, the standard deviation, and the autocorrelation of nondurable consumption growth. We do the same for durable expenditure, except that the standard deviation is somewhat lower than the empirical counterpart. The standard deviation of durable expenditure growth is 13% in the full sample and 8% in the model. A higher value of returns to scale can raise the spread in volatility between nondurable consumption and durable expenditure, by making it easier to transfer resources between the nondurable and durable sectors. However, this channel cannot fully account for the relatively high volatility of durable expenditure.

Figure 3 shows the optimal policy for the planner's problem under the benchmark param-

eters. We plot policy functions for a state with high productivity growth when  $\epsilon_t = \sigma_\epsilon$ , and a state with low productivity growth when  $\epsilon_t = -\sigma_\epsilon$ . Panel A shows that the share of input allocated to the production of durables rises in the productivity shock, holding the existing stock of durables constant. In response to a positive productivity shock, the expenditure on durables rises (shown in Panel B) and the relative price of durables falls (shown in Panel C). These policy functions verify the simple intuition that the expenditure on durables is more volatile and cyclical than that on nondurables.

Panel A also shows that the share of input allocated to the production of durables falls in the existing stock of durables, holding the productivity growth constant. Intuitively, the household has little need for additional durables when the existing stock, and hence its service flow, is already high. Both the expenditure on durables (shown in Panel B) and the user cost of durables (shown in Panel D) are more volatile when the stock of durables is relatively high. If we rearrange the accumulation equation (1) and compute the conditional variance of both sides,

$$\frac{D_{t-1}}{E_{t-1}} = \frac{\sigma_{t-1}(E_t/E_{t-1})}{\sigma_{t-1}(D_t/D_{t-1})}. \quad (28)$$

This relationship between the stock of durables and the conditional volatility of durable expenditure is a natural consequence of durability. A negative productivity shock causes the desired future service flow from durables to fall, which is accomplished through a reduction in the expenditure on new durables. When the existing stock is relatively high, such a reduction must be more pronounced.

### 4.3 Calibration to Profits

In our discussion of parameters above, we have deliberately omitted the fixed cost of operation. This is because the parameter has no bearing on the planner's problem, and consequently, any of the quantities reported in Panel A of Table 7. We now set this parameter

to  $f = 0.22$  in order to calibrate the model to the volatility of profits. Our empirical proxy for profits is operating income, which is sales minus the cost of goods sold. Data on sales and the cost of goods sold, which includes wages and salaries, are from Compustat and are available only for the postwar sample. In both the model and the data, the market portfolio is the combination of the nondurable and the durable firm.

Panel B of Table 7 reports the mean and the standard deviation of profit growth. Our simple model of operating leverage introduces a realistic wedge between the volatility of consumption expenditures and firm profits. For the nondurable firm, the standard deviation of profit growth is 3% in the model and 5% in the data. For the durable firm, the standard deviation of profit growth is 15% in the model and 13% in the data.

#### 4.4 Asset Returns

Equity is a leveraged claim on the firm's profits. In order to compare firm returns in the model to stock returns in the data, we must first introduce financial leverage. Consider a portfolio that is long  $V_{it}$  dollars in firm  $i$  and short  $bV_{it}$  dollars in the riskfree asset. The one-period return on the leveraged strategy is

$$\tilde{R}_{it} = \frac{1}{1-b}R_{it} - \frac{b}{1-b}R_{ft}. \quad (29)$$

In the model, we compute stock returns in this way using an empirically realistic leverage ratio. We compute the leverage ratio for all Compustat firms as the ratio of the book value of liabilities to the market value of assets (i.e., the sum of book liabilities and market equity). While the leverage ratio varies over time, it is on average 52% in the postwar sample. We therefore set  $b = 52\%$  in the calibration.

In Panel C of Table 7, we report the first two moments of asset returns implied by the model. The nondurable firm has excess returns (over the riskfree rate) with mean of 6.75% and a standard deviation of 10.08%. The durable firm has excess returns with mean of 9.13%

and a standard deviation of 13.67%. The spread in average returns between the two firms is more than 2%, which is comparable to the empirical counterpart. However, the spread in the volatility of returns is somewhat lower than the empirical counterpart because our model is not designed to resolve the equity volatility puzzle. The riskfree rate is 0.96% on average with low volatility, consistent with empirical evidence. Overall, the model supports the key empirical facts, that the durable portfolio has returns that are higher on average and more volatile.

## 4.5 Predictability of Returns

The model identifies two separate sources of predictability. The first source is the common component that is responsible for the predictability of the market portfolio. The IMRS (13) depends on the stock of durables as a ratio of nondurable consumption, which is proportional to the user cost of durables through the household's intratemporal first-order condition (14). The user cost of durables is more volatile when the stock of durables is relatively high, as shown in Panel D of Figure 3. Therefore, the IMRS is also more volatile when the stock of durables is relatively high.

The second source of predictability is the independent component that raises the predictability of the durable firm above and beyond that of the nondurable firm. This second source of predictability is essentially driven by the accumulation equation (1). As we have discussed above, the profits of the durable firm are more sensitive to aggregate productivity shocks when the stock of durables is relatively high. In other words, the conditional volatility of the profits of the durable firm is increasing in the existing stock of durables. As compensation for this higher conditional cash-flow risk, the durable firm must earn a higher expected return when the stock of durables is relatively high. This intuition is confirmed in Figure 4, which shows the profits and the market value of both firms as a function of the existing stock of durables.

To examine these implications in more detail, we simulate 10,000 samples, each consist-

ing of 50 annual observations. In each sample, we run a regression of excess returns onto the lagged durable expenditure-stock ratio. Panel A of Table 8 reports the mean and the standard deviation of the  $t$ -statistic from the regression across the simulated samples. We find that the regression coefficient is negative for both firms, explained by the common component of predictability. More importantly, the  $t$ -statistic for the durable firm is larger than that for the nondurable firm, explained by the independent component of predictability. Although these  $t$ -statistics are small on average, the moderate sampling variance implies that “statistically significant”  $t$ -statistics are not unusual within the model.

We obtain similar results when we instead focus on the predictability of absolute excess returns and absolute profit growth. In the simulated data, we regress each of these variables onto the lagged durable expenditure-stock ratio. For absolute excess returns, Panel B shows that the coefficients for both firms are negative with a  $t$ -statistic that is generally larger for the durable firm. For absolute profit growth, Panel C shows that the coefficient for the durable firm is generally negative as we would expect. In both cases, our findings are consistent with the empirical evidence in Tables 4 and 5.

## 4.6 Consumption Betas

We also examine the consumption betas for both firms because they provide a way to quantify the sources of risk. We compute these betas through a regression of excess returns onto the log growth rate of nondurable consumption,  $\log(C_t/C_{t-1})$ , and the log growth rate of durable stock,  $\log(D_t/D_{t-1})$ . Table 9 shows that the nondurable firm has a nondurable consumption beta of 2.87 and a durable consumption beta of  $-1.84$ . The durable firm has a nondurable consumption beta of 3.87 and a durable consumption beta of  $-2.85$ .

The nondurable beta is positive because nondurable consumption growth is directly related to aggregate productivity growth (see equation 6). Moreover, the nondurable beta is higher for the durable firm because its profits are more sensitive to aggregate productivity shocks, holding the existing stock of durables constant (see Figure 4).

As shown in Table 8, the durable expenditure-stock ratio captures the time variation in expected returns. Because expected returns are low when the durable expenditure-stock ratio is high, we expect durable consumption betas to be negative. This intuition follows immediately from the results for predictability and the fact that the growth rate of durables,  $D_t/D_{t-1}$ , is monotonic in the durable expenditure-stock ratio,  $E_t/D_t$ . Finally, durable consumption beta is more negative for the durable firm because it has expected returns that are more time-varying than those on the nondurable firm.

## 5 Relationship between Risk and Return

This section extends the analysis in Section 2 by further investigating the empirical properties of portfolios sorted by the durability of output. Specifically, we use a model of risk and return to show that the durability of output is a source of consumption risk that is priced in both the cross-section and the time series of expected returns.

We evaluate portfolio returns with respect to two different factor models. The first is the Fama-French (1993) three-factor model, in which the factors are excess market returns, SMB (small minus big market equity) portfolio returns, and HML (high minus low book-to-market equity) portfolio returns. The second is a consumption-based model, in which the factors are nondurable and durable consumption growth. The consumption-based model can be formally motivated as an approximation to the Euler equation (24).<sup>8</sup> As is well known, the Euler equation holds even in an economy in which production is different from the particular model described in Section 3. In that sense, the estimation in this section is more general than the calibration in the last section.

