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ESSAYS IN FINANCE AND PRODUCT MARKET

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ABSTRACT:

This dissertation consists of three essays which explorer the interaction between finance and product market choices. In the first essay, "A Corporate Finance Model with Customer Dynamics: The Leverage-Profitability Puzzle," I develop a dynamic trade-off model with quantity and pricing decisions where firms take into account their short term impact on profitability and long term impact on customer base. The model provides a novel mechanism that explains the leverage-profitability puzzle and makes new predictions about the leverage-profitability relation that are supported in the data.

In the second essay, "Quality versus Quantity Strategies in Product Markets," we study the strategies that monopolistic competitive firms follow as they respond to traditional shocks to technology and to quality-improving shocks. Our main modeling assumption is that demand is more sensitive to quality than it is to market share. This assumption is responsible for having quality shocks be the main driving force for most of what corporations do as opposed to traditional technology shocks. It also helps explain why firms with higher quality products have higher debt and lower credit spreads.

In the third essay, "Is Mismeasurement of Real Consumption Due to Product Turnover Relevant for Asset Prices?" I examine the long-standing equity premium puzzle, and test whether mismeasurement in real consumption due to ignoring quality changes embedded in product turnover has an effect. I find that the change in real consumption volatility is not sizable to account for the puzzle.

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First Chapter: A Corporate Finance Model with Customer Dynamics: The Leverage-Profitability Puzzle

Abstract

The negative empirical relation between leverage and profitability has been identified as the key evidence inconsistent with the trade-off theory of capital structure. The paper proposes a novel mechanism that reconciles the leverage-profitability puzzle with the trade-off theory. The model assumes that firms make pricing and quantity decisions that take into account their short term impact on profitability and their long term impact on customer base and market share. These decisions impact debt choices because a firm with better long term prospects can accumulate more debt. Simulation results from a calibrated version of the model are consistent with regressions of leverage on profitability. The model offers other predictions that I also bring to the data.

1 Introduction

In the trade-off theory of capital structure, firms balance the tax benefits of debt against expected bankruptcy costs in determining their optimal leverage. Profitable firms are expected to use more debt due to the lower expected bankruptcy costs. However, it is well documented in empirical studies that more profitable firms tend to have lower leverage ratios, conditional on firm size. Myers (1993, p. 83) argues that the negative relation between profitability and leverage is “the most telling evidence against the static trade-off theory.” Fama and French (2002, p. 30) also regard it as the “one scar on the trade-off theory.”

A variety of trade-off models have been developed to tackle the leverage-profitability puzzle, most of which focus on the adjustment costs of capital structure and assume firm cash flows are exogenous (e.g., Strebulaev, 2007). However, empirical support for these theories is less than satisfactory (e.g., Chen and Zhao, 2005; Eckbo and Kisser, 2020). This paper instead approaches the puzzle by relaxing the assumption of exogenous firm cash flows to study the interaction between finance and the business risk of the firm. I develop a trade-off capital structure model with endogenous firm cash flows. In particular, the paper argues that firms set prices and quantities strategically to grow their customer base in response to positive productivity shocks, affecting the tradeoff between interest tax shields and expected bankruptcy costs in the process.

Firms face monopolistic competition and operate in customer markets where consumers form external habits at the individual good level. The stock of habit represents a firm’s customer base or market share and derives from the history of past sales. As consumers of a particular good prefer to at least maintain the same level of consumption of that good by force of habit, the firm obtains some measure of pricing power from its customer base. The pricing decision of the firm becomes dynamic because of the intertemporal effect of current sales on future demand via the customer base. The firm may choose low prices or high quantities to boost market share and secure future customers at the cost of current profits. Financing decisions are made simultaneously by weighing the marginal benefit of tax deductibility of interest against the expected bankruptcy costs associated with rising leverage.

In the model, the relationship between leverage and profitability responds to productivity shocks via two channels. The first channel coincides with the conventional argument of the trade-off theory: A positive shock to productivity increases profitability and reduces expected bankruptcy costs causing the firm to lever up, giving rise to the usual prediction that leverage should be positively related to profitability. The model with endogenous customer base in this paper generates a second channel in which leverage and profitability move in opposite directions. I refer to this as the customer base channel. Following a positive productivity shock, in order to extend the benefits of the shock over time, the firm increases production in an aggressive manner to grow its customer base, which induces the firm to set lower prices and cut into profitability. In the meantime, the firm is able to borrow more against stronger expected sales backed by a larger customer base. Therefore, leverage increases while profitability is sacrificed as the customer base builds with the propagation of the positive productivity shock.

The two-channel framework is able to capture well the empirical relationship between leverage and profitability. Empirical studies confirming the leverage-profitability puzzle include firm size as a control variable, but once firm size is dropped from regressions explaining leverage, the correlation between leverage and profitability becomes insignificant. This suggests that the puzzle to be addressed is why, when comparing firms of equal size, the one with lower profitability has higher leverage. In a calibration of the model that matches key moments of the economy, there exists a significant negative relationship between leverage and profitability when holding firm size constant, but the relationship turns positive without the size control. Intuitively, following a positive productivity shock, the first channel dominates as both leverage and profitability increase due to improved productivity, creating a simple positive correlation. However, the coefficient of profitability becomes negative with size included in the regression because the size control absorbs the positive relation generated by the conventional channel, leaving the remaining relationship to be captured by the customer base channel that predicts a negative relation.

The model produces new predictions directly linked to the firm's customer base that can be tested in the data. First, incentives to build a customer base are stronger in industries with greater product differentiation. I proxy product differentiation with advertising expenditures and find that industries with product differentiation display a stronger everage-profitability relation. Second, the model predicts that firms with more persistent sales growth should display a more negative relation between leverage and profitability. In the model. As firms become more efficient in smoothing out productivity shocks via the customer base, sales growth is more persistent. Therefore, greater persistence of sales growth is associated with a strengthening of the customer base channel inducing a more negative leverage-profitability relationship. I provide evidence consistent with this prediction.

My paper is most closely related to the literature that studies the leverage-profitability puzzle. One well-developed explanation builds on the adjustment costs of leverage. Dynamic trade-off models such as Fischer, Heinkel, and Zechner (1989) and Goldstein, Ju, and Leland (2001) show that adjustment costs induce firms to allow variation in their leverage ratio before reaching boundaries that trigger refinancing. Fama and French (2002) recognize the possibility that the negative relation between leverage and profitability can be partly explained by transitory variation in leverage caused by swings in profits. Without refinancing, an increase in current profitability raises prospects for future profitability and in turn increases firm value, causing a decrease in leverage. Strebulaev (2007) provides a calibrated model and shows, in simulated data, that firms that do not refinance dominate, resulting in the observed negative relationship between leverage and profitability.

Several papers expand the set of financing choices by distinguishing between internal and external equity. Hennessy and Whited (2005) develop a dynamic model of investment and financing with equity issuance costs and a lower tax rate on capital gains than that on dividends, effectively giving internal equity an advantage over external equity. In their model, profitable firms are more likely to consider issuing debt for distributions to shareholders, while unprofitable firms are more likely to decide whether to issue debt or equity to fund investment. It follows that debt is less attractive in the former case. Lewellen and Lewellen (2006) emphasize the role that different tax treatment of capital gains and dividends plays in the results of such dynamic models. The distinction between internal and external equity resembles that of the pecking order theory potentially contributing to the reconciliation of the negative leverage-profitability relation in a trade-off framework.

Empirical evidence suggests that these explanations are not enough to resolve the leverage-profitability puzzle. Chen and Zhao (2005) show empirically that the negative relation between leverage and profitability survives after controlling for adjustment costs and tax environments. They point out that there could exist other interpretations of the trade-off theory that explain the puzzle, but the extensions based on adjustments costs and tax considerations are far from fully accounting for the negative relation. Danis et al. (2014) find a positive association between leverage and profitability when firms rebalance leverage by distributing cash to shareholders, consistent with the costly adjustment argument. However, Eckbo and Kisser (2020) show that the positive relation only exists when firms finance shareholder distributions by drawing down internal cash. Leverage is still negatively related to profitability when firms distribute to shareholders by issuing debt, which incurs much higher transaction costs than drawing down internal cash. All in all, existing extensions of the trade-off theory based on costly adjustment and differential taxation of internal and external equity appear insufficient to resolve the leverage-profitability puzzle.

The paper also contributes to a strand of literature that studies the interactions of firms' product market and debt choices. A related line of work argues that due to limited liability, debt becomes a strategic device that commits the firm to certain product market behavior (e.g., Maksimovic, 1988; Lyandres, 2006). Bronnerberg et al. (2012) and Foster et al. (2016) show that customer base is an important feature of the US economy. A growing number of papers use customer base to generate and explain interesting results. Albuquerque et al. (2019) argue that investment in corporate social responsibility grows the customer base and reduces firm risk. Gourio and Rudanko (2014) show that customer capital accumulation leads to a dampened response in capital investment to shocks.

The remainder of the paper is organized as follows. Section 2 presents the model. Section 3 discusses the calibration of the model, and reports the policy functions and impulse responses. Section 4 shows that under reasonable parameter values, the model generates regression results that are consistent with the data. The section also provides additional predictions from the model which are supported empirically. Section 5 concludes.

2 Model

This section introduces a standard trade-off model of capital structure, which is augmented with customer base in product markets. Firms make pricing and quantity decisions that affect both current profitability and future customer demand. Cash flows generated endogenously interact with firms' borrowing choices, driving the relationship between leverage and profitability. I describe the problem of households and that of firms, and provide a definition of the general equilibrium.

2.1 The Household Problem

There exists a continuum of identical households in the economy with lifetime utility incorporating deep habits formulated by Ravn et al. (2006). In particular, each household forms external habits across individual goods, indexed by $i \in [0, 1]$. The household, indexed by $j \in [0, 1]$, maximizes its expected lifetime utility given by

$$E_0 \sum_{t=0}^{\infty} \beta^t \; u(x_t^j, \; h_t^j), \tag{1}$$

where β is the time discount factor, h_t^j is the household's labor supply, and u denotes the period utility the household derives from consumption and leisure. The consumption composite x_t^j that accounts for habit formation is defined as

$$x_t^j = \left[\int_0^1 \left(\frac{c_{it}^j}{(s_{it-1})^{\theta}} \right)^{1-\frac{1}{\eta}} di \right]^{\frac{1}{1-\frac{1}{\eta}}}, \tag{2}$$

where c_{it}^j denotes the consumption of good i by household j in period t and s_{it-1} is the habit stock in consuming good i in period $t-1$. The parameter $\eta > 1$ is the intratemporal elasticity of substitution across goods which is constant between each pair of goods. Higher η implies that consumers are more sensitive to the relative prices of goods reducing the firm's pricing power.

The habit stock represents customer base for firm i, which all households take as given and evolves according to

$$s_{it} = s_{it-1}^{\rho} c_{it}^{1-\rho}. \tag{3}$$

The parameter θ measures the willingness of consumers to maintain consumption close to their habits. With a greater θ, demand for a good becomes more dependent on the habit stock, giving more pricing power to the firm and increasing the value of customer base. The parameter ρ measures the speed of adjustment of a good's habit stock to its current consumption. For small ρ, the habit stock is more heavily affected by current consumption of the good rather than the history of past consumption. Put differently, consumers grow attached faster and place more emphasis on their recent purchases.

The household consumes and saves from its labor income, bond holdings, and dividend earnings, subject to the budget constraint

$$\int_0^1 p_{it} c_{it}^j di + \frac{1}{1+r_t} b_{t+1}^j \leq \int_0^1 d_{it}^j di + w_t h_t^j + b_t^j, \tag{4}$$

where b_t^j is household j's bond holding at the beginning of period t, r_t is the risk-free rate in period t, and d_{it}^j is the dividend paid to household j by firm i. Because there are no aggregate shocks, w, r, and $\tilde{p}$ are constant. For simplicity, I remove the subscript of these prices henceforth.

Following Greenwood, Hercowitz, and Huffman (1988), I assume the period utility u to be of the form

$$u(x_t^j,\ h_t^j) = \frac{1}{1-\gamma}\left(x_t^j - \kappa \frac{\left(h_t^j\right)^{1+\varphi}}{1+\varphi}\right)^{1-\gamma}. \tag{5}$$

The parameters γ and κ measure households' relative risk aversion and labor disutility, respectively. The parameter φ is equal to the inverse of Frisch elasticity of labor supply.

Households allocate income across goods by minimizing the expenditure for any level of consumption x^j. Specifically, they face the following static problem

$$\tilde{p}x_t^j \equiv \min_{c_{it}^j} \int_0^1 p_{it} c_{it}^j di, \tag{6}$$

subject to the aggregation constraint (2). Solving the cost minimization problem, the demand for good i is given by

$$c_{it}^j = \left(\frac{p_{it}}{\tilde{p}}\right)^{-\eta} s_{it-1}^{\theta(1-\eta)} x_t^j. \tag{7}$$

Since the elasticity of substitution η is greater than 1, the parameter θ governing the good-level habit formation is negative so that a high level of habit induces households to consume more of the good.

Given the demand function (7), the minimal expense to consume one unit of x_t^j is

$$\tilde{p} = \left[\int_0^1 \left(p_{it} s_{it-1}^{\theta} \right)^{1-\eta} di \right]^{\frac{1}{1-\eta}}. \tag{8}$$

The price index is a geometric average of the individual prices weighted by habit stock of the goods.

Having solved the static expenditure minimization problem, the household's dynamic optimization problem can be rewritten as

$$\max_{\{x_t^j, h_t^j, b_{t+1}^j\}} E_0 \sum_{t=0}^{\infty} \beta^t \frac{1}{1-\gamma} \left(x_t^j - \kappa \frac{\left(h_t^j\right)^{1+\varphi}}{1+\varphi} \right)^{1-\gamma} \tag{9}$$

$$s.t.\ \tilde{p} x_t^j + \frac{1}{1+r} b_{t+1}^j \leq \int_0^1 d_{it}^j di + w h_t^j + b_t^j. \tag{10}$$

Combining the FOCs for consumption and labor supply gives

$$\kappa \left(h_t^j \right)^{\varphi} = \frac{w}{\tilde{p}}. \tag{11}$$

Labor supply is completely determined by the relative prices of leisure and the consumption composite. It is a feature of Greenwood-Hercowitz-Huffman preferences that there is no wealth effect in labor supply and that labor supply only responds to the real wage rate.

Denoting m_{t+1} as the stochastic discount factor, it can be shown that

$$m_{t+1} = \beta \frac{\left(x_{t+1}^{j} - \kappa \frac{\left(h_{t+1}^{j}\right)^{1+\varphi}}{1+\varphi}\right)^{-\gamma}}{\left(x_{t}^{j} - \kappa \frac{\left(h_{t}^{j}\right)^{1+\varphi}}{1+\varphi}\right)^{-\gamma}}. \tag{12}$$

The Euler equation that decides bond allocation is

$$1 = E_t[m_{t+1}(1 + r_t)]. \tag{13}$$

The equilibrium interest rates can be determined from the above standard Euler equation.