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<sup>8</sup>Strictly speaking, an approximation to the Euler equation introduces the log return on the wealth portfolio as a third factor (see Yogo (2006, Appendix C)). If we use the market return as an empirical proxy for the wealth portfolio, the estimate of its risk price is very small. We can therefore omit the factor in the following empirical analysis without substantively affecting the results. See Yogo (2006) for a further discussion of this issue.

## 5.1 Cross-Sectional Variation in Expected Returns

### 5.1.1 Empirical Framework

Let  $R_{it}$  denote the excess return on an asset  $i$  in period  $t$ . Let “nondurable consumption” refer to real nondurable and service consumption, where  $\Delta c_t$  denotes its log growth rate. Let “durable consumption” refer to the real stock of consumer durables, where  $\Delta d_t$  denotes its log growth rate. We model the cross-sectional relationship between risk and return through a linear factor model,

$$\mathbf{E}[R_{it}] = b_1 \text{Cov}(R_{it}, \Delta c_t) + b_2 \text{Cov}(R_{it}, \Delta d_t). \quad (30)$$

This equation says that the variation in expected returns across assets must reflect the variation in the quantity of risk across assets, measured by the covariance of returns with consumption growth. Appendix C contains details on the estimation of the linear factor model.

The test assets are the three Fama-French factors and the five industry portfolios. For the industry portfolios, we compute excess returns over the three-month T-bill. We use quarterly (rather than annual) data for the period 1951:1–2004:4 to obtain more precise estimates of the covariance between asset returns and consumption growth. Appendix A contains a detailed description of the consumption data.

### 5.1.2 Empirical Findings

Panel A of Table 10 reports the annualized excess returns on the eight portfolios. Among the five industry portfolios, the durable portfolio has the highest excess returns with mean of 8.19%. The service portfolio has the lowest excess returns with mean of 5.66%. The spread in average excess returns between the durable and the service portfolio is 2.53%, which is comparable to the size premium of 2.87% in this sample period. The nondurable portfolio has unusually high excess returns in this sample period with mean of 8.07%. This finding can

be explained by the relatively high returns on energy stocks during the decade 1965–1974 (see Table 3).

In the first column of Table 11, we examine whether the Fama-French three-factor model explains cross-sectional returns on the eight portfolios. The risk price for the market factor is 3.24, and the risk price for the HML factor is 2.60. The risk price for the SMB factor is not significantly different from zero. The  $R^2$  is 67%, which suggests that the Fama-French model explains some of the variation in average excess returns. However, the  $J$ -test (i.e., the test of overidentifying restrictions) rejects the model with a  $p$ -value of 3%. The rejection highlights the importance of including industry portfolios in cross-sectional asset pricing tests, which has been recently emphasized by Lewellen, Nagel, and Shanken (2006).

In the second column of Table 11, we examine whether the consumption-based model explains cross-sectional returns on the eight portfolios. The risk price for nondurable consumption growth is 22, while the risk price for durable consumption growth is 93. Of the two risk factors, only durable consumption growth has a risk price that is significantly different from zero, implying that this factor alone explains most of the variation in average excess returns. The  $R^2$  of the model is 92%, which is higher than that for the Fama-French model. The  $J$ -test fails to reject the model with a  $p$ -value of 22%.

Table 10 reports the betas and the alphas for the eight portfolios. As shown in Panel C, the service portfolio has a nondurable consumption beta of 4.79 and a durable consumption beta of  $-1.01$ . The nondurable portfolio has a nondurable consumption beta of 4.01 and a durable consumption beta of 0.16. The durable portfolio has a nondurable consumption beta of 7.45 and a durable consumption beta of  $-1.49$ . Thus firms that produce durable goods have both a higher nondurable consumption beta and a lower durable consumption beta than firms that produce nondurable goods and services. This pattern is precisely that predicted by the model, as reported in Table 9.

Interestingly, the investment portfolio has the largest alpha with respect to the consumption-based model. In other words, this portfolio has average returns that are too low relative to

their measured risk. As shown in Panel B, the investment portfolio also has a large alpha with respect to the Fama-French model. This finding is hard to rationalize in our model because we abstract from investment goods, but it suggests a potentially interesting avenue for future research (see Papanikolaou (2006)).

## 5.2 Time Variation in Expected Returns

### 5.2.1 Empirical Framework

We model the time-series relationship between risk and return through a conditional factor model,

$$\mathbf{E}_{t-1}[R_{it}] = b_1 \text{Cov}_{t-1}(R_{it}, \Delta c_t) + b_2 \text{Cov}_{t-1}(R_{it}, \Delta d_t). \quad (31)$$

This equation says that the variation in expected returns over time must reflect the variation in the quantity of risk over time, measured by the conditional covariance of returns with consumption growth.

Following the approach in Campbell (1987) and Harvey (1989), we model the conditional moments in equation (31) as linear functions of a vector of instruments  $x_{t-1}$ , observed at  $t - 1$ . For a set of assets indexed by  $i$ , we estimate the linear regression model

$$R_{it} = \Pi'_i x_{t-1} + \epsilon_{it}, \quad (32)$$

$$\epsilon_{it} \Delta c_t = \Upsilon'_{i1} x_{t-1} + \eta_{i1t}, \quad (33)$$

$$\epsilon_{it} \Delta d_t = \Upsilon'_{i2} x_{t-1} + \eta_{i2t}. \quad (34)$$

The conditional factor model (31) implies cross-equation restrictions of the form

$$\Pi_i = b_1 \Upsilon_{i1} + b_2 \Upsilon_{i2}. \quad (35)$$

Appendix C contains further details on estimation of the conditional factor model.

Our estimation is based on four excess returns and three instruments. The excess returns are the market portfolio over the three-month T-bill and each of the PCE (service, nondurable, and durable) portfolios *over the market portfolio*. The instruments are the durable expenditure-stock ratio, the dividend yield for the market portfolio, and a constant. In the estimation, we impose the risk prices  $b_1 = 22$  and  $b_2 = 93$ , which are the estimated risk prices from Table 11. This procedure ensures that the asset-pricing implications for the time series are consistent with those for the cross-section.

### 5.2.2 Empirical Findings

Panel A of Table 12 reports estimates of the regression model (32) for the conditional mean of excess returns. The estimates imply that the durable expenditure-stock ratio is the key instrument that explains time variation in expected returns. The estimated coefficient is  $-0.20$  for excess returns on the market portfolio. Because the durable expenditure-stock ratio is procyclical, the negative coefficient implies that the equity premium is countercyclical.

The estimated coefficient is  $0.03$  for excess returns on the service portfolio over the market portfolio. The positive coefficient implies that the expected return on the service portfolio is *less cyclical* than that on the market portfolio. In contrast, the estimated coefficient is  $-0.07$  for excess returns on the durable portfolio over the market portfolio. The negative coefficient implies that the expected return on the durable portfolio is *more cyclical* than that on the market portfolio. Between these two extremes is the expected return on the nondurable portfolio, which is slightly more cyclical than the market portfolio.

In Panels B and C, we investigate whether the cyclical variation in expected returns is matched by cyclical variation in risk, measured by the conditional covariance of returns with consumption growth. In particular, Panel C reports estimates of the regression model (34) for the conditional covariance of returns with durable consumption growth. The durable expenditure-stock ratio predicts the product of the innovations to market return and durable

consumption growth with a coefficient of  $-0.21$ . Because the durable expenditure-stock ratio is procyclical, the negative coefficient implies that the conditional covariance of the market return with durable consumption growth is countercyclical.

The estimated coefficient is  $0.03$  for excess returns on the service portfolio over the market portfolio. The positive coefficient implies that the conditional covariance for the service portfolio is *less cyclical* than that for the market portfolio. In contrast, the estimated coefficient is  $-0.08$  for excess returns on the durable portfolio over the market portfolio. The negative coefficient implies the conditional covariance for the durable portfolio is *more cyclical* than that for the market portfolio.

Panel B of Figure 2 is a visual representation of the results in Table 12. The figure shows a time-series plot of expected excess market returns (i.e., the equity premium), implied by the estimates in Table 12. The heavy line represents the total equity premium,  $\mathbf{E}_{t-1}[R_{it}]$ , and the light line represents the part due to durable consumption,  $b_2\text{Cov}_{t-1}(R_{it}, \Delta d_t)$ . The difference between the two lines is the premium due to nondurable consumption. The plot reveals two interesting facts. First, the equity premium is strongly countercyclical, that is, highest at business-cycle troughs and lowest at peaks. Second, the two lines move closely together, which implies that most of the time variation in the equity premium is driven by the time variation in durable consumption risk.

Figure 5 shows the premium on the service, the nondurable, and the durable portfolio over the market portfolio. A portfolio strategy that is long on the service portfolio and short on the market portfolio has procyclical expected returns. For example, expected returns are low during the 1960:2–1961:3 and 1980:1–1982:4 recessions. In contrast, a portfolio strategy that is long on the durable portfolio and short on the market portfolio has countercyclical expected returns. For example, expected returns are high during the same two recessions.

In summary, Table 12 uncovers a new empirical fact that the premium on the service portfolio is less cyclical, and the premium on the durable portfolio is more cyclical than that on the market portfolio. The countercyclical variation in expected returns is matched by

countercyclical variation in the quantity of risk, as captured by the conditional covariance of returns with durable consumption growth. Durable stocks deliver unexpectedly low returns during recessions when durable consumption growth is low. Therefore, investors demand a higher premium for holding durable stocks during recessions, above and beyond the usual compensation for stock market risk.

## 6 Conclusion

The literature on the cross-section of stock returns has documented a number empirical relationships between characteristics and expected returns. Although these studies provide useful descriptions of stock market data, they provide a limited insight into the underlying economic determinants of stock returns. Consequently, proposed explanations for these empirical findings represent a broad spectrum of ideologies, which include compensation for yet undiscovered economic risk factors (Fama and French 1993), investor mistakes (De Bondt and Thaler 1985, Lakonishok, Shleifer, and Vishny 1994), and data snooping (Lo and MacKinlay 1990). A more fruitful approach to the study of stock returns is to find direct empirical relationships between sources of systematic risk and expected returns. For instance, Pástor and Stambaugh (2003) find evidence that aggregate liquidity risk is priced in the cross-section of stock returns.

Ultimately, prices should not be viewed as characteristics by which to rationalize differences in expected returns. Instead, prices and expected returns should jointly be explained by more fundamental aspects of firm heterogeneity, such as the demand for their output. In this paper, we have shown that durability of output is an important determinant of demand that is priced in the cross-section of stock returns. Firms that produce durable goods have higher average returns, and their expected returns vary more over the business cycle. We suspect that there are other, and perhaps more important, aspects of demand that explain differences in expected returns.

## Appendix A Consumption Data

We work with two samples of consumption data: a longer annual sample for the period 1930–2004 and a shorter quarterly sample for the period 1951:1–2004:4. We construct our data using the following tables from the BEA.

- NIPA Table 2.3.4: Price Indexes for Personal Consumption Expenditures by Major Type of Product.
- NIPA Table 2.3.5: Personal Consumption Expenditures by Major Type of Product.
- NIPA Table 7.1: Selected Per Capita Product and Income Series in Current and Chained Dollars.
- Fixed Assets Table 8.1: Current-Cost Net Stock of Consumer Durable Goods.

Nondurable consumption is the properly chain-weighted sum of real PCE on nondurable goods and real PCE on services. The data for the stock of durable goods are available only at annual frequency (measured at each year end). We therefore construct a quarterly series that is consistent with the accumulation equation (1), using quarterly data for real PCE on durable goods. The depreciation rate for durable goods, implied by the construction, is about 6% per quarter. In computing growth rates, we divide all quantities by the population. In matching consumption growth to returns at the quarterly frequency, we use the “beginning-of-period” timing convention as in Campbell (2003).

To deflate asset returns and cash-flow growth, we use the consumer price index (CPI) for all urban consumers from the Bureau of Labor Analysis. The CPI is the only consistent time series for consumer prices going back to 1926, which is the beginning of the CRSP database. The CPI is based on a basket of goods and services from eight major groups of expenditures: food and beverages; housing; apparel; transportation; medical care; recreation; education and communication; and other nondurable goods and services. Because the CPI measures

the price of nondurable goods and services, our deflating methodology is consistent with our modeling convention that the nondurable good is the numeraire in the economy.

## Appendix B Numerical Solution of the Model

### B.1 Central Planner's Problem

We first rescale all variables by the appropriate power of aggregate productivity to make the planner's problem stationary. We define the rescaled value function  $\widehat{J}_t = J_t/X_t^{1+\alpha(\lambda-1)}$ . We also define the rescaled variables  $\widehat{C}_t = C_t/X_t$ ,  $\widehat{E}_t = E_t/X_t^\lambda$ ,  $\widehat{D}_t = D_t/X_t^\lambda$ , and  $\widehat{P}_t = P_t/X_t^{1-\lambda}$ . Let  $\Delta X_{t+1} = X_{t+1}/X_t$ . By homotheticity, we can solve an equivalent problem defined by the Bellman equation

$$\begin{aligned} \widehat{J}_t = \widehat{J}(\widehat{D}_{t-1}, \Delta X_t) &= \max_{\widehat{E}_t} \{ (1 - \beta) u(\widehat{C}(\widehat{E}_t), \widehat{D}_t)^{1-1/\sigma} \\ &\quad + \beta (\mathbf{E}_t [\Delta X_{t+1}^{(1-\gamma)(1+\alpha(\lambda-1))} \widehat{J}(\widehat{D}_t, \Delta X_{t+1})^{1-\gamma}])^{1/\kappa} \}^{1/(1-1/\sigma)}, \end{aligned} \quad (\text{B1})$$

$$\widehat{C}(\widehat{E}_t) = (1 - \widehat{E}_t^{1/\theta})^\theta. \quad (\text{B2})$$

The law of motion for the state variables are given by

$$\widehat{D}_t = (1 - \delta) \frac{\widehat{D}_{t-1}}{\Delta X_t^\lambda} + \widehat{E}_t \quad (\text{B3})$$

and equation (4).

We discretize the state space and solve the dynamic program through policy iteration. We start with an initial guess that the user cost is  $Q_t = \delta P_t$ . Then the intratemporal first-order condition (14) implies that

$$\frac{\alpha}{1 - \alpha} \left( \frac{\widehat{D}_t}{\widehat{C}_t} \right)^{-1} = \delta \widehat{P}_t. \quad (\text{B4})$$

Our initial guess of the policy function,  $\widehat{E}_t = E(\widehat{D}_{t-1}, \Delta X_t)$ , is the solution to the system of three nonlinear equations (16), (B2), and (B4). We then use the following recursion to solve the problem.

1. Compute the value function  $\widehat{J}_i$  corresponding to the current policy function  $\widehat{E}_i$ .
2. Update the policy function  $\widehat{E}_{i+1}$ , using  $\widehat{J}_i$  and the intratemporal first-order condition (14).
3. If  $\|\widehat{E}_{i+1} - \widehat{E}_i\|$  is less than the convergence criteria, stop. Otherwise, return to step 1.

## B.2 Asset Prices

As shown by Yogo (2006, Appendix B), the value of the claim to total consumption expenditure is related to the value function (12) through the equation

$$V_{Mt} = \frac{C_t^{1/\sigma} (D_t/C_t)^{\alpha(1/\sigma-1)} J_t^{1-1/\sigma}}{(1-\beta)(1-\alpha)} - C_t - P_t D_t. \quad (\text{B5})$$

We use the solution to the planner's problem to compute the return on the wealth portfolio (23) and the IMRS (13). We then solve for the (rescaled) value of the two firms by iterating on the Euler equations

$$\widehat{V}_{Ct} = \widehat{V}_C(\widehat{D}_{t-1}, \Delta X_t) = \mathbf{E}_t[M_{t+1} \Delta X_{t+1} (\widehat{V}_C(\widehat{D}_t, \Delta X_{t+1}) + \widehat{\Pi}_{C,t+1})], \quad (\text{B6})$$

$$\widehat{V}_{Et} = \widehat{V}_E(\widehat{D}_{t-1}, \Delta X_t) = \mathbf{E}_t[M_{t+1} \Delta X_{t+1} (\widehat{V}_E(\widehat{D}_t, \Delta X_{t+1}) + \widehat{\Pi}_{E,t+1})]. \quad (\text{B7})$$

We compute the riskfree rate through equation (25).

# Appendix C Estimating the Relationship between Risk and Return

We use the following notation throughout this appendix. The vector  $R_t = (R_{1t}, \dots, R_{Nt})'$  denotes the time  $t$  observation on  $N$  excess returns with mean  $\mu_R$  and covariance matrix  $\Sigma_R$ . The vector  $f_t = (f_{1t}, \dots, f_{Ft})'$  denotes the time  $t$  observation on  $F$  factors with mean  $\mu_f$  and covariance matrix  $\Sigma_f$ . The vector  $x_t$  denotes the time  $t$  observation on  $I$  instruments. For any parameter vector  $\theta$ , the symbol  $\hat{\theta}$  denotes a corresponding consistent estimator.