2.2 The Firm Problem

Each good i is manufactured by a monopolistically competitive firm that maximizes the discounted value of free cash flows. The firm's problem can be summarized as

$$\max_{\{y_{it}, p_{it}, h_{it}, b_{i,t+1}\}} E_0 \sum_{t=0}^{\infty} m_t d_{it} \tag{14}$$

$$\begin{aligned} s.t. \quad d_{it} &= (1-\tau)(p_{it} y_{it} - w h_{it}) + \frac{1}{1+r} b_{it+1} - b_{it} \\ &\quad + \tau r b_{it+1} - (1-\tau) \frac{1}{\nu} \left(\frac{b_{it}}{p_{it} y_{it}} \right)^{\nu} p_{it} y_{it}, \end{aligned} \tag{15}$$

where y_{it} is output of firm i, p_{it} is the price of good i, h_{it} is the labor input, and b_{it} is the debt balance at the beginning of period t.

Equation (15) illustrates the firm's flow of funds. The free cash flow in period t, d_{it}, consists of four components: income from sales, net debt issuance, tax saving from interest deductions, and cost of leverage. Cost of leverage, the last term in (15), mimics the expected bankruptcy costs and can be considered as the extra interest that the firm has to pay due to credit risk. Intuitively, a firm's borrowing contraint depends on its ability to generate cash flows, consistent with Albuquerque and Hopenhayn (2004). This reduced-form specification follows Glover, Gomes, and Yaron (2011) and allows for mathematical simplification. The parameter ν determines the magnitude of expected bankruptcy costs.

In production, the firm faces the demand schedule aggregated from the continuum of households

$$y_{it} \equiv \int_0^1 c_{it}^j dj = \left(\frac{p_{it}}{\tilde{p}}\right)^{-\eta} s_{it-1}^{\theta(1-\eta)} x_t, \tag{16}$$

where $x_t \equiv \int_0^1 x_t^j dj$ is the aggregate consumption of the habit-adjusted composite. Labor is the sole production factor and the production function is

$$y_{it} = (a_{it} h_{it})^{\alpha}, \tag{17}$$

where a_{it} denotes firm productivity that is subject to idiosyncratic productivity shocks. The parameter α measures the degree of returns to scale.

The firm's optimization problem can be written in recursive notation:

$$V(s_{it}, b_{it}, a_{it}) = \max_{\{y_{it}, p_{it}, h_{it}, b_{it+1}\}} (1-\tau)(p_{it}y_{it} - wh_{it}) + \frac{1}{1+r}b_{it+1} - b_{it} + \tau r b_{it+1}$$
$$-(1-\tau)\frac{1}{\nu}\left(\frac{b_{it}}{p_{it}y_{it}}\right)^{\nu} p_{it}y_{it} + E\left[m_{t+1}V(s_{it+1}, b_{it+1}, a_{it+1})\right] \tag{18}$$

$$s.t. \quad s_{it} = s_{it-1}^{\rho} c_{it}^{1-\rho} \tag{19}$$

$$y_{it} = \left(\frac{p_{it}}{\tilde{p}}\right)^{-\eta} s_{it-1}^{\theta(1-\eta)} x_t \tag{20}$$

$$y_{it} = (a_{it}h_{it})^{\alpha} \tag{21}$$

The labor demand can be obtained straight from the production function so the paper solves the problem using the FOCs with respect to y_{it}, p_{it} and b_{it+1}. Attach multiplier ζ_{it} to equation (20). The FOC with respect to y_{it} is

$$(1-\tau)\left[\left(1 + (1-\frac{1}{\nu})(\frac{b_{it}}{p_{it}y_{it}})^{\nu}\right)p_{it} - \frac{1}{\alpha}\frac{w}{a_{it}}y_{it}^{\frac{1}{\alpha}-1}\right] + E_t\left[m_{t+1}V_s(t+1)\right](1-\rho)s_{it-1}^{\rho}y_{it}^{-\rho} = \zeta_{it} \tag{22}$$

As shown in (22) the marginal benefit of an additional unit of output ζ_{it} consists of two components. The first term on the left-hand side is the increase in current sales net of bankruptcy costs and production costs. The second term represents the benefit of increasing the customer base.

The FOC with respect to p_{it} gives

$$(1-\tau)\left[1 + (1-\frac{1}{\nu})(\frac{b_{it}}{p_{it}y_{it}})^{\nu}\right]y_{it} - \eta\zeta_{it}\frac{y_{it}}{p_{it}} = 0. \tag{23}$$

The first term indicates the benefit of a unit increase in the price, which is the extra revenue from selling at a higher price. The benefit is offset by a decrease in the quantity that the firm is able to sell. As the second term shows, the decline in revenue is given by the product of the decrease in quantity $\eta \frac{y_{it}}{p_{it}}$ and the marginal benefit of output ζ_{it}. As elasticity of substitution η increases, the firm loses more sales from a price increase.

The choice of debt is governed by

$$\tau r = E_t \left[m_{t+1}(1-\tau) \left(\frac{b_{it+1}}{p_{it+1} y_{it+1}} \right)^{\nu - 1} \right] \tag{24}$$

The firm balances the benefit of interest tax shield, i.e., the term on the left-hand side, against the marginal increase in expected bankruptcy costs discounted to today.

2.3 Equilibrium Definition

The paper studies the stationary recursive competitive equilibrium for this economy where the distribution of firms is constant over time. Because each firm has a different history of idiosyncratic productivity shocks, the cross-section of firms features different levels of productivity, debt, and habit stock. A stationary competitive equilibrium can then be defined as a set of stationary processes $\{h^*_{it}, b^*_{it}, y^*_{it}, p^*_{it}, s^*_{it}\}$ and aggregate variables $(x^*, h^*, b^*, \tilde{p}^*, w^*, r^*)$ where

1. A continuum of identical households solve their utility maximization problem in (9). The solution to (9) is (x^*, h^*, b^*) given prices $(w^*, \tilde{p}^*, r^*)$.

2. Each firm producing a differentiated good solves the optimization problem in (18). The solution to (18) is $(h_i^*, b_i^*, y_i^*, p_i^*, s_i^*)$ given $(x^*, \tilde{p}^*, w^*, r^*)$.

3. All markets clear:

   - In the labor market

   $$h_t \equiv \int_0^1 h_t^j dj = \int_0^1 h_{it} di.$$

   - In the product market: $c_{it} = y_{it}$, and

   $$x_t = \left[\int_0^1 \left(\frac{c_{it}}{s_{it-1}^{\theta}} \right)^{1-\frac{1}{\eta}} di \right]^{\frac{1}{1-\frac{1}{\eta}}}.$$

   - In the bond market

   $$b_t \equiv \int_0^1 b_t^j dj = \int_0^1 b_{it} di.$$

3 Model Solution

In the absence of an analytical solution to the model, I calibrate the model and solve it numerically. In this section, I discuss the model calibration and present the policy functions and impulse responses. An examination of how firm's policies respond to productivity shocks sheds light on the novel customer base channel.

3.1 Calibration

I calibrate the model to represent the US economy. A period in the model is set to represent one year, avoiding seasonal fluctuations in sales. The time discounting factor β is set to 0.95, implying an annual risk free rate of 5%, which is close to the average 12-month LIBOR rate since 1986. The relative risk aversion parameter σ is set to 5, following the literature on consumption asset pricing. I choose the elasticity of substitution across goods η to equal 3, which is consistent with estimates by Broda and Weinstein (2006).

There are two parameters governing labor choices. I set φ to 1, which implies a Frisch elasticity of labor supply of 1, within the range of estimates in Reichling and Whalen (2012). I set κ to 2.5 so that households devote about a quarter of their time to work on average, consistent with studies on time allocation.

The degree of returns to scale α is set to 0.9 to obtain a reasonable level of gross margin ratio. Persistence and volatility of idiosyncratic productivity shocks follow estimates from Khan and Thomas (2008).

Corporate tax rate is set to 40%, close to the average of maximum tax rates between 1971 and 2018, while the cost of leverage parameter ν is calibrated to be 10 to deliver an average leverage ratio of 0.184.

The parameters governing deep-habit formation are central to the quantitative analysis of the leverage-profitability relation. I pick $\theta = -0.25$ and $\rho = 0.25$ so that the average mark-up, i.e., price over marginal cost, is around

1.2 (Jauregui, 2019) and that persistence of sales is comparable to that in the data.

Table 1 summarizes my parameter choices.

[Table 1 about here.]

3.2 Summary Statistics

Table 2 displays summary statistics under the baseline parameterization and in the data. I follow the literature and use the annual Compustat database. I exclude financial firms (SIC codes 6000 to 6999) and utilities (SIC codes 4900 to 4999). The sample consists of observations without missing data on the variables of interest. Variables of interest are debt, market equity, sales, cost of goods sold, and earnings before interest and taxes. The final sample has 206,024 annual observations over the period 1971 to 2018. I perform a 5% winsorization in both tails of the distribution to remove outliers.

Panel A reports the moments that I intend to match in the calibration process. In the baseline calibration, the model produces moments that are in proximity to those observed in the data. Average market leverage generated by the model is 0.184, close to the median market leverage of the Compustat sample, which is 0.173. Mark-up, the gross margin ratio and hours worked are also close to those in the data. Persistence of sales is higher in the model but the data estimate tends to be understated as firms with shorter time series are overweighted when calculating this statistic. These parameters are within two standard deviations of the sample mean.

Panel B lists other moments calculated using data simulated by the model to compare to the Compustat firms. The average interest coverage ratio and debt-to-EBITDA ratio are slightly higher in the calibrated model than the empirical estimates, but stay well within one standard deviation of the Compustat average levels. Since firms in the model do not own capital or any tangible asset, I use the sum of debt and distributions to shareholders as a proxy for book assets to calculate asset turnover for the simulated data. Asset turnover in the model is also close to the average asset turnover across the Compustat firms.

[Table 2 about here.]

3.3 Optimal Firm Policies

In this section, I present the firm's policy functions evaluated at the mean productivity level to show how firms with different levels of borrowing and customer base finance and make pricing and production decisions in customer markets.

As shown in Panel A of Figure 1, output increases with current debt. The first order condition in (22) states that current debt affects output choices via the expected bankruptcy costs that are decreasing in sales. As current debt increases, firms produce more to increase sales in order to lower the expected bankruptcy costs. Moreover, output is more sensitive to debt for firms with lower levels of customer base. Because the cost function is convex, there is a greater benefit in increasing customer base at low levels of customer base. When customer base is high, firms rather increase prices than increase output as would be expected of a monopolist. Output generally increases with customer base because customer base shifts the demand function outward allowing firms to sustain high prices without a sharp decline in demand. However, the opposite relation between output and customer base is observed at high debt levels when the objective of lowering bankruptcy costs dominates, causing firms to aggressively increase output to prop up sales at the cost of monopoly profits.

In general, price moves in the opposite direction of output given the downward-sloping demand function. However, it is worth noting that price and output both increase with customer base when debt levels are not extremely high because firms with a larger customer base are able to sell more to attached customers without cutting prices, behaving more like a monopolist.

In terms of optimal debt choices in Panel C, firms with a larger customer base are able to borrow more because the expectation of high price and high output reduces the expected bankruptcy costs. Debt choices also increase with current debt levels because firms with more debt produce more as previously noted, generating greater growth in the customer base which raises expected sales and allows for more borrowing. This also explains the mirror images of debt and future customer base choices. Furthermore, at low levels of customer base, debt choices are more sensitive to current debt levels. As argued earlier, due to the decreasing marginal benefit of customer base, firms with low customer base increase output more aggressively as current debt increases. Based on the evolution of habit, this leads to a more significant increase in future customer base and borrowing.

Panel E and Panel F of Figure 1 show that there exists a negative correlation between leverage and profitability especially when firms have high current debt and low customer base. The plot for output policy best explains this observation. Aggressive expansion in production is expected at high levels of current debt due to high expected bankruptcy costs, and at low levels of customer base due to decreasing returns to customer base. Firms that produce more aggressively have to set relatively lower prices as constrained by the demand functions, giving up some monopoly profits. On the other hand, more output leads to a larger customer base in the future and an increase in sales projections, raising debt capacity and leverage.

[Figure 1 about here.]

3.4 Impulse Response to a Productivity Shock

To understand how customer base affects the relationship of leverage and profitability in an otherwise standard trade-off model of capital structure, it is helpful to examine the responses of firm variables to idiosyncratic productivity shocks, the only source of uncertainty that firms are subject to in the model. I plot the impulse responses for firms with average levels of debt and customer base.

Figure 2 compares the customer base model and an identical model without customer base. The latter model demonstrates how firm policies respond to shocks in standard trade-off models and serves as a benchmark to identify the effects of the customer base channel. The conventional channel, which is present in both models, entails the following. When a positive productivity shock hits, the firm increases output on impact due to a decrease in marginal costs. Price declines as the firm faces a downward sloping demand function. Equity surges reflecting the good news and debt rises as expected future cash flows increase and expected bankruptcy costs decrease.

However, in the model with customer base, output responds more aggressively than in the model without customer base, due to the firm's incentive to build its customer base. Customer base becomes more valuable following the positive shock as the firm can produce more at lower costs. In order to extend the benefit of the shock, the firm increases output more than it would in the absence of customer base, to grow its customer base and secure stronger future demand. It also explains the hump in the output response. In the meantime, as shown in the response of prices, customer base increases the firm's monopoly power allowing for a smaller cut in prices despite increasing output more aggressively.

In Panel E of Figure 2, because customer base augments the demand function and makes firms behave more like monopolists, firm profitability experiences a more significant increase than in the model without customer base. Due to the role that customer base plays in the propagation of the positive productivity shock, a hump shape is observed in both firm profitability and leverage. The firm expands aggressively and cuts into profitability to grow its customer base causing a delay in the peak of profitability. In contrast, profitability in the model without customer base spikes on impact and returns to normal quickly due to the lack of demand dynamics. Leverage leads profitability in response as the increase in the firm's customer base allows for more borrowing.

[Figure 2 about here.]

Figure 3 offers more clarity on the impact of customer base on the relationship between leverage and profitability the way in which it is studied in the literature. Previous tests explaining capital structure include firm size as a determinant, because the trade-off theory also argues that bigger firms are less risky and should have higher leverage ratios. Therefore, I plot residuals from regressions of the impulse responses of leverage and profitability on sales. The dynamics of these residuals should be more closely connected to the relation between leverage and profitability conditional on size.

On the left, the customer base model, represented by the solid line, shows a decline in profitability after size is controlled for. This is because once size absorbs the increase in profitability generated by the conventional channel, a significant increase in output induced by the customer base channel sacrifices the firm's short term profitability for long term customer demand. On the right, I show the response of leverage after adjusting for size. Expectations of high sales due to growth in the firm's customer base enable the firm to carry more leverage in the model with customer base. Therefore, following the positive shock, leverage and profitability move in opposite directions when the conventional channel that predicts a positive relation is mostly accounted for by size. In contrast, the model without customer base, represented by the dashed line, only generates short-lived responses in profitability and leverage. The residual relation between leverage and profitability after controlling for size remains positive.