## C.1 Cross-Sectional Estimation

We estimate the linear factor model by two-step generalized method of moments (GMM) (see Cochrane (2001, Chapter 13.2) and Yogo (2006, Appendix C)). The parameters of the model are the vector of risk prices  $b$  and factor means  $\mu_f$ . Stack the parameters in a vector as  $\theta = (b', \mu_f')'$ , and also stack the data in a vector as  $z_t = (R_t', f_t')'$ . Define the moment function

$$e(z_t, \theta) = \begin{bmatrix} e_N(z_t, \theta) \\ e_F(z_t, \theta) \end{bmatrix} = \begin{bmatrix} R_t - R_t(f_t - \mu_f)'b \\ f_t - \mu_f \end{bmatrix}. \quad (\text{C1})$$

The linear factor model (30) implies the moment restriction  $\mathbf{E}[e(z_t, \theta_0)] = 0$  at the true parameter  $\theta = \theta_0$ .

In the first stage, we use the weighting matrix

$$W = \begin{bmatrix} \det(\hat{\Sigma}_R)^{-1/N} I_N & 0 \\ 0 & \hat{\Sigma}_f^{-1} \end{bmatrix}, \quad (\text{C2})$$

which puts an equal weight on each of the  $N$  asset-pricing moment restrictions. As a measure

of first-stage fit, we compute the statistic

$$R^2 = 1 - \frac{\|\sum_t e_N(z_t, \hat{\theta})\|^2}{\|\sum_t (R_t - \hat{\mu}_R)\|^2}. \quad (\text{C3})$$

We compute heteroskedasticity- and autocorrelation-consistent (HAC) standard errors through the VARHAC procedure with automatic lag length selection by the Akaike information criteria (see Den Haan and Levin (1997)).

## C.2 Time-Series Estimation

We estimate the conditional factor model by two-step GMM (see Yogo (2006, Appendix D)).

The linear regression model (32)–(34), in more compact notation, is

$$R_{it} = \Pi'_i x_{t-1} + \epsilon_{it} \quad (i = 1, \dots, N), \quad (\text{C4})$$

$$\epsilon_{it} f_{jt} = \Upsilon'_{ij} x_{t-1} + \eta_{ijt} \quad (i = 1, \dots, N; j = 1, \dots, F). \quad (\text{C5})$$

The parameters of the model are the vector of risk prices  $b$  and the conditional covariance matrices

$$\Upsilon_j = [\Upsilon_{1j} \cdots \Upsilon_{Nj}] \quad (I \times N), \quad (\text{C6})$$

$$\Upsilon = [\Upsilon_1 \cdots \Upsilon_F] \quad (I \times NF). \quad (\text{C7})$$

Stack the parameters in a vector as  $\theta = (b', \text{vec}(\Upsilon)')'$ , and also stack the data in a vector as  $z_t = (R'_t, f'_t, x'_{t-1})'$ . Define the moment function

$$e(z_t, \theta) = \begin{bmatrix} R_t - (\sum_{j=1}^F b_j \Upsilon_j)' x_{t-1} \\ \text{vec}([R_t - (\sum_{j=1}^F b_j \Upsilon_j)' x_{t-1}] f'_t) - \Upsilon' x_{t-1} \end{bmatrix} \otimes x_{t-1}. \quad (\text{C8})$$

The conditional factor model (31) implies the moment restriction  $\mathbf{E}[e(z_t, \theta_0)] = 0$  at the true parameter  $\theta = \theta_0$ .

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Table 1: Properties of the PCE Portfolios

We sort NYSE, AMEX, and Nasdaq stocks into five industry portfolios based on their SIC codes. The industries are defined by their primary contribution to final demand according to the NIPA input-output tables. We compute portfolio properties in December of each year and report the time-series average over the indicated sample period. The reported properties are the number of firms in each portfolio, the share of total market equity that each portfolio represents, log dividend yield, log book-to-market equity, and log liabilities-to-market equity.

Variable	Services	Nondurables	Durables	Investment	Other
Panel A: Sample Period 1927–2004					
Number of Firms	415	401	189	638	1175
Share of Market Equity (%)	14.6	35.3	15.9	16.7	17.5
Dividend Yield	-2.97	-3.12	-3.04	-3.29	-3.24
Panel B: Sample Period 1951–2004					
Number of Firms	547	493	233	844	1616
Share of Market Equity (%)	10.2	39.2	15.6	17.2	17.8
Dividend Yield	-3.01	-3.18	-3.09	-3.42	-3.34
Book-to-Market Equity	-0.24	-0.71	-0.52	-0.63	-0.58
Liabilities-to-Market Equity	0.07	-0.82	-0.13	-0.62	0.63

Table 2: Sales and Operating Income for the PCE Portfolios

The table reports descriptive statistics for the log annual growth rate of sales and operating income for the PCE portfolios. Operating income is sales minus the cost of goods sold. Correlation is with the log growth rate of real service consumption, nondurable consumption, and durable expenditure. Data on sales and the cost of goods sold are from Compustat and are deflated by the CPI. The sample period is 1951–2004.

Statistic	Services	Nondurables	Durables
Panel A: Sales			
Mean (%)	5.62	4.54	3.15
Standard Deviation (%)	5.94	5.43	8.16
Correlation with the Growth of			
Service Consumption	0.13	-0.01	0.62
Nondurable Consumption	0.19	0.04	0.49
Durable Expenditure	0.07	-0.10	0.81
Panel B: Operating Income			
Mean (%)	5.36	4.70	3.00
Standard Deviation (%)	5.99	5.55	12.77
Correlation with the Growth of			
Service Consumption	0.25	0.27	0.60
Nondurable Consumption	0.20	0.31	0.39
Durable Expenditure	0.29	0.33	0.79

Table 3: Excess Returns on the PCE Portfolios

We sort NYSE, AMEX, and Nasdaq stocks into five industry portfolios based on their SIC codes. The industries are defined by their primary contribution to final demand according to the NIPA input-output tables. The table reports the mean and the standard deviation of annual real excess returns over the three-month T-bill.

Period	Services	Nondurables	Durables	Investment	Other
Panel A: Average Excess Returns (%)					
1927–2004	5.99	8.52	10.40	8.18	8.51
1927–1934	-4.47	2.74	10.59	5.28	5.77
1935–1944	12.65	9.48	17.16	13.67	11.31
1945–1954	11.33	16.67	18.73	18.58	16.47
1955–1964	11.09	10.65	12.00	11.43	8.89
1965–1974	-6.13	-0.39	-6.00	-0.23	-2.78
1975–1984	7.68	6.31	10.99	4.77	8.04
1985–1994	8.19	11.73	9.10	1.60	8.74
1995–2004	5.47	9.76	10.67	9.77	11.07
Panel B: Standard Deviation of Excess Returns (%)					
1927–2004	18.70	18.68	29.27	28.27	22.33
1927–1934	25.33	34.09	59.31	58.08	42.69
1935–1944	24.72	18.38	33.61	28.28	23.51
1945–1954	14.77	16.79	23.15	25.13	17.48
1955–1964	15.23	15.02	21.73	25.60	17.80
1965–1974	12.51	16.86	22.82	23.47	22.10
1975–1984	11.39	14.33	24.99	19.16	15.64
1985–1994	15.62	14.99	14.96	8.87	16.56
1995–2004	22.86	17.44	25.59	28.50	20.78

Table 4: Predictability of Excess Returns

The table reports predictive regressions for real excess returns (over the three-month T-bill) and the absolute value of excess returns for the PCE portfolios. The lagged predictor variables are the log durable expenditure-stock ratio and each portfolio's own log dividend yield. Heteroskedasticity-consistent standard errors are in parentheses. Coefficients significant at the 10% level (i.e.,  $t$ -statistic greater than 1.645) are in bold type.