[Figure 3 about here.]

4 Cross-Sectional Regression Analysis

4.1 The Leverage-Profitability Puzzle

In this section, I conduct a cross-sectional test on simulated data generated by the calibrated model. Previous studies on the determinants of leverage consistently include size and profitability as factors appearing to affect capital structure.[1] The negative relation between leverage and profitability is only significant when firm size is accounted for in regressions explaining leverage. Table 3 performs regressions of leverage on lagged size and lagged profitabil-

[1] See for example Titman and Wessels (1988), Rajan and Zingales (1995), Fama and French (2002), Baker and Wurgler (2002), and Frank and Goyal (2009).

ity. In the first two columns, I report the regression results using Compustat data as reference. Following the literature, leverage is measured as the ratio of debt to the sum of debt and market equity. Size is the logarithm of sales and profitability is the ratio of earnings before interest and taxes (EBIT) to sales. Since EBIT is equal to gross margin in my model, I also measure profitability as the ratio of gross margin to sales for robustness. All regressions in the paper include firm and year fixed effects, and standard errors are clustered by both firm and year and are reported in parentheses. The evidence confirms the usual result in the literature. Since profitable firms are expected to have lower expected bankruptcy costs and benefit more from interest tax shield, the literature traditionally interprets the negative coefficient of profitability as evidence against the trade-off theory.

The third column reports the regression based on simulated data from the model with customer base, whereas the last column presents results from the model without customer base. Regression results in Column 3 are consistent with those observed in the data. However, the model without customer base generates a positive coefficient of profitability consistent with the prediction of a standard trade-off model. The last two columns demonstrate that the customer base channel gives rise to a negative relation between leverage and profitability.

It is also interesting that in the regressions using Compustat data, leverage is more negatively related to the ratio of gross margin to sales than the ratio of EBIT to sales, implying that a significant portion of the negative coefficient is contributed by variation in the gross margin ratio. Since pricing has important implications for a firm's gross margin, it becomes more reasonable to endogenize firm cash flows with dynamic pricing decisions in understanding the interaction of leverage and profitability.

[Table 3 about here.]

4.2 The Leverage Regressions and Product Differentiation

The model also provides new predictions directly linked to the firm's customer base. I argue that incentives to build a customer base are stronger in industries with greater product differentiation. According to the marketing literature, there exists a positive association between brand loyalty and product differentiation (e.g., Wernerfelt, 1991; Dick and Basu, 1994). On one hand, firms differentiate their products to increase customer loyalty. On the other hand, product differentiation has much the effect of customer loyalty in terms of charging monopoly prices. Therefore, I expect a more negative relation between leverage and profitability in industries with greater product differentiation.

I sort 4-digit SIC industries by advertising expenditures and classify industries with above average advertising expenditures as industries with product differentiation. The regression results are reported in Table 4. The interaction term between profitability and the dummy variable for industries with product differentiation illustrates the impact of product differentiation on the leverage-profitability relation. The economic magnitude is significant. Relative to industries without product differentiation, industries with product differentiation show a leverage-profitability relation that is about twice as strong, regardless of the measure of profitability.[2]

[Table 4 about here.]

4.3 The Leverage Regressions and Sales Growth Persistence

The model also predicts that firms with more persistent sales growth exhibit a stronger negative relation between leverage and profitability. In the model, as the parameter governing persistence of customer base ρ decreases, firms are more effective in building their customer base by adjusting current production, which strengthens the customer base channel. As firms actively smooth out productivity shocks using the customer base, sales growth becomes more persistent. Therefore, I use persistence of sales growth as a proxy for the parameter of customer base persistence ρ. Higher sales growth persistence should be associated with a stronger negative leverage-profitability relationship, which is consistent with regressions in Panel A of Table 5.

The first two columns measure profitability as the ratio of EBIT to sales, while the last two columns use the gross margin ratio. In Columns 1 and 3, persistence of sales growth is an indicator variable that takes on 1 if firms

[2] I also use the measures of market concentration and product similarity calculated by Hoberg & Phillips (2016) as proxies for product differentiation. In untabulated results, the coefficients of the proxies are insignificant but have signs consistent with predictions from my model.

have above median serial correlation of sales growth, whereas in Columns 2 and 4, it is equal to the serial correlation of sales growth for the firm. According to Column 1, firms with above median persistence of sales growth show a negative leverage-profitability that is about 50% stronger.

Panel B reports regressions using simulated data assuming different values of ρ. As the parameter for persistence of customer base ρ decreases, the coefficient of profitability becomes more negative. In untabulated results, ρ is found to be negatively correlated sales growth persistence based on simulations.

[Table 5 about here.]

4.4 Alternative Parameterizations

The following section demonstrates model results under alternative parameterizations. Table 6 summarizes the coefficient of profitability in leverage regressions as well as the first moment of leverage using simulated data. Under each parameterization, I change one parameter value and keep the other parameter values the same as the baseline parameterization in Table 1.

This exercise produces additional predictions that potentially can be tested. For example, when the corporate tax rate decreases from 45% to 35%, leverage is more negatively related to profitability in simulated data. However, it should be noted that capital structure choices depend on a set of factors. Ideal tests of these predictions require holding the other relevant factors that are not being tested constant. In addition, it is difficult to obtain reliable proxies for parameters relating to habit-adjusted demand such as θ and η.

In panel B, a lower value of ν is associated with high cost of leverage. It is natural that average leverage is lower when expected bankruptcy costs are high. Moreover, higher cost of leverage increases the value of customer base, as high expectations of sales backed by a larger customer base reduce expected bankruptcy costs, which motivates firms to increase output more to build a customer base at the cost of current profitability and leads to a more negative coefficient of profitability. The same reasoning holds for a tax rate decrease, in which case interest tax shield becomes less attractive tilting the trade-off toward reducing expected bankruptcy costs.

As shown in Panel C, a decrease in η attenuates the coefficient of profitability. Equation (7) shows that demand for the good benefits less from building a customer base as η decreases. The intuition is that the boost in demand from growing the firm's customer base is limited when customers are reluctant to substitute across goods.

When θ is equal to zero, the model is reduced to the model without customer base. Therefore, it is reasonable that when θ approaches zero, the negative relation between leverage and profitability becomes less significant, as the customer base channel is weakened.

As the parameter of returns to scale α increases in Panel E, the production function becomes less concave. The marginal benefit of customer base also decreases at a lower rate, strengthening the customer base channel and predicting a more negative leverage-profitability relationship. When idiosyncratic shocks become more persistent and volatile, the value of customer base increases because it is more important for firms to smooth out shocks with the customer base. Hence, I observe more negative coefficients of profitability with higher values of ρ_ϵ and σ_ϵ. The comparative static with respect to the time discount factor is similar to the reasoning of tax rate and cost of leverage: Firms have to offer higher interest rates when consumers with lower β are less willing to save, which increases tax savings from interest expenses. Firms thus care less about growing their customer base to reduce expected bankruptcy costs. The negative relation generated by the customer base channel is significantly attenuated.

[Table 6 about here.]

5 Conclusion

The literature interprets the observed negative relationship between profitability and leverage as critical evidence against the trade-off theory of capital structure. Although model extensions have been developed, mainly based on adjustment costs and distinction between internal and external equity, the empirical puzzle remains unsettled. This paper recognizes the interactions of product market and capital structure decisions, and presents a standard trade-off model with endogenous cash flows where firms produce and set prices balancing the short term impact on profitability and long term impact on customer base. In the model, the leverage-profitability relationship is determined via two channels: a conventional channel that predicts a positive relationship, and a novel customer base channel predicting a negative one. Firms increase output aggressively following positive productivity shocks in order to grow their customer base at the cost of current profitability. My model predicts that the size control in leverage-profitability regressions absorbs the conventional channel, whereas the customer base channel is responsible for the negative coefficient of profitability in regressions explaining leverage. The model also predicts that the leverage-profitability relationship should be more significant for firms with greater product differentiation and more persistent sales growth, consistent with the data.

References

[1] R. Albuquerque and H. A. Hopenhayn, "Optimal lending contracts and firm dynamics," *Review of Economic Studies*, vol. 71, no. 2, pp. 285–315, 2004.

[2] R. Albuquerque, Y. Koskinen, and C. Zhang, "Corporate social responsibility and firm risk: Theory and empirical evidence," *Management Science*, vol. 65, no. 10, pp. 4451–4469, 2019.

[3] M. Baker and J. Wurgler, "Market timing and capital structure," *The Journal of Finance*, vol. 57, no. 1, pp. 1–32, 2002.

[4] B. J. Bronnenberg, J.-P. H. Dubé, and M. Gentzkow, "The evolution of brand preferences: Evidence from consumer migration," *The American Economic Review*, vol. 102, no. 6, pp. 2472–2508, 2012.

[5] L. Chen and X. S. Zhao, "Profitability, mean reversion of leverage ratios, and capital structure choices," *Working Paper*, 2005.

[6] A. Danis, D. A. Rettl, and T. M. Whited, "Refinancing, profitability, and capital structure," *Journal of Financial Economics*, vol. 114, no. 3, pp. 424–443, 2014.

[7] A. S. Dick and K. Basu, "Customer loyalty: Toward an integrated conceptual framework," *Journal of the Academy of Marketing Science*, vol. 22, pp. 99–113, 1994.

[8] B. E. Eckbo and M. Kisser, "The leverage-profitability puzzle revisited with costly rebalancing," *Working paper*, 2020.

[9] E. F. Fama and K. R. French, "Testing trade-off and pecking order predictions about dividends and debt," *The Review of Financial Studies*, vol. 15, no. 1, pp. 1–33, 2002.

[10] E. O. Fischer, R. Heinkel, and J. Zechner, "Dynamic capital structure choice: Theory and tests," *The Journal of Finance*, vol. 44, no. 1, pp. 19–40, 1989.

[11] M. Z. Frank and V. K. Goyal, "Capital structure decisions: Which factors are reliably important?," *Financial Management*, vol. 38, pp. 1–37, 2009.

[12] F. Gourio and L. Rudanko, "Customer capital," *The Review of Economic Studies*, vol. 81, no. 3 (288), pp. 1102–1136, 2014.

[13] B. Glover, J. F. Gomes, and A. Yaron, "Corporate taxes, leverage, and business cycles," *Working Paper*, 2011.

[14] J. Greenwood, Z. Hercowitz, and G. W. Huffman, "Investment, capacity utilization, and the real business cycle," *The American Economic Review*, vol. 78, no. 3, p. 402, 1988.

[15] C. A. Hennessy and T. M. Whited, "Debt dynamics," *The Journal of Finance*, vol. 60, no. 3, pp. 1129–1165, 2005.

[16] G. Hoberg and G. Phillips, "Text-based network industries and endogenous product differentiation," *The Journal of Political Economy*, vol. 124, pp. 1423–1465, Oct 2016.

[17] A. Khan and J. K. Thomas, "Idiosyncratic shocks and the role of nonconvexities in plant and aggregate investment dynamics," *Econometrica*, vol. 76, no. 2, pp. 395–436, 2008.

[18] J. Lewellen and K. Lewellen, "Internal equity, taxes, and capital structure," *Working Paper*, 2006.

[19] E. Lyandres, "Capital structure and interaction among firms in output markets: Theory and evidence," *The Journal of Business*, vol. 79, no. 5, pp. 2381–2421, 2006.

[20] V. Maksimovic, "Capital structure in repeated oligopolies," *The RAND Journal of Economics*, vol. 19, no. 3, pp. 389–407, 1988.

[21] S. C. Myers, "Still searching for optimal capital structure," *Journal of Applied Corporate Finance*, vol. 6, no. 1, pp. 4–14, 1993.

[22] R. G. Rajan and L. Zingales, "What do we know about capital structure? some evidence from international data," *The Journal of Finance*, vol. 50, no. 5, pp. 1421–1460, 1995.

[23] M. Ravn, S. Schmitt-Grohe, and M. Uribe, "Deep habits," *Review of Economic Studies*, vol. 73, no. 1, pp. 195–218, 2006.

[24] F. Reichling and C. Whalen, "Review of estimates of the frisch elasticity of labor supply," *Working Paper*, 2012.

[25] R. Goldstein, N. Ju, and H. Leland, "An ebit-based model of dynamic capital structure," *The Journal of Business*, vol. 74, no. 4, pp. 483–512, 2001.

[26] I. A. Strebulaev, "Do tests of capital structure theory mean what they say?," *Journal of Finance*, vol. 62, no. 4, pp. 1747–1787, 2007.

[27] S. Titman and R. Wessels, "The determinants of capital structure choice," *The Journal of Finance*, vol. 43, no. 1, pp. 1–19, 1988.

[28] B. Wernerfelt, “Brand loyalty and market equilibrium,” *Marketing Science*, vol. 10, no. 3, 1991.

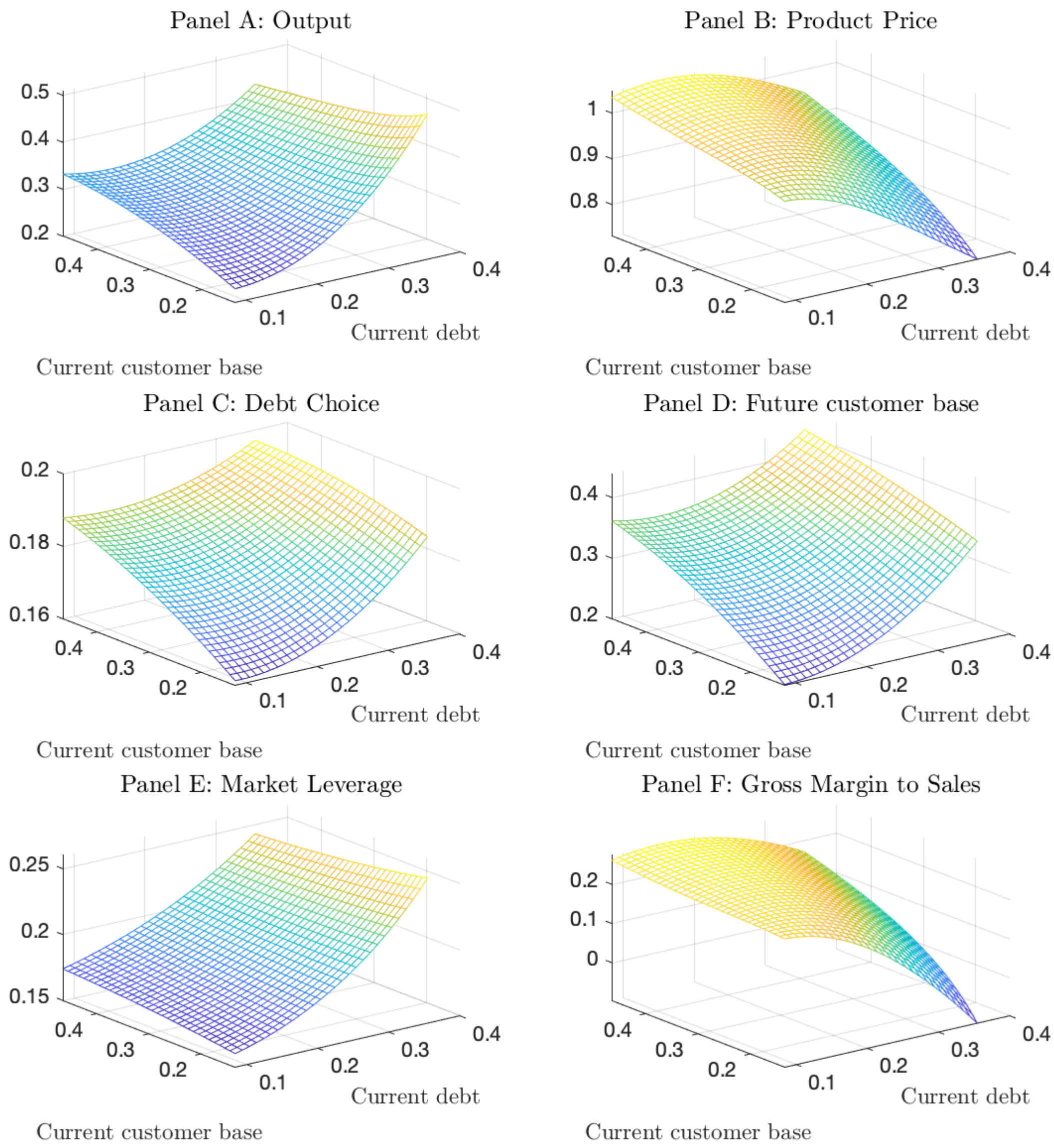


FIGURE 1

Optimal Firm Policies

Notes: The figure plots optimal firm choices as a function of customer base and debt for a firm at the mean productivity level.

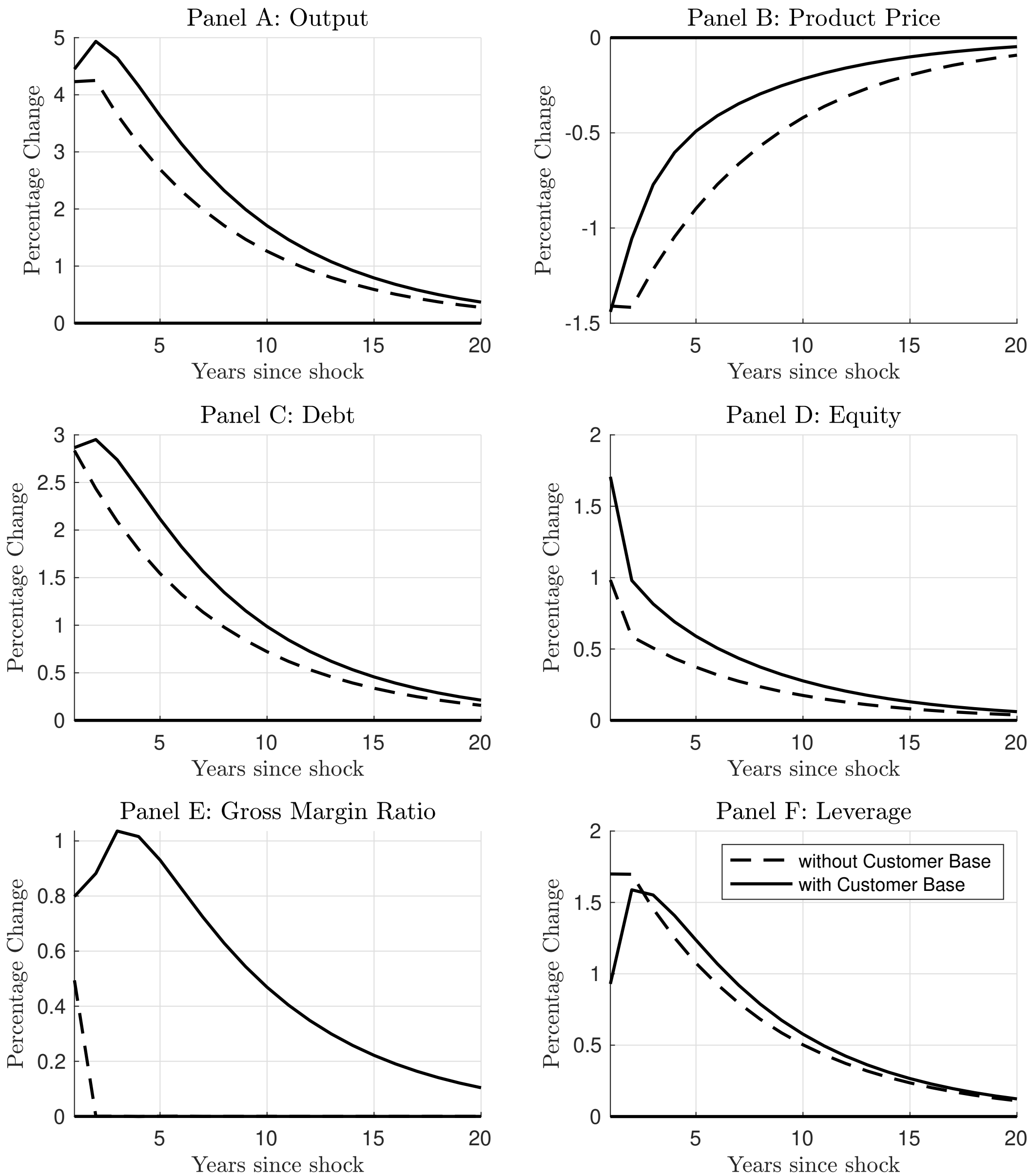


FIGURE 2

Impulse responses to a firm-level productivity shock

Notes: The responses are in percentage deviations from steady state. Solid line represents the model with customer base and dashed line represents the model without customer base.

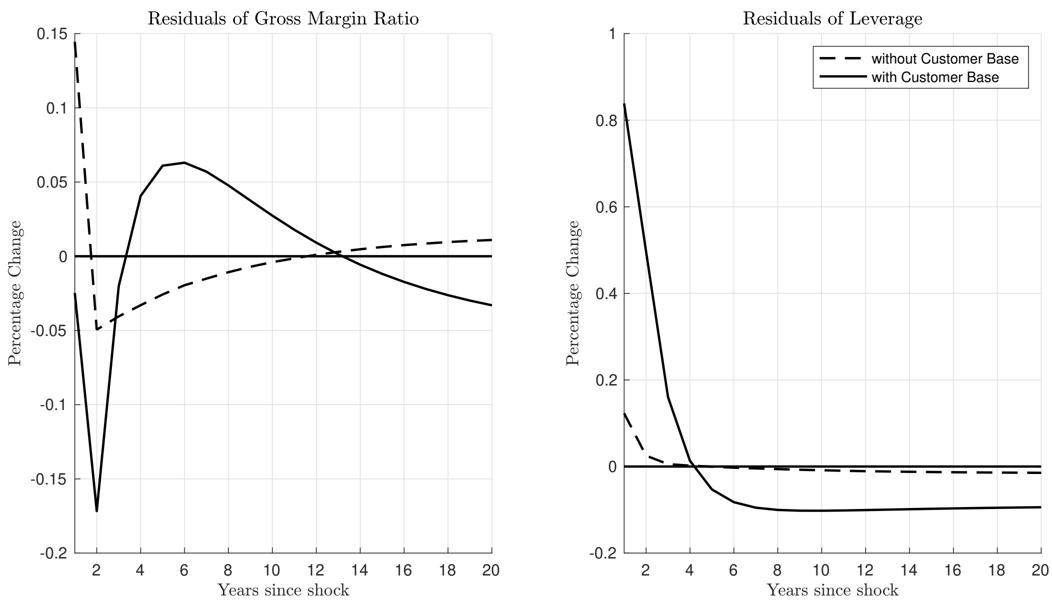


FIGURE 3

Adjusted impulse responses to a firm-level productivity shock controlling for sales

Notes: The responses are in percentage deviations from steady state. Solid line represents the model with customer base and dashed line represents the model without customer base.

TABLE 1

Calibration

	Parameter	Symbol	Value	Source
Demand	Time discount factor	β	0.95	Historic LIBOR rates
	Relative risk aversion	σ	5	Consumption asset pricing literature
	Elasticity of substitution across goods	η	3	Broda and Weinstein (2006)
Labor Supply	Frisch elasticity of labor supply	φ	1	Reichling and Whalen (2012)
	Labor disutility	κ	2.5	Hours worked per worker
Production	Persistence of productivity shock	ρ_ϵ	0.859	Khan and Thomas (2008)
	Volatility of productivity shock	σ_ϵ	0.022	Khan and Thomas (2008)
	Labor returns to scale	α	0.9	Gross margin ratio
Leverage	Corporate tax rate	τ	0.4	Historic US corporate tax rates
	Cost of leverage	ν	10	Market leverage
Customer Base	Persistence of habit stock	ρ	0.25	Persistence of sales
	Degree of habit formation	θ	-0.25	Mark-up

TABLE 2

Summary Statistics

	Data		Model
Variable	Mean	Std	Mean
Panel A: Targeted Moments			
Market leverage	0.246	0.243	0.184
Mark-up	1.36	0.295	1.197
Gross margin to sales	0.332	0.247	0.248
Serial correlation of sales	0.757	0.307	0.922
Time devoted to work	0.23		0.253
Panel B: Other Moments			
Asset turnover	1.146	0.747	1.355
Interest coverage ratio	6.015	26.439	8.150
Debt-to-EBITDA ratio	1.446	2.723	2.461
Serial correlation of gross margin to sales	0.494	0.374	0.866
Serial correlation of market leverage	0.495	0.345	0.929

Data come from the annual Compustat database following the literature. Financial firms and utilities are excluded. The sample contains observations without missing data on variables necessary to calculate leverage ratios and measures of profitability over the period 1971 to 2018. A 5% winsorization is performed to remove outliers.

Variable definitions: market equity = no. of shares outstanding (csho) × closing price (prcc_f); debt = long-term debt (dltt) + short-term debt (dlc); market leverage = debt / (debt + market equity); mark-up = price / marginal cost; gross margin = net sales (sale) - cost of goods sold (cogs); asset turnover = net sales / assets; interest coverage ratio = earnings before interest and taxes (ebit) / interest expense (xint); Debt-to-EBITDA ratio = debt / earnings before interest, taxes, depreciation, and amortization (ebitda)

TABLE 3

Regressions of Leverage

	Debt to Assets$_t$			
	In the Data		Model with Customer Base	Model without Customer Base
$Size_{t-1}$	0.031***	0.027***	0.073***	0.041***
	(0.002)	(0.002)	(0.000)	(0.000)
$Gross\ Margin\ to\ Sales_{t-1}$		-0.077***	-0.043***	0.106***
		(0.007)	(0.005)	(0.002)
$EBIT\ to\ Sales_{t-1}$	-0.022***			
	(0.002)			
# Firms	15,686	15,686	1,000	1,000
# Observations	183,264	183,277	100,000	100,000

The table reports results from panel regressions of market leverage. Simulated data from the model assume the baseline parameterization displayed in Table 1.
All regressions include firm and year fixed effects. Standard errors are clustered by firm and year and reported in parentheses. Statistical significance at the 1% level is indicated by three asterisks.

TABLE 4

The Leverage Regressions and Product Differentiation

Profitability Measure	EBIT to Sales	Gross Margin to Sales
	(1)	(2)
$Size_{t-1}$	0.031***	0.027***
	(0.002)	(0.002)
$Profitability_{t-1}$	-0.022***	-0.072***
	(0.002)	(0.007)
$Profitability_{t-1} \times Industry$	-0.018*	-0.097***
$with\ Product\ Differentiation$	(0.009)	(0.027)
# Firms	15,686	15,686
# Observations	183,264	183,277

This table reports regressions of leverage and the impact of product differentiation on the coefficient of profitability. Product differentiation is proxied by advertising expenditures over total assets. Industries with above average advertising expenditures over assets are classified as industries with product differentiation. I use the same Compustat dataset but the sample size decreases due to missing data on advertising. Profitability is measured as the ratio of EBIT to sales in Column 1 and the ratio of gross margin to sales in Column 2.

All regressions include firm and year fixed effects. Standard errors are clustered by firm and year and reported in parentheses. Statistical significance at the 1% (10%) level is indicated by three (one) asterisks.

TABLE 5

The Leverage Regressions and Persistence of Sales Growth

Panel A: In the Data				
Profitability Measure	EBIT to Sales		Gross Margin to Sales	
	(1)	(2)	(3)	(4)
$Size_{t-1}$	0.032***	0.032***	0.027***	0.027***
	(0.002)	(0.002)	(0.002)	(0.002)
$Profitability_{t-1}$	-0.019***	-0.023***	-0.062***	-0.075***
	(0.002)	(0.002)	(0.008)	(0.007)
$Profitability_{t-1} \times$	-0.010***	-0.015***	-0.041***	-0.071***
$Persistence\ in\ Sales\ Growth$	(0.004)	(0.004)	(0.011)	(0.013)
# Firms	12,271		12,271	
# Observations	172,081		172,094	

Panel B: With Simulated Data				
	More persistent sales growth $\longleftrightarrow$ Less persistent sales growth			
	$\rho = 0.15$	$\rho = 0.2$	$\rho = 0.25$	ρ=0.35
$Size_{t-1}$	0.079***	0.077***	0.073***	0.074***
	(0.000)	(0.000)	(0.000)	(0.000)
$Gross\ Margin\ to\ Sales_{t-1}$	-0.082***	-0.073***	-0.043***	-0.036***
	(0.006)	(0.004)	(0.005)	(0.004)

This table reports regressions of leverage and the impact of persistence of sales growth on the coefficient of profitability. Panel A use the Compustat data. Profitability is calculated as the ratio of EBIT to sales in Columns 1 and 2. Gross margin ratio is used in Columns 3 and 4. Persistence of sales growth is an indicator variable that takes on the value of 1 for firms with above median serial correlation of sales growth in Columns 1 and 3. Alternatively, it is equal to the serial correlation in sales growth in Columns 2 and 4. Panel B report regressions using simulated data generated by the model. All regressions include firm and year fixed effects. Standard errors are clustered by firm and year and reported in parentheses. Statistical significance at the 1% level is indicated by three asterisks.