Lagged Predictor	Sample Period 1927–2004			Sample Period 1951–2004								
	Services	Nondurables	Durables	Services	Nondurables	Durables						
Panel A: Excess Returns												
Durable Expenditure-Stock	-0.20 (0.13)	-0.19 (0.14)	-0.40 (0.25)	<b>-0.42</b> (0.24)	<b>-0.75</b> (0.30)	<b>-0.61</b> (0.31)	-0.14 (0.35)	0.07 (0.31)	<b>-1.11</b> (0.45)	<b>-1.09</b> (0.44)		
Dividend Yield	<b>0.17</b> (0.06)	<b>0.26</b> (0.06)	<b>0.17</b> (0.10)	<b>0.17</b> (0.10)	0.09 (0.07)	0.09 (0.07)	<b>0.24</b> (0.06)	<b>0.24</b> (0.06)	<b>0.24</b> (0.11)	0.09 (0.11)		
$R^2$	0.04	0.11	0.03	0.17	0.10	0.12	0.00	0.16	0.10	0.12		
Panel B: Absolute Excess Returns												
Durable Expenditure-Stock	<b>-0.15</b> (0.09)	<b>-0.17</b> (0.09)	-0.13 (0.12)	-0.11 (0.11)	-0.34 (0.21)	<b>-0.36</b> (0.18)	0.12 (0.18)	0.07 (0.19)	0.16 (0.18)	0.23 (0.18)	-0.18 (0.25)	-0.18 (0.26)
Dividend Yield	-0.05 (0.04)	<b>0.09</b> (0.05)	<b>0.09</b> (0.07)	<b>0.09</b> (0.07)	0.11 (0.07)	0.11 (0.07)	-0.03 (0.04)	0.07 (0.05)	-0.01 (0.05)	-0.01 (0.07)	-0.01 (0.07)	-0.01 (0.07)
$R^2$	0.05	0.07	0.04	0.08	0.11	0.15	0.01	0.02	0.01	0.04	0.01	0.01

Table 5: Predictability of the Volatility of Cash-Flow Growth

The table reports predictive regressions for the absolute value of real sales growth, operating-income growth, and five-year dividend growth for the PCE portfolios. The lagged predictor variables are the log durable expenditure-stock ratio and each portfolio's own log dividend yield. Heteroskedasticity-consistent standard errors are in parentheses. Coefficients significant at the 10% level (i.e.,  $t$ -statistic greater than 1.645) are in bold type. The sample period is 1951–2004.

Lagged Predictor	Services		Nondurables		Durables	
Panel A: Absolute Sales Growth						
Durable Expenditure-Stock	0.14 (0.09)	0.01 (0.07)	<b>0.25</b> (0.09)	<b>0.24</b> (0.08)	<b>-0.20</b> (0.09)	<b>-0.20</b> (0.09)
Dividend Yield		<b>-0.08</b> (0.02)		-0.01 (0.02)		0.03 (0.02)
$R^2$	0.04	0.31	0.17	0.18	0.07	0.10
Panel B: Absolute Operating-Income Growth						
Durable Expenditure-Stock	-0.11 (0.13)	-0.20 (0.18)	<b>0.23</b> (0.04)	<b>0.22</b> (0.05)	-0.26 (0.16)	-0.25 (0.16)
Dividend Yield		-0.06 (0.04)		-0.01 (0.02)		0.03 (0.03)
$R^2$	0.01	0.06	0.26	0.28	0.04	0.06
Panel C: Absolute 5-Year Dividend Growth						
Durable Expenditure-Stock	0.15 (0.23)	-0.06 (0.24)	<b>-1.17</b> (0.31)	<b>-1.09</b> (0.30)	<b>-1.46</b> (0.51)	<b>-1.43</b> (0.50)
Dividend Yield		<b>-0.18</b> (0.08)		<b>0.12</b> (0.06)		-0.09 (0.17)
$R^2$	0.00	0.14	0.27	0.32	0.13	0.14

Table 6: Parameters in the Benchmark Calibration

Parameter	Symbol	Value
Depreciation rate of durable good	$\delta$	22%
Preferences:		
Discount factor	$\beta$	0.98
EIS	$\sigma$	2
Risk aversion	$\gamma$	10
Utility weight on durable good	$\alpha$	0.12
Technology:		
Growth rate	$\mu$	2.0%
SD of i.i.d. component	$\sigma_\epsilon$	2.1%
SD of shock to persistent component	$\sigma_\nu$	1.3%
Autocorrel of persistent component	$\phi$	0.78
Production:		
Returns to scale	$\theta$	0.70
Relative productivity of durable sector	$\lambda$	1.80
Fixed cost of operation	$f$	0.22
Financial leverage	$b$	52%

Table 7: Calibration of the Model and Implied Asset Returns

Panel A reports moments for various quantities in the data and in the calibrated model. The quantities are the log growth rate of real nondurable and service consumption, the log growth rate of real durable expenditure, the ratio of durable expenditure to its stock, and the ratio of durable expenditure to nondurable consumption. Panel B reports moments for the log growth rate of real operating income (profits in the model). Panel C reports moments for excess portfolio returns over the three-month T-bill rate (over the riskfree rate in the model). Table 6 lists the parameters of the calibrated model.

Variable	Statistic	Sample Period		Model
		1930–2004	1951–2004	
Panel A: Consumption Growth				
Nondurable Consumption	Mean (%)	1.88	2.06	2.00
	SD (%)	2.26	1.13	3.00
	Autocorrel	0.43	0.30	0.46
Durable Expenditure	Mean (%)	3.38	3.68	3.60
	SD (%)	13.44	6.58	7.71
	Autocorrel	0.26	0.10	0.27
Durable Expenditure-Stock	Mean (%)	23.57	24.66	24.70
	SD (%)	3.73	1.64	2.93
	Autocorrel	0.79	0.65	0.88
Durable-Nondurable Expenditure	Mean (%)	14.02	15.17	14.56
	SD (%)	2.71	1.17	0.98
	Autocorrel	0.87	0.70	0.78
Panel B: Profit Growth				
Market Portfolio	Mean (%)		4.30	2.00
	SD (%)		5.44	3.58
Nondurable & Service Portfolio	Mean (%)		4.64	2.00
	SD (%)		5.03	2.65
Durable Portfolio	Mean (%)		3.00	2.00
	SD (%)		12.77	14.84
Panel C: Excess Returns				
Market Portfolio	Mean (%)	7.39	7.40	6.99
	SD (%)	18.65	15.85	10.44
Nondurable & Service Portfolio	Mean (%)	7.03	7.25	6.75
	SD (%)	17.51	15.21	10.08
Durable Portfolio	Mean (%)	9.81	8.83	9.13
	SD (%)	28.28	23.20	13.67
T-bill / Riskfree Asset	Mean (%)	0.90	1.66	0.96
	SD (%)	4.17	2.45	0.76

Table 8: Predictability of Excess Returns in the Model

We use the calibrated model to simulate 10,000 samples, each consisting of 50 annual observations. In Panel A, we run a regression of excess returns (over the riskfree rate) onto the lagged durable expenditure-stock ratio and report the mean and the standard deviation of the  $t$ -statistic across the simulated samples. In Panel B (Panel C), we repeat the same exercise for a regression of the absolute value of excess returns (profit growth) onto the lagged durable expenditure-stock ratio. Table 6 lists the parameters of the calibrated model.

Statistic	Portfolio		
	Market	Nondurables	Durables
Panel A: Excess Returns			
Mean of $t$ -stat	-0.61	-0.60	-0.71
SD of $t$ -stat	1.05	1.05	1.04
Panel B: Absolute Excess Returns			
Mean of $t$ -stat	-0.35	-0.33	-0.54
SD of $t$ -stat	1.08	1.08	1.06
Panel C: Absolute Profit Growth			
Mean of $t$ -stat	1.13	2.59	-1.27
SD of $t$ -stat	1.30	1.74	1.13

Table 9: Consumption Betas in the Model

The table reports the nondurable and the durable consumption beta in the calibrated model. We compute the betas through a regression of excess returns (over the riskfree rate) onto nondurable consumption growth, durable stock growth, and a constant. Table 6 lists the parameters of the calibrated model.

Statistic	Portfolio		
	Market	Nondurables	Durables
Nondurable Beta	2.97	2.87	3.87
Durable Beta	-1.91	-1.84	-2.58

Table 10: Average Returns and Betas for the Fama-French and the PCE Portfolios

Panel A reports average excess returns on the three Fama-French factors and the five industry portfolios. For the industry portfolios, excess returns are over the three-month T-bill. Panel B reports the betas and the alphas for the Fama-French three-factor model. Panel C reports the betas and the alphas for the consumption-based model, in which the factors are nondurable and durable consumption growth. All returns and alphas are reported in annualized percentage units. The sample period is 1951:1–2004:4.

Statistic	Fama-French Portfolios			Industry Portfolios				
	Market	SMB	HML	Services	Nondurables	Durables	Investment	Other
Mean (%)	7.67	2.87	3.92	5.66	8.07	8.19	6.43	7.43
Panel A: Excess Returns								
Market Beta	1.00	0.00	0.00	0.87	0.91	1.13	1.11	1.06
SMB Beta	0.00	1.00	0.00	-0.07	-0.29	0.15	0.18	0.17
HML Beta	0.00	0.00	1.00	0.10	0.01	0.15	-0.07	0.02
Alpha (%)	0.73	0.99	0.03	-0.59	2.32	-0.51	-1.29	-0.31
Panel B: Fama-French Model								
Panel C: Consumption-Based Model								
Nondurable Beta	5.43	1.87	0.15	4.79	4.01	7.45	6.69	5.51
Durable Beta	-0.65	-0.25	0.75	-1.01	0.16	-1.49	-1.26	-0.77
Alpha (%)	0.03	0.36	0.39	0.80	-0.31	0.31	-1.00	0.17

Table 11: Cross-Sectional Test on the Fama-French and the PCE Portfolios  
The table reports estimated factor risk prices for the Fama-French three-factor model and the consumption-based model. The test assets are the three Fama-French portfolios and the five industry portfolios. Estimation is by two-step GMM. HAC standard errors are in parentheses. The mean absolute pricing error (MAE) and  $R^2$  are based on the first-stage estimate. The  $p$ -values for the  $J$ -test are in parentheses.

Factor Price	Fama-French	Consumption-Based
Market	3.24 (1.14)	
SMB	1.05 (1.22)	
HML	2.60 (1.41)	
Nondurables		22.30 (25.39)
Durables		93.11 (38.87)
MAE (%)	0.85	0.42
$R^2$	0.67	0.92
$J$ -test	12.36 (0.03)	8.21 (0.22)

Table 12: Expected Returns and Conditional Covariance with Consumption Growth  
Panel A reports estimates of a regression model for expected excess returns. Panel B (Panel C) reports estimates of a regression model for the conditional covariance of returns with nondurable (durable) consumption growth. Estimation uses four excess returns and three lagged instruments. The excess returns are the market portfolio over the three-month T-bill and each of the PCE portfolios over the market portfolio. The instruments are log durable expenditure-stock ratio, log dividend yield for the market portfolio, and a constant. Estimation is by two-step GMM. Heteroskedasticity-consistent standard errors are in parentheses. Coefficients significant at the 10% level (i.e.,  $t$ -statistic greater than 1.645) are in bold type.

Instrument	Market	Excess Returns over Market		
		Services	Nondurables	Durables
Panel A: Expected Excess Returns				
Durable Expenditure-Stock	<b>-0.20</b> (0.03)	<b>0.03</b> (0.01)	<b>-0.03</b> (0.01)	<b>-0.07</b> (0.01)
Dividend Yield	0.00 (0.01)	0.01 (0.00)	0.00 (0.00)	0.00 (0.00)
Panel B: Covariance with Nondurable Consumption				
Durable Expenditure-Stock	<b>-0.13</b> (0.03)	0.02 (0.01)	0.00 (0.01)	<b>-0.04</b> (0.02)
Dividend Yield	0.00 (0.01)	0.00 (0.00)	-0.01 (0.00)	0.01 (0.00)
Panel C: Covariance with Durable Consumption				
Durable Expenditure-Stock	<b>-0.21</b> (0.04)	<b>0.03</b> (0.01)	<b>-0.03</b> (0.02)	<b>-0.08</b> (0.02)
Dividend Yield	-0.01 (0.01)	<b>0.01</b> (0.00)	0.00 (0.00)	-0.01 (0.01)

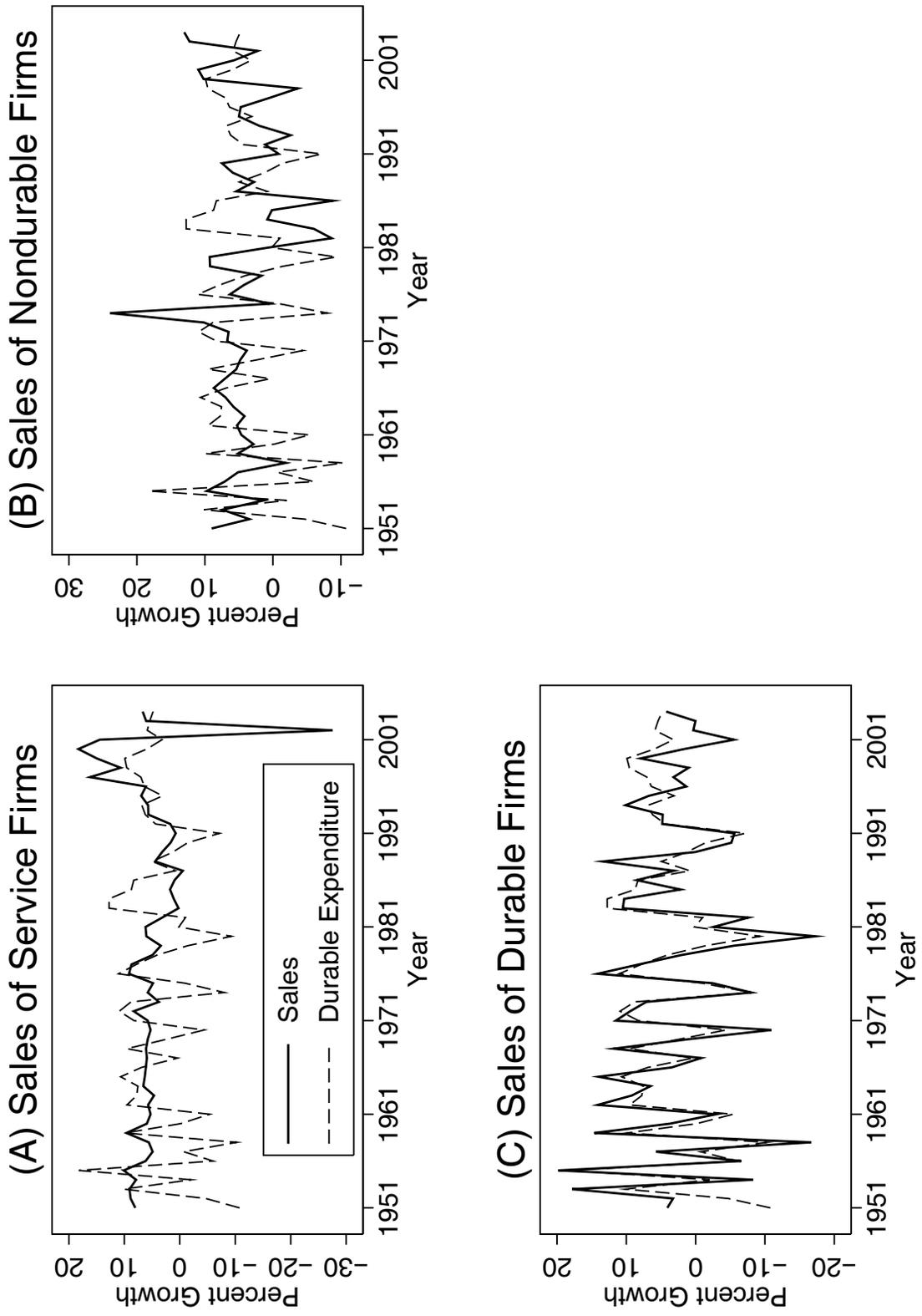


Figure 1: Sales Growth for the PCE Portfolios

The figure shows the log annual growth rate of sales for the PCE portfolios. The dashed line in each panel is the log growth rate of real durable expenditure. Data on sales are from Compustat and are deflated by the CPI. The sample period is 1951–2004.