TABLE 6

Alternative Parameterizations

	Coefficient of Profitability	*Mean of Leverage*
Panel A: Corporate tax rate		
$\tau = 0.35$	-0.067***	0.165
$\tau = 0.45$	-0.007	0.201
Panel B: Cost of leverage		
$\nu = 8$	-0.056***	0.180
$\nu = 12$	-0.038***	0.194
Panel C: Elasticity of substitution across goods		
$\eta = 2.5$	-0.003	0.142
$\eta = 3.5$	-0.163***	0.234
Panel D: Degree of habit formation		
$\theta = -0.2$	0.001	0.167
$\theta = -0.3$	-0.171***	0.205
Panel E: Labor returns to scale		
$\alpha = 0.85$	-0.023***	0.156
$\alpha = 0.95$	-0.093***	0.220
Panel F: Persistence of idiosyncratic productivity shocks		
$\rho_\epsilon = 0.8$	0.000	0.184
$\rho_\epsilon = 0.9$	-0.088***	0.184
Panel G: Volatility of idiosyncratic productivity shocks		
$\sigma_\epsilon = 0.01$	-0.013***	0.184
$\sigma_\epsilon = 0.03$	-0.058***	0.184
Panel H: Time discount factor		
$\beta = 0.9$	0.062***	0.402
$\beta = 0.98$	-0.036***	0.067

The table summarizes the coefficient of profitability in leverage regressions performed in the same manner as in Table 3 and the first moment of leverage in simulated data under alternative parameterizations.

Statistical significance at the 1% level is indicated by three asterisks.

Second Chapter: Quality versus Quantity Strategies in Product Markets

Abstract

This paper studies the strategies that monopolistic competitive firms follow as they respond to traditional shocks to technology and to quality-improving shocks. Firms that are buffeted by the former tend to invest relatively more on market share whereas firms that are buffeted by the later tend to invest more in quality. Our main modeling assumption is that demand is more sensitive to quality than it is to market share. This assumption is responsible for having quality shocks be the main driving force for most of what corporations do as opposed to traditional technology shocks. It also helps explain why firms with higher quality products have higher debt and lower credit spreads.

1 Introduction

Firms make investments in product attributes that appeal to customers by increasing the marginal utility they derive from consumption. For example, a firm may spend resources on creating an image of status associated with a product. A firm may also invest in corporate social responsibility as a way to build a clientele: by reducing its carbon footprint and advertising it, the firm may increase the utility that customers derive from its products (Servaes and Tamayo, 2013, and Albuquerque, Koskinen, and Zhang, 2019). A different strategy that firms pursue to influence customers is via an aggressive pricing policy. Examples of firms pursuing one or the other strategy abound, Whole Foods versus Market Basket in the retail distribution industry, T-Mobile versus Consumer Cellular in the phone carrier business, and Mercedes Benz versus Toyota in the car industry.

We introduce a model with firm heterogeneity where firms are hit by shocks to product quality and by traditional productivity-enhancing shocks. In the model, a high quality product delivers higher utility for the same number of units consumed relative to a low quality product. Thus, customers are willing to pay more for a higher quality product. Productivity-enhancing shocks instead allow the firm to produce more units at a lower cost. A firm that is hit by a positive product-quality shock chooses to allocate more resources to enhance its product quality earlier on and then to invest in growing a customer base later on. In contrast, a firm that is hit by a traditional productivity shock can best take advantage of it by aggressively lowering prices and expanding output. The model is thus able to capture the differential strategies that firms pursue.

The choices that firms make at the product level carry over to their financing. We show that firms that are hit by a product quality shock have more stable and more persistent cash flows and more stable and persistent debt levels and leverage relative to firms that are hit by a traditional shock to productivity of the same magnitude. This leads to a distribution of firms across quality and market share that depends on the debt levels of firms. Firms with higher quality products also are able to have higher market share and can borrow more, whereas firms with low product quality tend to have lower market share and lower debt. We solve for the general equilibrium of the model so that borrowing costs reflect the average performance of the firms in the economy. If the distribution of firms has greater mass of firms with high quality and high customer base, then there is more borrowing in equilibrium and the representative household optimally increases the interest rate. The general equilibrium allow us to address shocks to aggregate demand such as the COVID-19 pandemic shock.

Using the model solution, we construct a variance decomposition analysis. We are able to show that shocks to product quality explain a significantly higher portion of the firm's choices than traditional shocks to productivity. This is because the incentive to invest in quality after a shock to productivity is of second order of importance compared to the incentive to invest in growing the customer base directly. Growing customer base allows the firm to sell more in the future and in that way take advantage of its surge in productivity. However, the elasticity of demand to a higher customer base is much lower than the elasticity of demand to higher product quality, which we believe is a reasonable assumption. Thus, firm cash flow, and also firm debt are significantly more driven by quality shocks than they are by productivity shocks.

We then use the model to study how firms respond to a one-time shock of 30% to aggregate demand as was the case in the recent COVID-19 pandemic. In the model, output drops significantly due to a weaker demand. Firms lower prices to compete in these bad times. This evidence is consistent with the drop in the CPI for all urban consumers in the US of 0.4% in March of 2020, followed by a drop of 0.8% in April, and another drop of 0.1% in May. Firms also adjust product quality downwards consistent with evidence in Granja and Moreira (2021). However, the model shows that the adjustment to product quality is much smaller than the adjustment through prices. Firms prefer to adjust prices to weather temporary shocks to demand. Despite the significant drop in output, equity only sees a two percentage point decrease. The reason for the small drop in market equity values is that the discount rate is constant in the model, and so equity changes only due to variation in projected cash flows. One interpretation of this result is that most of the variation in equity prices observed in the stock market during the 'fever period' in February and March of 2020 was due to discount rate changes. On the financing side, debt goes down almost as much as output. In the data, we do not observe that corporate debt slowed down during COVID-19 pandemic as predicted by the model. One possible explanation is the absence in the model of the Fed whose policies kept liquidity abundant for corporations during the crisis. In that regard, our model provides a counterfactual to study the impact of the Fed interventions: had firms not been able to enjoy increased liquidity through the Fed, borrowing costs would have risen and debt would have fallen significantly.

Halling, Yu, and Zechner (2021) show that firms with high Environment, Social, and Governance performance have lower bond spreads, and that the effect is driven mostly by the product-related dimension of ESG.

The paper proceeds as follows. The next section provides a general equilibrium model with heterogeneous firms where firms can choose to grow through quality investments or by expanding quality through aggressive pricing. Section 3 provides a calibration of the model and Section 4 gives the model main results. Section 5 concludes the paper.

2 A simple model of quality and quantity choice

Time is infinite and indexed by $t = 0, 1, 2, ...$ The economy is populated by a continuum of identical households with mass one, by a continuum of heterogeneous firms on the unit interval, a financial intermediary, and a government. We index households with a superscript j and firms with a subscript i. We start by describing the problem faced by households.

2.1 Households

Households are both customers and investors in the economy. There is a representative household in the economy with lifetime preferences given by

$$E_0 \sum_{t=0}^{\infty} \beta^t \, u(x_t^j, \; h_t^j), \tag{1}$$

E_0 is the expectations operator conditional on information available at time 0, $\beta < 1$ is the discount factor, and period utility is

$$u(x_t^j, \; h_t^j) = \frac{1}{1-\gamma} \left[x_t^j - \kappa \frac{\left(h_t^j\right)^{1+\varphi}}{1+\varphi} \right]^{1-\gamma}. \tag{2}$$

Utility depends on an aggregate consumption good, x_t^j, and labor supply, h_t^j, where γ is the coefficient of relative risk aversion, $\varphi > 0$ is the elasticity of labor supply, and $\kappa > 0$ describes the relative disutility of labor.

Following Ravn et al. (2006), the consumption good is an aggregate of the consumption of a continuum of goods, where the household displays habit towards these goods:

$$x_t^j = \left[\int_0^1 a_{it} \left(\frac{c_{it}^j}{s_{it-1}^{\theta}} \right)^{1-\frac{1}{\eta}} di \right]^{\frac{1}{1-\frac{1}{\eta}}}. \tag{3}$$

The consumption of good i at time t by the household is c_{it}^j, a_{it} is the level of quality of good i at time t, and s_{it-1} is the habit stock in consuming good i at time $t-1$, with the last two taken as exogenous across households. Quality increases the benefit associated with the consumption of a marginal unit of the good and with $\theta < 0$ households demand more of the good with a higher habit level. The evolution of habit stock follows

$$s_{it} = s_{it-1}^{\rho} c_{it}^{1-\rho}, \tag{4}$$

where the parameter ρ determines the persistence of the stock of habit. Below, we shall refer to the habit stock as customer base.

The household's budget constraint is

$$\tilde{p}_t x_t^j + b_{t+1}^j \leq \int_0^1 d_{it} di + w_t h_t^j + (1 + r_t) b_t^j + \pi_t + T_t, \tag{5}$$

where $\tilde{p}_t$ is the price of the aggregate consumption basket, b_t^j is the amount of one-period bonds bought in period $t-1$ that mature at period t and earn an interest rate of r_t, d_{it} is the dividend paid by firm i at time t, w_t is the wage rate, π_t is the profit from the financial intermediation sector, and T_t is a government's tax rebate.

The household chooses $(c_{it}^j, b_{t+1}^j, h_t^j)$ to maximize (1), subject to the conditions (2) through (5). As part of this intertemporal decision, there is a static decision of how much to consume of each good. That problem solves

$$\tilde{p}_t = \min_{c_{it}^j} \int_0^1 p_{it} c_{it}^j di$$

subject to

$$\left[\int_0^1 a_{it} \left(\frac{c_{it}^j}{s_{it-1}^\theta} \right)^{1-\frac{1}{\eta}} di \right]^{\frac{1}{1-\frac{1}{\eta}}} \geq 1.$$

The solution to this problem is a demand function

$$c_{it}^j = \left(\frac{p_{it}}{\tilde{p}_t} \right)^{-\eta} s_{it-1}^{\theta(1-\eta)} a_{it}^\eta x_t^j.$$

Quality increases demand for the good because it increases the marginal benefit to consume the good. Customer base also increases demand provided $\eta > 1$. But with $\eta > 1$, unless θ is very large and negative, the elasticity of demand to quality is higher than the elasticity of demand to customer base.

The solution to problem also gives the price of unit of the basket x_t^j,

$$\begin{aligned} \tilde{p}_t &= \int_0^1 p_{it} c_{it} di \\ &= \left[\int_0^1 \left(p_{it} s_{it-1}^\theta \right)^{1-\eta} a_{it}^\eta di \right]^{\frac{1}{1-\eta}}. \end{aligned}$$

The rest of the household's optimization problem is given by the first order condition for the labor choice

$$\kappa(h_t^j)^{\varphi} = \frac{w_t}{\tilde{p}_t} \tag{6}$$

the Euler equation for the optimality of consumption

$$1 = E_t\left(m_{t+1}\right)\left(1 + r_t\right) \tag{7}$$

with the stochastic discount factor being

$$m_{t+1} = \beta \frac{\left(x_{t+1} - \kappa \frac{h_{t+1}^{1+\varphi}}{1+\varphi}\right)^{-\gamma}}{\left(x_t - \kappa \frac{h_t^{1+\varphi}}{1+\varphi}\right)^{-\gamma}} \frac{\tilde{p}_t}{\tilde{p_{t+1}}}. \tag{8}$$

2.2 Firms

Firm i is a monopolistic competitor and produces y_{it} that it sells at price p_{it} subject to the demand function

$$y_{it} = \left(\frac{p_{it}}{\tilde{p}_t}\right)^{-\eta} s_{it-1}^{\theta(1-\eta)} a_{it}^{\eta} x_t. \tag{9}$$

The firm uses h_{it}^1 labor input to produce its output and h_{it}^2 labor input to improve its quality. The two production functions are

$$y_{it} = \varepsilon_{it}(h_{it}^1)^{\alpha} \tag{10}$$

$$n_{it} = \upsilon_{it}(h_{it}^2)^{\psi} \tag{11}$$

and investment in quality, n_{it}, accumulates according to the equation

$$a_{it+1} = (1-\delta)a_{it} + n_{it}. \tag{12}$$

The productivity shock ε_{it} and the product-quality shock υ_{it} are independent, mean zero, auto-regressive processes of order 1 in logs.

Firms are owned by the households and because all households are identical, dividends are discounted using the stochastic discount factor, m_t. Firm i chooses $(h_{it}^1, h_{it}^2, y_{it}, p_{it}, n_{it}, b_{i,t+1}, a_{it+1})$ to maximize the expected discounted value of dividends

$$\sum_{t=0}^{\infty} m_t d_{it}, \tag{13}$$

subject to conditions (9) through (12) and with dividends equal to

$$\begin{aligned} d_{it} &= (1-\tau)(p_{it}y_{it} - w_t(h_{it}^1 + h_{it}^2)) + b_{it+1} - (1+\tilde{r}_{it})b_{it} \\ &\quad + \tau\tilde{r}_t b_{it} - \iota(b_{it+1} - b_{it})^2. \end{aligned} \tag{14}$$

Dividends equal the net of tax operating income plus the cash flow from increasing the level of debt and the tax advantage of debt, minus a cost of adjusting debt, with $\iota > 0$. The firm pays an interest rate on its debt of

$$\tilde{r}_t = r_t + \frac{1}{\nu}\left(\frac{b_{it}}{p_{it-1}y_{it-1}}\right)^{\nu}. \tag{15}$$

The credit spread paid by the firm is $\tilde{r}_t - r_t$. We define the credit spread exogenously as an increasing function of current borrowing and a decreasing function of revenues with ν being the elasticity of the credit spread to debt to revenues. This approach follows Gomes et al. (2016) and represents a reduced form for bankruptcy costs, without having to explicitly model firm default. Overall, the model is a dynamic version of the static trade-off theory (see also Zhang, 2021).

2.3 Financial intermediary

The financial intermediary is a passive agent. It borrows from the representative household at a risk free rate and invests with firms. It then returns profits that equal the sum of the expected bankruptcy costs and the refinancing costs to the household minus the debt repayment to the household,

$$\begin{aligned}\pi_t &= \int \left[(1+\tilde{r}_{it})b_{it} - b_{it+1} + \iota(b_{it+1}-b_{it})^2\right] \, di - \int \left[(1+r_t)b_t^j - b_{t+1}^j\right] dj \\ &= \int \left[\frac{1}{\nu}\left(\frac{b_{it}}{p_{it-1}y_{it-1}}\right)^{\nu} b_{it} + \iota(b_{it+1}-b_{it})^2\right] \, di, \end{aligned} \tag{16}$$

where the second equality follows from using the equilibrium condition that total firm debt equals total household lending.

Our focus is on the properties of the firm distribution and how firms respond to traditional productivity shocks and quality-improving shocks and these results to not depend on whether the costs of adjusting debt are rebated back to the household.

2.4 Government

The government transfers the tax proceeds from corporate profits in a lump sum fashion to the household sector,

$$T_t = \tau \int \left(p_{it} y_{it} - w_t (h^1_{it} + h^2_{it}) - \tilde{r}_{it} b_{it} \right) di \qquad (17)$$

2.5 Definition of equilibrium

In the competitive equilibrium of the economy, the household chooses $(c^j_{it}, b^j_{t+1}, h^j_t)$ to maximize (1), subject to the conditions (2) through (5), and given prices $(r_t, w_t, p_{it}, \tilde{p}_t)$, profits and dividends (d_{it}, π_t), and government transfers T_t. Firm i chooses $(h^1_{it}, h^2_{it}, y_{it}, p_{it}, n_{it}, b_{i,t+1}, a_{it+1})$ to maximize (13) subject to conditions (9) through (12) and equation (14), and given prices $(r_t, w_t, \tilde{p}_t)$. The financial intermediary pays profits given by equation (16) and the government pay transfers to households of (17). Finally, the bond market clears $\int b_{it} di = b^j_t$, the labor market clears $\int \left(h^1_{it} + h^2_{it} \right) di = h^j_t$, and the goods market clears for each good i, $c^j_{it} = y_{it}$.