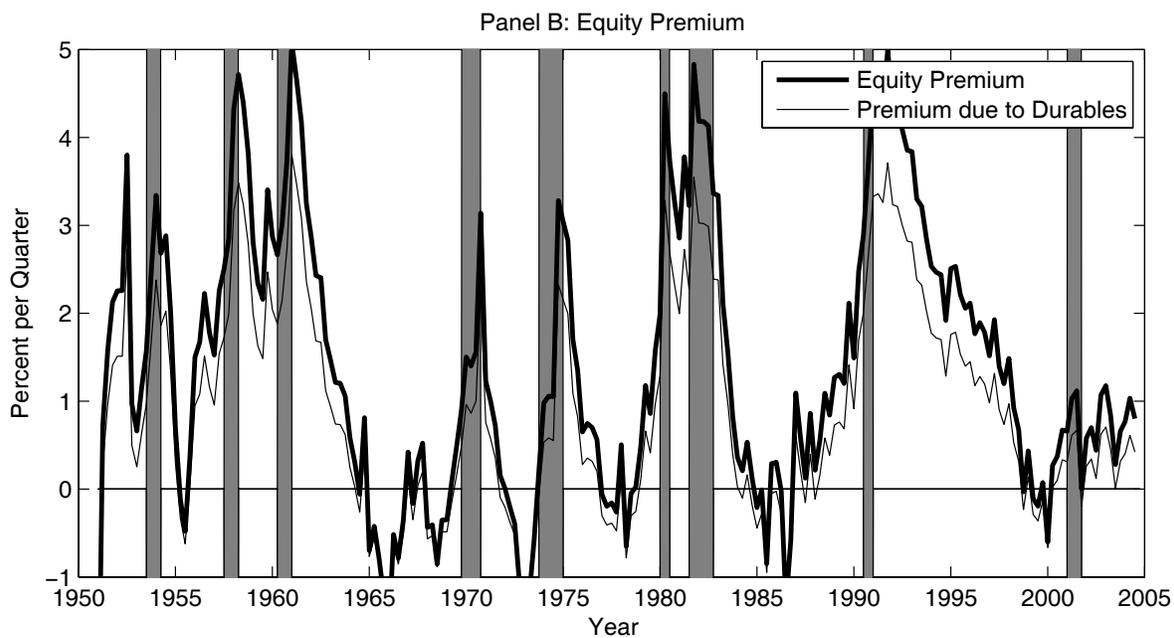
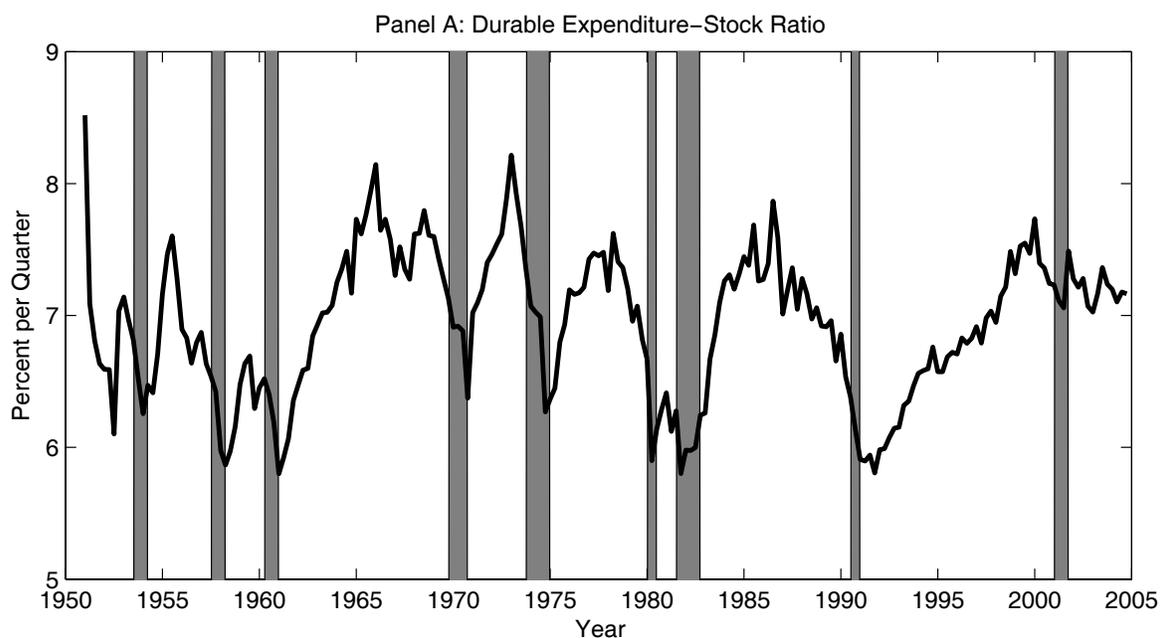


Figure 2: Time Variation in the Equity Premium

Panel A is a time-series plot of the durable expenditure-stock ratio. Panel B is a time-series plot of expected excess returns on the market portfolio over the three-month T-bill rate, implied by the regression model estimated in Table 12. The sample period is 1951:1–2004:3, and the shaded regions are NBER recessions.

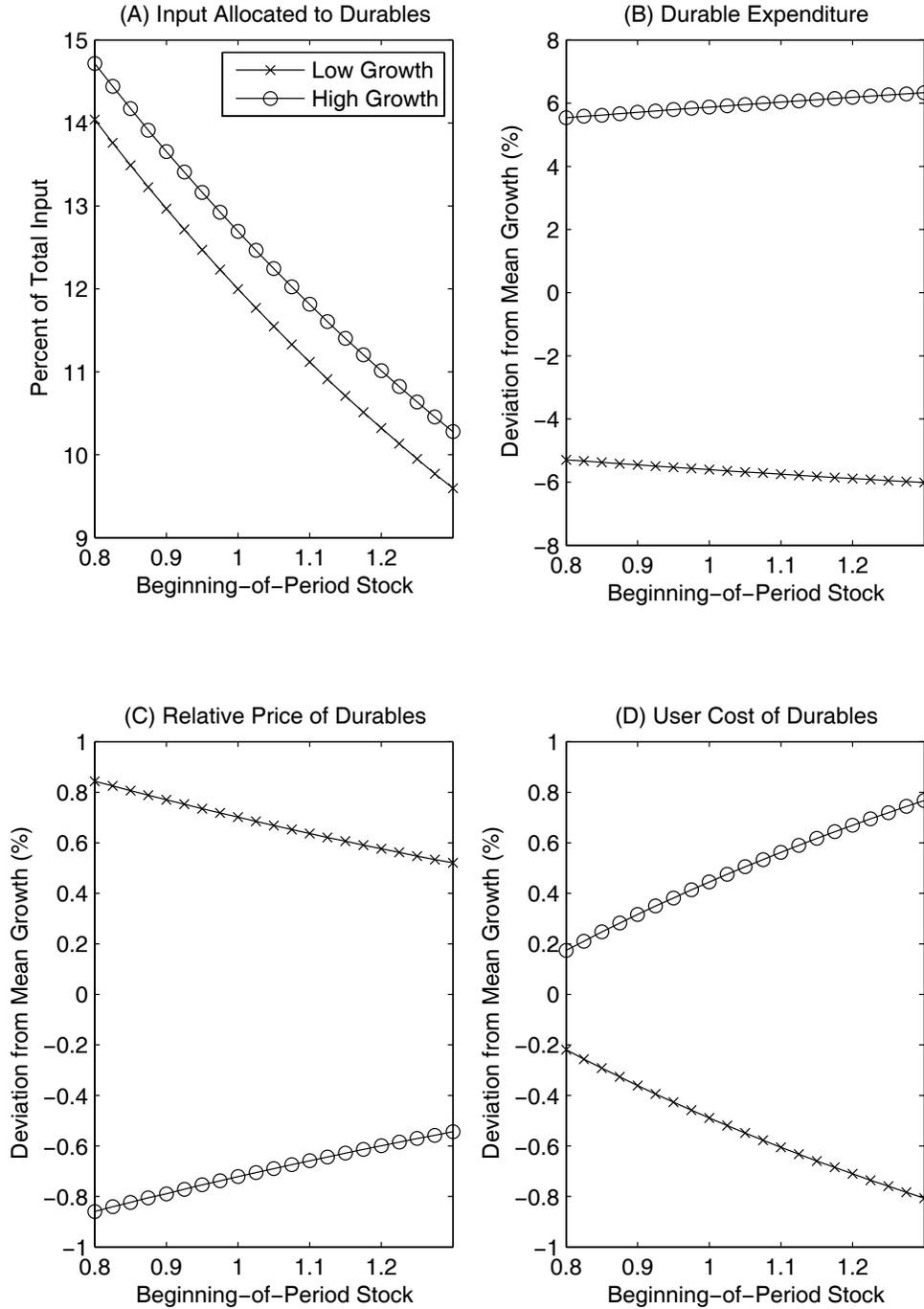


Figure 3: Optimal Production and Equilibrium Price of the Durable Good

In the notation described in the text, the figure shows (A)  $1 - L_t$ , (B)  $E_t$ , (C)  $P_t$ , and (D)  $Q_t$ . High (low) growth refers to the state when the i.i.d. component of productivity growth is one standard deviation above (below) the mean (i.e.,  $\epsilon_t = \pm\sigma_\epsilon$  and  $z_t = 0$ ). All quantities, except for the share of input allocated to durables, are reported as percent deviation from the corresponding value in steady state (i.e.,  $\epsilon_t = 0$  and  $z_t = 0$ ). The horizontal axis is the normalized stock of durables at the beginning of period (i.e.,  $D_{t-1}/X_{t-1}^\lambda$ ). Table 6 lists the parameters of the calibrated model.

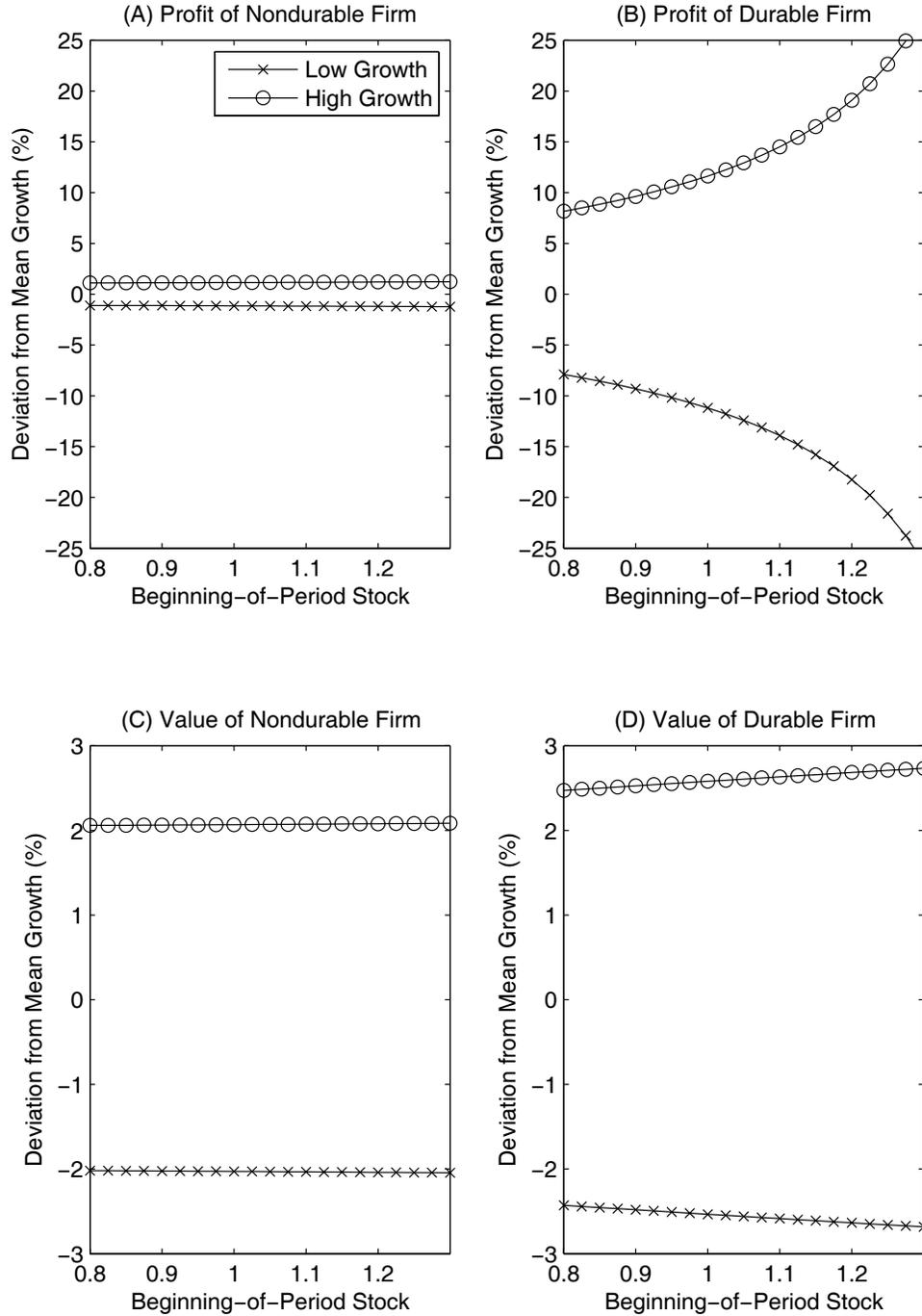


Figure 4: Profits and Equilibrium Asset Prices

In the notation described in the text, the figure shows (A)  $\Pi_{Ct}$ , (B)  $\Pi_{Et}$ , (C)  $V_{Ct}$ , and (D)  $V_{Et}$ . High (low) growth refers to the state when the i.i.d. component of productivity growth is one standard deviation above (below) the mean (i.e.,  $\epsilon_t = \pm\sigma_\epsilon$  and  $z_t = 0$ ). All quantities are reported as percent deviation from the corresponding value in steady state (i.e.,  $\epsilon_t = 0$  and  $z_t = 0$ ). The horizontal axis is the normalized stock of durables at the beginning of period (i.e.,  $D_{t-1}/X_{t-1}^\lambda$ ). Table 6 lists the parameters of the calibrated model.

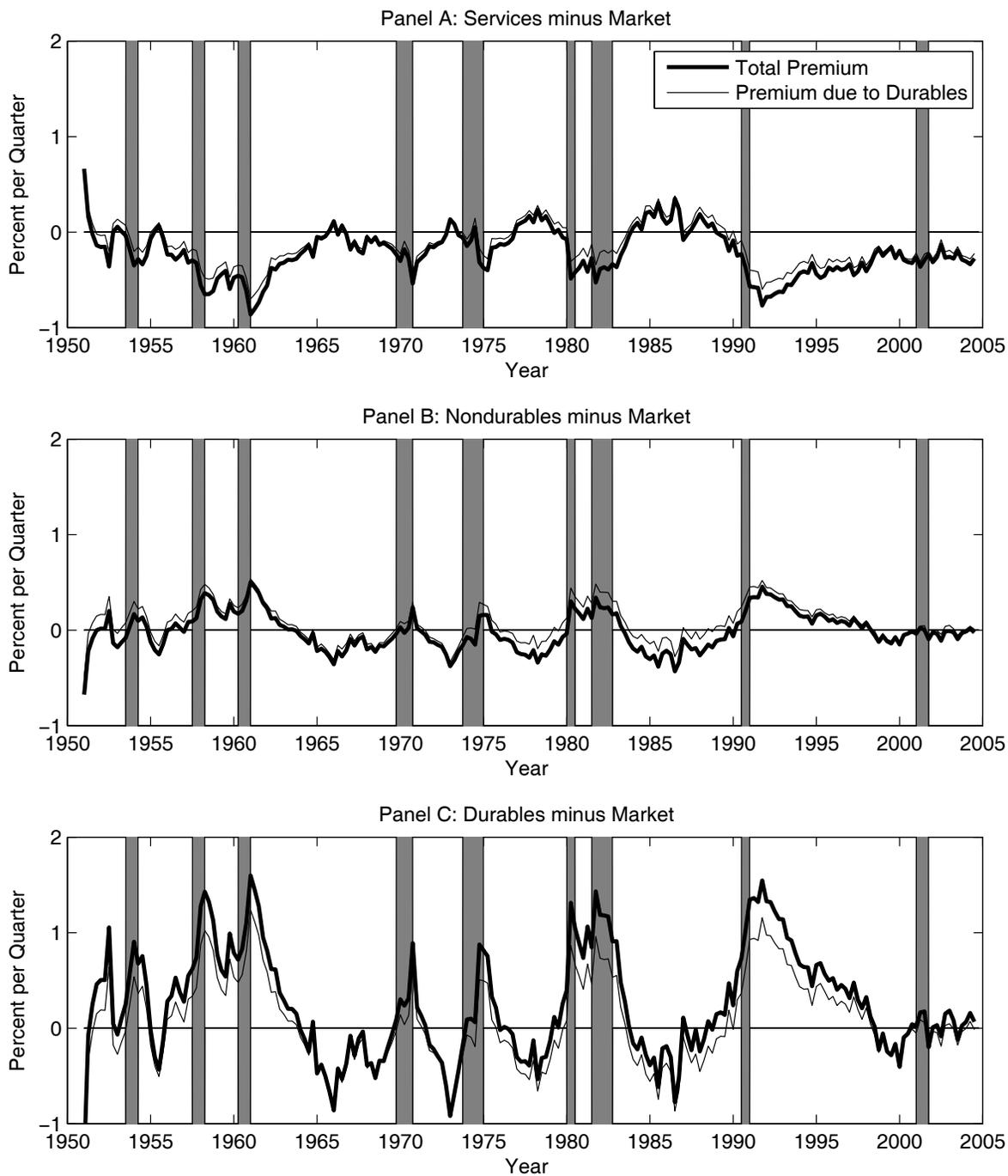


Figure 5: Time Variation in Expected Returns on the PCE Portfolios  
 The panels are time-series plots of expected excess returns on each of the PCE portfolios over the market return, implied by the regression model estimated in Table 12. The sample period is 1951:1–2004:3, and the shaded regions are NBER recessions.