3 Model calibration

In the absence of an analytical solution to the model, we calibrate the model and solve it numerically. This section discusses the parameter choices.

Table 1 lists all the model parameters and the calibrated values.

We set the time discounting factor β to 0.95, which fixes the each period in the model to be one year and the annual real interest rate to be 5%. The coefficient of relative risk aversion γ is set to 5, largely consistent with the literature on consumption-based asset pricing. We set the elasticity of substitution across goods η to 1.5, following Backus et al. (1994). The parameters κ and φ govern labor choices. φ is set to 0.6, so that the Frisch elasticity of labor supply equals 1.67, in accordance with Chetty et al (2011). κ is set to 1, implying that households on average spend a third of their time working.

Following Ravn et al. (2006), we set the degree of deep habit formation θ to -0.2 and the persistence of habit stock ρ to 0.8. Considering that labor is the sole variable factor of production, we set α to 0.95, in accordance with Basu and Fernald (1997)'s finding that a typical industry in the US has constant or slightly decreasing returns to scale. The persistence and volatility of the productivity shock are assumed in line with the estimates from Khan and Thomas (2008). As for the process of quality improvement, the depreciation rate of quality δ is set to 0.2, comparable to that of R&D stock in Hall et al. (2005). The parameter that determines the degree of returns to scale in quality improvement ψ is set to 0.5, which leads to an average R&D spending to sales of 6%, consistent with the US estimates (Business Research and Development, 2018). We assume for now that

Table 1: Model calibration

	Parameter description	Symbol	Value	Source
Demand	Time discount factor	β	0.95	Historical interest rates
	Relative risk aversion coefficient	γ	5	Consumption-based asset pricing literature
	Elasticity of substitution across goods	η	1.5	Backus et al. (1994)
Labor supply	Inverse of Frish elasticity of labor supply	φ	0.6	Chetty et al. (2011)
	Labor disutility	κ	1	Hours worked on average
Production	Returns to scale in production	α	0.95	Basu and Fernald (1997)
	Persistence of productivity shock	ρ_{ε}	0.85	Khan and Thomas (2008)
	Volatility of productivity shock	σ_{ε}	0.025	Khan and Thomas (2008)
Quality	Returns to scale in quality improvement	ψ	0.5	Average R&D to sales
	Depreciation of quality	δ	0.2	Hall et al. (2005)
	Persistence of quality shock	ρ_{ε}	0.85	
	Volatility of quality shock	σ_{ε}	0.025	
Customer base	Degree of deep habit formation	θ	-0.2	Ravn et al. (2005)
	Persistence of habit stock	ρ	0.8	Ravn et al. (2005)
Leverge	Corporate tax rate	τ	0.3	Graham (1996)
	Cost of leverage	ν	11	Market leverage

the persistence and volatility of the quality shock are the same as the productivity shock to facilitate comparison.

The corporate tax rate τ is set to 30%, consistent with estimates from Graham (1996). The parameter for cost of leverage ν is set to 11, which leads to an average debt to equity ratio of 0.1.

4 Results

4.1 Distribution of firms

We solve the calibrated model which features a stationary distribution of firms. The distribution of firms is over the full state space. Here, we focus on the distribution of firms over customer base, product quality, and borrowing.

[Figure 1 here]

Figure 1 shows the stationary distribution of firms along the dimensions of product quality, customer base, and borrowing. The top panel shows that firms with higher quality also tend to have higher customer base. This is because the firm's demand schedule (equation (9)) increases with both customer base and product quality. Both allow the firm to sustain high prices without significantly decreasing output. Moreover, the marginal benefit of increasing customer base is higher for firms with higher quality, and vice-versa, which makes quality and customer base complimentary. Firms with higher quality or customer base tend to borrow more since these firms generate more cash flows which reduces the cost of leverage. The middle panel is very similar to the top panel in that high quality firms tend to have higher debt and also higher customer base. However, there is an important difference between the top and the middle panels. By comparing the two panels, we can see that there is much more dispersion of firms along the quality dimension than along the customer base dimension. In the top panel, where we condition on high and low product quality, it can be seen that the equilibrium distribution of firms puts some weight on high product quality that also have low customer base firms and high debt and also on low product quality firms with high customer base and low debt. These are extreme versions of the Mercedes Benz- and the Toyota-like firms, respectively. Once we condition on top and bottom firms in terms of customer base, as done in the middle panel, there is much less dispersion across leverage and product quality.

The bottom panel conditions on debt-to-equity. There are a bit of all sorts of firms with low (high) debt, though mostly low (high) debt firms tend to have low (high) customer base and low (high) quality.

[Figure 2 here]

4.2 Impulse responses

Figure 2 plots the average firm's impulse response function following a one-standard deviation positive shock to production productivity. The blue line is for the model we study and the red line is for a similar type-firm that cannot adjust quality.

As the firm is able to produce more efficiently, it increases production. However, because it faces a downward-sloping demand function, the firm cuts prices in order for demand to absorb the higher production. The current increase in production also boosts customer base, which allows for higher prices in the future. Note however, that customer base does not increase nearly as much for the firm with fixed quality and output declines at a faster speed.

Investment in product quality also jumps on impact. Firms with high productivity but constrained by consumer demand invest in quality so that the firm can take advantage of the positive shock by producing more without significantly lowering the price in the future. Moreover, the increase in customer base also makes product quality more valuable as the firm can charge more consumers a higher price for its better product. The firm essentially extends the benefits of the shock over time via the slow build-up in customer base and quality.

Equity has a more persistent increase over time than the productivity shock due to the resiliency mechanism brought by customer base and quality. Because profitability tracks customer base, ROE also displays a hump-shape curve. Note also that there is a significant multiplier in equity when the firm is able to adjust quality.

The response of debt resembles that of customer base and product quality because the cost of borrowing depends on the firm's ability to generate cash flows from sales which is determined by the customer base and quality. Leverage also displays a hump-shape curve, which leads to a prediction that firms do not immediately increase leverage to a maximum following a positive shock, and that leverage peaks when the firm has built up it customer base with a high quality product in the product market. The credit spread decreases after a traditional productivity shock because the firm cannot immediately increase debt to match the increase in sales due to adjustment costs.

Figure 3 plots the average firm's impulse response function following a one-standard deviation positive shock to the product quality. Unlike in response to a productivity shock, the firm does not increase its output significantly on impact because quality investment takes time to affect customer demand. However, output indeed goes up on impact, accompanied by a small decrease in price, because quality and customer base are complementary. In anticipation of better product quality in the future, the marginal benefit of customer base increases for the firm, which induces the firm to sell more and grow its customer base pre-emptively.

[Figure 3 here]

There are three other important differences between quality shocks and traditional technology shocks. Despite the fact that both shocks have the same standard deviation and persistence, the magnitudes of the effects of the quality shock are much higher. This is because the elasticity of demand to quality improvements is much higher than that to customer base. That is, in the model, the customer has a much greater attachment to a product of high quality than she does to a product that is mass consumed. This differential elasticity drives the magnitude of the effects.

Another interesting difference is that with the quality shock, ROE decreases on impact. the reason is that the payoff to increasing quality is not immediate and the firm's profits are low as the firm invests in quality.

Finally, in response to a quality shock, the firm increases debt not because revenues are high currently, but because it wants to minimize adjustment costs in the future. This leads to a jump in the credit spread.

In summary shocks to product quality may come in the short run with low ROE and high credit spreads, whereas traditional shocks to productivity come with high ROE and low credit spreads.

4.3 Variance decomposition

Table 2 reports the variance decomposition of firm policies. Note that even though the two sources of uncertainty in the model follow identical stochastic processes, the effects of quality and productivity shocks in explaining these firm variables are quite different.

It is not surprising that much of the variation in product quality and investment in quality is driven by shocks to the quality investment technology. However, it is less obvious that quality shocks also contribute to the majority of variation in output and customer base, which normally would be expected to come from productivity shocks. This is because firms with positive shocks to productivity cannot take advantage by producing more without significantly decreasing prices and thus profit margins. Firms may aggressively expand production to grow its customer base and extend the benefits of positive productivity shocks, but positive shocks to increase product quality play a more dominant role since firms with higher quality

Table 2: Variance decomposition

(in percent)	Productivity shock	Quality Shock
Productivity ε	100	0
Product quality a	7.12	92.88
Quality investment n	6.76	93.24
Labor for quality inv. h^1	11.74	88.26
Labor for production h^2	11.66	88.34
Output y	22.97	77.03
Product price p	94	6
Customer base s	21.06	78.94
Debt b	11.61	88.39
Firm cash flow d	12.18	87.82
Equity v	10.2	89.8
Debt to equity $\frac{b}{v}$	10.56	89.44
Quality inv. technology υ	0	100

are able to sell more holding prices constant, and moreover increase their customer base. In other words, the production side uncertainty has less of an effect on firm product market choices due to customer demand that firms are subject to. It is also in line with the observation that variation in prices arises mostly from productivity shock, whereas quality shocks allow firms to adjust output without moving prices.

4.4 Assessing the implications from a demand shock to firm resilience

In this subsection, we study the effects that a one-time shock to aggregate consumption of -30% has on firm policies. This exercise is intended to capture the firm choices due to the COVID-19 pandemic.

[Figure 4 here]

Figure 4 shows the firms' responses following a negative shock to aggregate consumption. Output drops significantly due to a weaker demand by an amount that closely mimics the drop in aggregate consumption. To limit the decline in output, firms compete by lowering prices.

Labor allocated to production declined precipitously, accompanying the loss of output. However, labor allocated to quality investment declined much less so, one order of magnitude of difference. Likewise, customer base suffers a sharp decline, whereas product quality suffers a much smaller decline.

In the model, product quality is a resiliency device that allows firms to weather temporary shocks to demand much better than market share as given by customer base. The main reason for this result is that demand responds to quality much more than it does to customer base. It is therefore more important for the firm to preserve product quality than it is to preserve customer base.

Equity sees a moderate two percentage-point decrease. Since the discount rate is constant in our model, the variation in equity is completely to due to projected decreases in cash flows. This result offers a benchmark to the effect of the COVID-19 pandemic on equity without variation in the discount rate.

On the financing side, debt goes down almost as much as output, contributing to a significant decline in leverage. We did not observe that corporate debt slowed down during the COVID-19 pandemic as predicted in the figure. This could be explained by the fact that the Fed kept liquidity abundant for corporations. In that regard, our model also provides an interesting counterfactual to study the impact of the Fed interventions, had the firms not been able to enjoy low borrowing costs and continue issuing debt.

5 Conclusion

This paper studies the implications of traditional technology shocks and of quality-improving shocks to firm policies. The main modeling assumption is that demand is more sensitive to quality than it is to market share. This assumption is responsible for having quality shocks be the main driving force for most of what corporations do as opposed to traditional technology shocks. It also helps explain why firms with higher quality products have higher debt and lower credit spreads.

In future research we intend to explore the effect that negative shocks to quality, such as product scandals as the one that involved Volkswagen's emission controls or Perrier's water contamination and product recall, lead firms to change their leverage choices. On the reverse, we are also interested in exploring how corporate social responsibility about product quality increases customer resilience. How does the elasticity of demand change for firms that improve their CSR?

References

Albuquerque, R., Y. Koskinen, and C. Zhang (2019). Corporate social responsibility and firm risk: Theory and empirical evidence. *Management Science 65*, 4451–4469.

Backus, D. K., P. J. Kehoe, and F. E. Kydland (1994). Dynamics of the trade balance and the terms of trade: The j-curve? *the American Economic Review 84*, 84–103.

Basu, S. and J. G. Fernald (1997). Returns to scale in u.s. production: Estimates and implications. *Journal of Political Economy 105*, 249–283.

Chetty, R., A. Guren, D. Manoli, and A. Weber (2011). Are micro and macro labor supply elasticities consistent? a review of evidence on the intensive and extensive margins. *the American Economic Review 101*, 471–475.

Glover, B., J. F. Gomes, and A. Yaron (2011). Corporate taxes, leverage, and business cycles. Working paper, Carnegie Mellon University, Pittsburgh, PA.

Graham, J. R. (1996). Debt and the marginal tax rate. *Journal of Financial Economics 41*, 41–73.

Granja, J. and S. Moreira (2020). Product innovation and credit market disruptions. Working paper, University of Chicago, Chicago, IL.

Hall, B. H., A. Jaffe, and M. Trajtenberg (2005). Market value and patent citations. *The RAND Journal of Economics 36*, 16–38.

Halling, M., J. Yu, and J. Zechner (2021). Primary corporate bond markets and social responsibility. Working paper, University of Luxembourg, Luxembourg.

Khan, A. and J. K. Thomas (2008). Idiosyncratic shocks and the role of nonconvexities in plant and aggregate investment dynamics. *Econometrica 76*, 395–436.

Ravn, M., S. Schmitt-Grohé, and M. Uribe (2006). Deep habits. *Review of Economic Studies 73*, 195–218.

Servaes, H. and A. Tamayo (2013). The impact of corporate social responsibility on firm value: The role of customer awareness. *Management Science 59*, 1045–1061.

Zhang, X. (2021). A corporate finance model with customer dy- namics: The leverage-profitability puzzle. Working paper, Boston College, Boston, MA.

Figure 1: Stationary distribution of firms

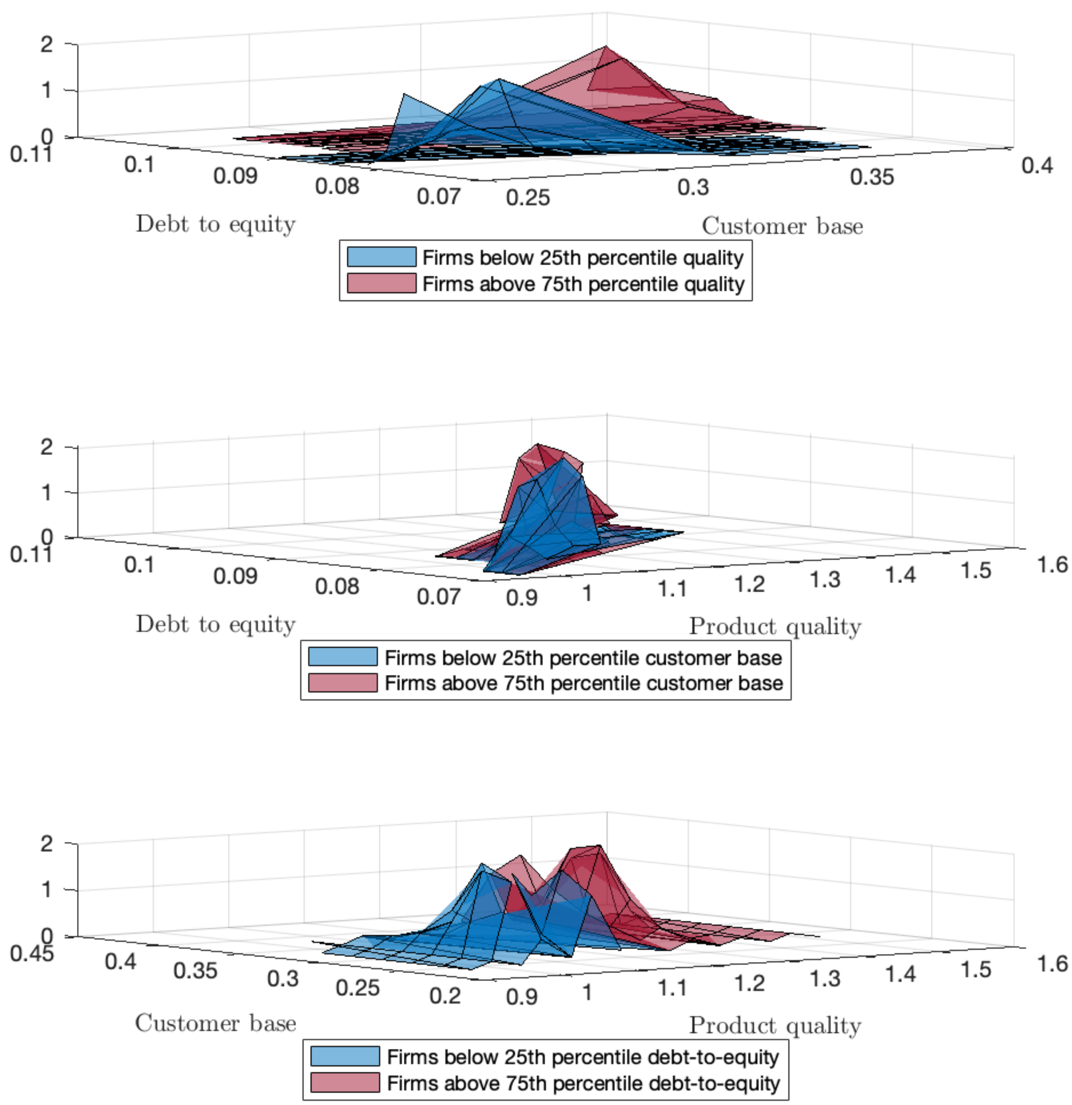


Figure 2: Impulse responses to a positive productivity shock

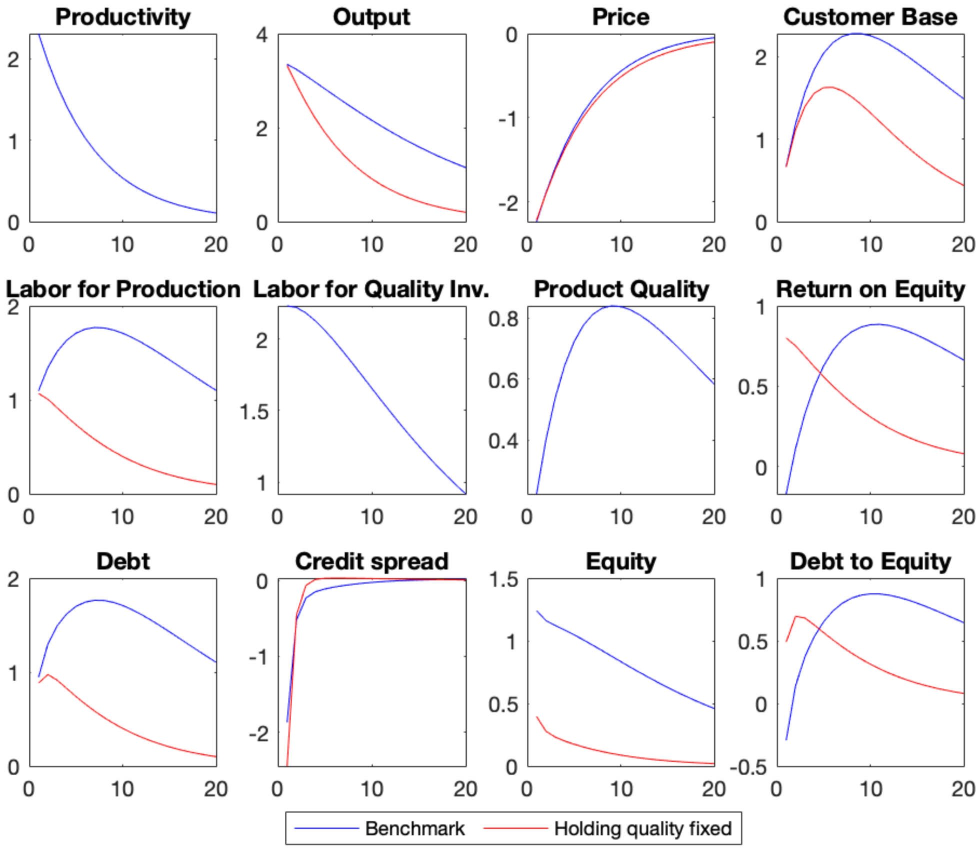


Figure 3: Impulse responses to a positive quality shock

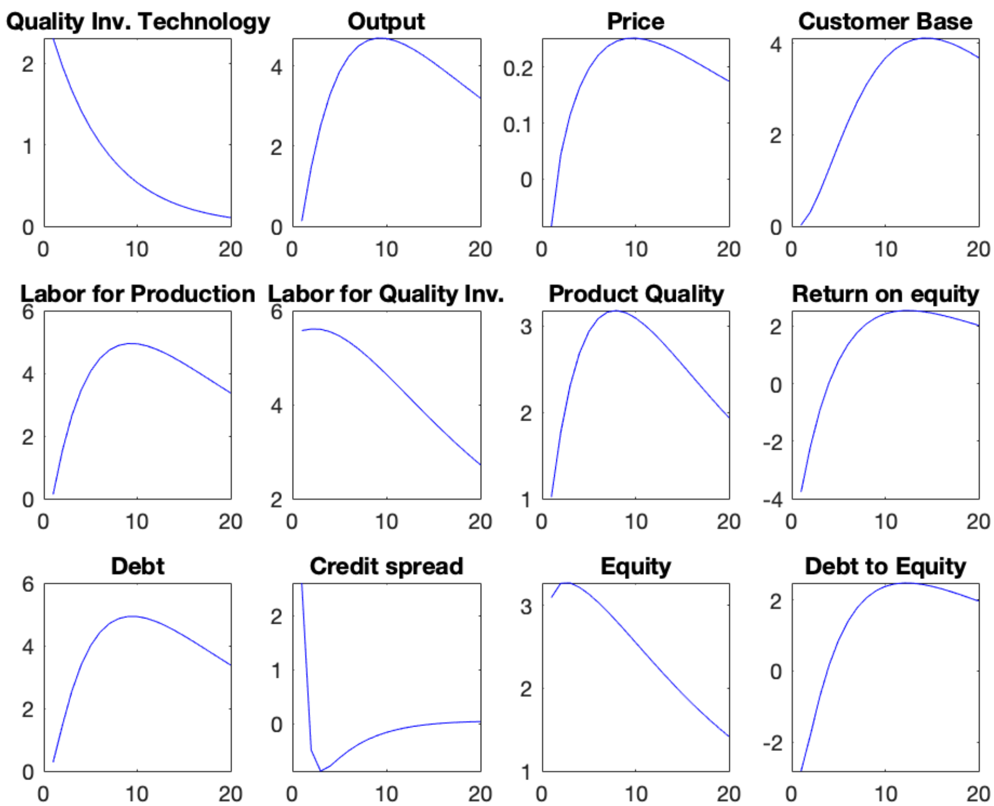
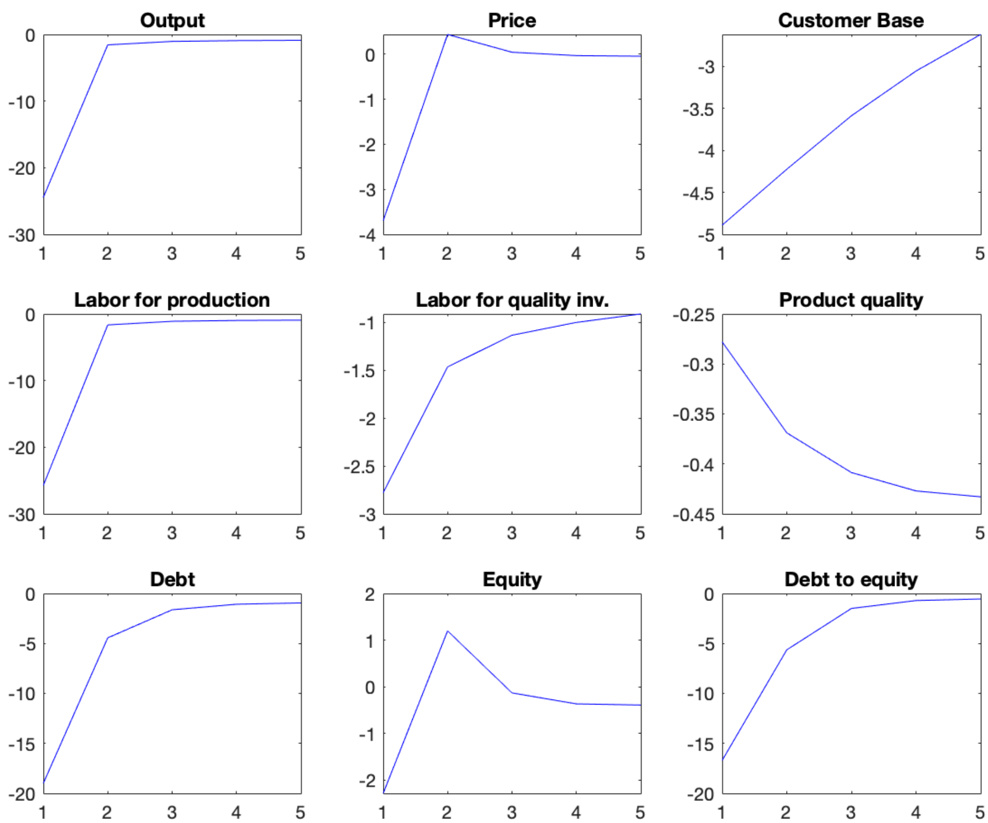


Figure 4: Firm policies following a demand decline
induced by the COVID-19 pandemic



Is Mismeasurement of Real Consumption Due to Product Turnover Relevant for Asset Prices?

Abstract

Empirical research finds little support for the standard consumption-based asset pricing model (CCAPM). Product turnover as a result of creative destruction embodies quality upgrading by Schumpeter (1942)'s argument, making it relevant for measuring real consumption. Adopting a recent approach to measuring the cost of living which accounts for changes in product variety in the consumer market, I test whether the poor performance of CCAPM comes from the fact that real consumption is mismeasured using the current fixed-basket price index. Per-capita real consumption growth is faster and more negatively skewed after adjusting for product turnover, while the volatility of consumption growth remains largely unchanged. Moreover, the adjustment does not improve the ability of consumption risk to explain the cross-section of equity returns.

1 Introduction

Consumption-based asset pricing models in theory provide an attractive explanation for the variation in expected returns across assets, where the risk ium is determined by an asset's exposure to consumption risk. As argued by Lucas (1978) and Breeden (1979), investors are willing to pay a higher price for assets that pay off during bad times when consumption declines. Therefore, assets that co-vary less with consumption fluctuations have higher insurance value and lower expected return in the cross-section. On the other hand, the empirical studies on consumption-based asset pricing tend to find rejections despite its theoretical appeal. Mehra and Prescott (1985) point out that the low volatility of consumption growth in the data cannot justify the high equity um. Consumption risk, measured by the covariance of asset returns and aggregate consumption on nondurables and services, also fails to explain the cross-section of expected asset returns (Mankiw and Shapiro (1986), Breeden, Gibbons, and Litzenberger (1989)).

Empirical evidence against the standard model leads to research that revises the underlying assumptions of the model. Models are developed for alternative specifications of preferences (Epstein and Zin (1989), Abel (1990), Constantinides (1990)). Some authors introduce features such as limited participation and incomplete markets (Mankiw and Zeldes (1991), Constantinides and Duffie (1996)). Closely related to this paper, a strand of literature studies the measurement error in proxies for aggregate consumption. Savov (2011) uses garbage to track consumption, which accounts for the informal sector and avoids the timing mismatch between expenditure-based measures and actual consumption. Jagannathan and Wang (2008) argue costly consumption adjustment and show that the fourth-quarter consumption growth is more informative as households are more likely to review their consumption choices for various end-of-year incentives. In Yogo (2006), nondurable consumption and durable consumption are nonseparable in the representative household's utility function. Hence, the conventional measure based on nondurable consumption is not a good indicator of the marginal utility of the agent.

In this paper, I study the potential mismeasurement in real consumption due to product turnover. Joseph Schumpeter argues in his book *Capitalism, Socialism and Democracy* that "the fundamental impulse that sets and keeps the capitalist engine in motion comes from the new consumers' goods, the new methods of production or transportation, the new markets, the new forms of industrial organization that capitalist enterprise creates" (Schumpeter, p.84). Hence, product turnover is an important embodiment of technological innovation that sustains economic growth. Given that the current price index used to deflate nominal consumption is based on a fixed basket of goods and does not adjust for quality upgrading during Schumpeter's creative destruction process, disregarding product turnover in the consumer market can potentially underestimate real consumption growth. The macroeconomic literature shows evidence that product creation and destruction account for a large share of aggregate consumption (Bernard, Redding, and Schott (2010), Broda and Weinstein (2010)). Therefore, the bias in the observed real consumption can be of large magnitude. Furthermore, Shleifer (1986) builds a model that explains business cycles with product turnover, where firms implement innovations and introduce new products when aggregate demand is high. Broda and Weinstein (2010) find evidence of procyclical net product creation.

Considering the interaction between business cycles and product turnover as well as the product quality implications of product turnover, I test whether the bias arising from product turnover in current measures of aggregate consumption is a reason for the limited success of the CCAPM in the empirical literature. I measure the product turnover bias in aggregate consumption by the difference in inflation calculated from price indexes with or without consideration of product turnover. The approach to constructing alternative price indexes follows Redding and Weinstein (2017). Data are from the Nielsen HomeScan database which contains information on the price, quantity, and relevant product characteristics of purchases made by a large sample of U.S. households from 2004 to 2015.

Between 2005 and 2015, accounting for product turnover increases the average per-capita real consumption growth by 3 percentage points per year but the volatility of real consumption growth remains unchanged. Interestingly, real consumption growth becomes more negatively skewed, as highlighted in the literature that features rare disasters in a consumption-based asset pricing model. However, it should be noted that the time series is too short to make robust inferences. Adopting Martin (2013)'s methodology, I estimate the equity premium using the adjusted sample moments of consumption growth and the predicted equity premium increases slightly, which is insufficient to resolve the equity premium puzzle.

In the cross section, I run regressions on the 25 Fama-French (1993) size and book-to-value portfolios and obtain the standard errors using GMM to correct for non i.i.d errors. The price of risk associated with exposure to the bias in consumption growth due to product turnover is insignificant and negative. The results suggest that measurement error in real consumption arising from product turnover is not responsible for the poor performance of the CCAPM. However, product turnover can still be relevant for asset prices in a general equilibrium setting, where firms' innovation process is also modeled.

The rest of the paper is organized as follows. Section II reviews the literature on consumption-based asset pricing and product turnover. Section III lays out the approach used to measure the bias in real consumption due to product turnover. Section IV describes the data and Section V presents empirical methodology and results. Finally, Section VI concludes.

2 Related Literature

The literature on consumption-based asset pricing relates returns to their exposures to changes in aggregate consumption. According to the standard model assuming time-separable power utility (Lucas (1978) and Breeden (1979)), the risk premium of an asset is determined by the covariance of its return and aggregate consumption growth to a first order approximation. Mankiw and Shapiro (1986) and Breeden, Gibbons, and Litzenberger (1989) compare the market CAPM and the CCAPM using different test assets over different sample periods. While the former paper finds evidence in favor of the market CAPM, the latter shows that the CCAPM performs as well as the market CAPM. Nevertheless, the CCAPM cannot explain the cross-section of expected returns in either case. Hansen and Singleton (1982) apply GMM to estimate the model and find rejections based on the overidentification test.

The less than satisfactory performance of the CCAPM leads to studies that relax the assumptions of the standard model. Some examine more general preference specifications. Epstein and Zin (1989) and Bansal and Yaron (2004) show that recursive utility functions can accommodate low interest rates and a high equity premium simultaneously by separating risk aversion and intertemporal elasticity of substitution. By modeling consumption growth with a predictable component, Bansal and Yaron (2004) resolve the asset pricing puzzles with a reasonable level of risk aversion. These papers evaluate their respective models based on calibration exercises, where a few moment conditions derived from the model are examined in the data. Subsequent research moves on to formal model estimation and testing. Abel (1990), Constantinides (1990), and Campbell and Cochrane (1999) work with preferences featuring habit formation.

Epstein and Zin (1991) and Campbell (1996) use proxies for the aggregate wealth portfolio to recover the pricing kernel for recursive utility and find mixed results. Parker and Julliard (2007) measure long run consumption risk as the covariance of returns and consumption growth over a long period following the return and show that their ultimate consumption risk measure explains the variation in expected returns as well as the Fama and French (1993) 3-factor model. Bansal, Gallant, and Tauchen (2007) take a simulation approach to estimating the habit model and the long-run risks model. They obtain plausible estimates of the preference parameters, and find that both models pass the overidentification test. Chen and Ludvigson (2009) apply a Sieve Minimum Distance procedure to estimate the functional form of habit formation and the other preference parameters at the same time. Their estimated habit function suggests habit formation is internal and generates a positive stochastic discount factor that prices the cross-section of stock returns better than the Fama-French 3-factor model.

Another strand of literature relaxes the representative agent assumption and points to the implications of investor heterogeneity in asset pricing. Constantinides and Duffie (1996) argue that heterogeneity in terms of uninsurable labor income shocks results in Euler equations that depend on aggregate consumption growth as well as the cross-sectional distribution of individual consumption growth. When the cross-sectional variance is negatively correlated with aggregate consumption growth, their incomplete markets model predicts a higher equity premium with lower risk aversion than the representative agent model, which is supported by the finding of countercyclical idiosyncratic income risk by Storesletten, Telmer, and Yaron (2004). With incomplete markets, the intertemporal marginal rate of substitution across households does not converge. Brav, Constantinides, and Geczy (2002), Cogley (2002) and Balduzzi and Yao (2007) use different approaches to aggregating individuals' Euler equations and report conflicting results on whether equity premium can be explained with plausible risk aversion. Some researchers investigate investor heterogeneity with regard to stock market participation. Mankiw and Zeldes (1991) find that the consumption of stockholders is more volatile and more significantly correlated with excess stock returns. Vissing-Jorgensen (2002) shows that distinguishing between stockholders and non-stockholders improves the performance of a consumption-based model with incomplete markets.

A set of papers consider alternative measures of aggregate consumption in empirical tests of the CCAPM. Dunn and Singleton (1986) and Yogo (2006) model the intraperiod consumer utility function as nonseparable in durable and nondurable consumption, which implies a linear factor model in durable and nondurable consumption growth. Savov (2011) adopts garbage as a novel measure of consumption, arguing that expenditure-based consumption measures ignore the informal factor and may have a timing mismatch with actual consumption. Jagannathan and Wang (2007) show that the fourth-quarter year-over-year consumption growth performs as well as the Fama-French 3 factors in explaining the variation in cross-sectional returns, consistent with that investors are mostly likely to make consumption and investment decisions simultaneously at the end of each calendar year due to holidays, tax consequences, and end-of-year bonuses.

This paper studies potential mismeasurement in the aggregate consumption data from the prospective of product turnover. The current deflator used to calculate real aggregate consumption is based on a fixed basket of goods and services. Schumpeter (1942) argues that quality improvements occur during the process of new products replacing outdated products. Therefore, a price index constructed with a fixed basket should contain an upward bias for not considering quality upgrading arising from creative destruction.

As documented in the empirical literature, product creation and destruction play an important role in aggregate output. Bernard, Redding, and Schott (2010) find that 54 percent of firms change their product mix every five years. On average, product creation by both existing and entering firms accounts for more than 30 percent of output and product destruction accounts for about 35 percent of output within a 5-year census period. Broda and Weinstein (2010) using more disaggregated data find that new products comprise 9 percent of expenditures in a year while the value of disappearing products is 3 percent. Their results also confirm that the magnitude of product turnover is higher than establishment turnover (Dunne, Roberts, and Samuelson 1988). More importantly, they find that net product creation is strongly procyclical, consistent with the innovation cycle model of Shleifer (1986) where firms coordinate implementation of innovations to take advantage of high aggregate demand. Axarloglou (2003) also find evidence that product introduction is more responsive to cyclical fluctuations in aggregate demand than seasonal fluctuations. Shleifer's intuition is also supported by research on firm entry and exit which finds that net business formation is strongly procyclical (Devereux, Head, and Lapham (1996)).

Feenstra (1994), Broda and Weinstein (2010), and Redding and Weinstein (2017) exploit the idea that quality changes can be inferred from changes in prices and market shares, and derive exact price indexes for constant elasticity of substitution preferences that accommodate product entry and exit. I follow Redding and Weinstein (2017) to construct price indexes with and without accounting for product turnover. The advantage of their approach is that it allows product substitution with elasticity of substitution estimated from the data as opposed to the conventional price indexes with zero elasticity of substitution, and accounts for quality changes in existing products compared to Freenstra (1994).

3 Adjustment for Product Turnover

In this section, I apply the framework of measuring the cost of living introduced by Redding and Weinstein (2017). All major price indexes are nested in this framework with different parameter restrictions, which allows me to isolate discrepancies in the cost of living attributed to product turnover. The following derivation is borrowed from their paper.

Utility of the representative household is defined as a constant elasticity of substitution (CES) function:

$$U_t = \left[\sum_{k \in \Omega_t} (\phi_{kt} C_{kt})^{\frac{\sigma-1}{\sigma}} \right]^{\frac{\sigma}{\sigma-1}}, \tag{1}$$

where C_{kt} is the consumption of good k at time t; ϕ_{kt} is the preference parameter for good k at time t, which can be interpreted as a parameter of subjective taste or quality; σ is the elasticity of substitution across goods, assumed to be constant over time. Taking derivatives to obtain the demand functions, I have the cost of unit utility (P_t):

$$P_t = \left[\sum_{k \in \Omega_t} \left(\frac{P_{kt}}{\phi_{kt}} \right)^{1-\sigma} \right]^{\frac{1}{1-\sigma}}. \tag{2}$$

It follows that the expenditure share for good l at time t is:

$$S_{lt} \equiv \frac{P_{lt} C_{lt}}{\sum_{k \in \Omega_t} P_{kt} C_{kt}} = \frac{(\frac{P_{lt}}{\phi_{lt}})^{1-\sigma}}{\sum_{k \in \Omega_t} (\frac{P_{kt}}{\phi_{kt}})^{1-\sigma}}. \tag{3}$$

The change in the cost of living from time $t-1$ to time t is then:

$$\begin{aligned}
\Phi_{t-1,t} \equiv \frac{P_t}{P_{t-1}} &= \left[\frac{\sum_{k\in\Omega_t} \left(\frac{P_{kt}}{\phi_{kt}}\right)^{1-\sigma}}{\sum_{k\in\Omega_{t-1}} \left(\frac{P_{k,t-1}}{\phi_{k,t-1}}\right)^{1-\sigma}} \right]^{\frac{1}{1-\sigma}} \\
&= \left[\frac{\lambda_{t-1,t}}{\lambda_{t,t-1}} \frac{\sum_{k\in\Omega_{t,t-1}} \left(\frac{P_{kt}}{\phi_{kt}}\right)^{1-\sigma}}{\sum_{k\in\Omega_{t,t-1}} \left(\frac{P_{k,t-1}}{\phi_{k,t-1}}\right)^{1-\sigma}} \right]^{\frac{1}{1-\sigma}},
\end{aligned} \tag{4}$$

where $\Omega_{t,t-1}$ represents the set of goods that exist at both time $t-1$ and time t and

$$\lambda_{t,t-1} \equiv \frac{\sum_{k\in\Omega_{t,t-1}} \left(\frac{P_{kt}}{\phi_{kt}}\right)^{1-\sigma}}{\sum_{k\in\Omega_t} \left(\frac{P_{kt}}{\phi_{kt}}\right)^{1-\sigma}} = \frac{\sum_{k\in\Omega_{t,t-1}} S_{kt}}{\sum_{k\in\Omega_t} S_{kt}}, \tag{5}$$

$$\lambda_{t-1,t} \equiv \frac{\sum_{k\in\Omega_{t,t-1}} \left(\frac{P_{k,t-1}}{\phi_{k,t-1}}\right)^{1-\sigma}}{\sum_{k\in\Omega_{t-1}} \left(\frac{P_{k,t-1}}{\phi_{k,t-1}}\right)^{1-\sigma}} = \frac{\sum_{k\in\Omega_{t,t-1}} S_{k.t-1}}{\sum_{k\in\Omega_{t-1}} S_{k,t-1}}.$$

Hence, $\lambda_{t,t-1}$ is essentially the expenditure share at time t of goods that already exist at time $t-1$, and $\lambda_{t-1,t}$ is the expenditure share at time $t-1$ of goods that do not exit at time t. Noting that from (2), I have

$$\left[\sum_{k\in\Omega_{t,t-1}} \left(\frac{P_{kt}}{\phi_{kt}}\right)^{1-\sigma} \right]^{\frac{1}{1-\sigma}} \equiv P_t^*, \tag{6}$$

which is the cost of unit utility at time t when the set of goods available contains only goods that exist at both time t and time $t-1$. I can then rewrite the change in the cost of living (4) as:

$$\Phi_{t-1,t} = \Big(\frac{\lambda_{t-1,t}}{\lambda_{t,t-1}} \Big)^{\frac{1}{1-\sigma}} \frac{P_t^*}{P_{t-1}^*}. \tag{7}$$

The first term on the right hand side in the above equation represents the bias in a price index that does not adjust for product turnover. Using (3), the expenditure share of good l among goods that exist at time t and time $t-1$ can be written as:

$$S_{lt}^* \equiv \frac{P_{lt}C_{lt}}{\sum_{k\in\Omega_{t,t-1}} P_{kt}C_{kt}} = \frac{(\frac{P_{lt}}{\phi_{lt}})^{1-\sigma}}{\sum_{k\in\Omega_{t,t-1}}(\frac{P_{kt}}{\phi_{kt}})^{1-\sigma}} = \frac{(\frac{P_{lt}}{\phi_{lt}})^{1-\sigma}}{P_t^{*\,1-\sigma}}, \quad l \in \Omega_{t,t-1}. \tag{8}$$

Taking logs of (8) and rearranging terms, I obtain:

$$ln\, P_t^* = \frac{1}{\sigma-1}\, ln\, S_{lt}^* + ln\, P_{lt} - ln\, \phi_{lt}, \quad l \in \Omega_{t,t-1}. \tag{9}$$

Summing across goods in $\Omega t, t-1$ and then taking average, (9) becomes:

$$ln\, P_t^* = \frac{1}{\sigma-1}\, ln\, \tilde{S}_t^* + ln\, \tilde{P}_t^* - ln\, \tilde{\phi}_t^*, \quad l \in \Omega_{t,t-1}, \tag{10}$$

where $\tilde{S}_t^* = (\prod_{k\in\Omega_{t,t-1}} S_{kt})^{1/N_{t,t-1}}$, $\tilde{P}_t^* = (\prod_{k\in\Omega_{t,t-1}} P_{kt})^{1/N_{t,t-1}}$, $\tilde{\phi}_t^* = (\prod_{k\in\Omega_{t,t-1}} \phi_{kt})^{1/N_{t,t-1}}$, and $N_{t,t-1}$ is the number of common goods at time t and time $t-1$. $\tilde{S}_t^*$, $\tilde{P}_t^*$, and $\tilde{\phi}_t^*$ are geometric averages across common goods. Then I difference (10) over time and have:

$$ln\Big(\frac{P_t^*}{P_{t-1}^*}\Big) = \frac{1}{\sigma-1}\, ln\Big(\frac{\tilde{S}_t^*}{S_{t-1}^{\tilde{*}}}\Big) + ln\Big(\frac{\tilde{P}_t^*}{P_{t-1}^{\tilde{*}}}\Big) - ln\Big(\frac{\tilde{\phi}_t^*}{\phi_{t-1}^{\tilde{*}}}\Big). \tag{11}$$

Assuming on average demand shocks are zero, that is, $ln\left(\frac{\tilde{\phi_t^*}}{\tilde{\phi_{t-1}^*}}\right) = 0$, (11) can be rewritten as:

$$\frac{P_t^*}{P_{t-1}^*} = \left(\frac{\tilde{S_t^*}}{\tilde{S_{t-1}^*}}\right)^{\frac{1}{\sigma-1}} \left(\frac{\tilde{P_t^*}}{\tilde{P_{t-1}^*}}\right) \tag{12}$$

When I plug (12) into (7), I arrive at the unified price index formula proposed by Redding and Weinstein (2017):

$$\Phi_{t-1,t} \equiv \frac{P_t}{P_{t-1}} = \left(\frac{\lambda_{t,t-1}}{\lambda_{t-1,t}}\right)^{\frac{1}{\sigma-1}} \left(\frac{\tilde{S_t^*}}{\tilde{S_{t-1}^*}}\right)^{\frac{1}{\sigma-1}} \left(\frac{\tilde{P_t^*}}{\tilde{P_{t-1}^*}}\right). \tag{13}$$

I apply the above formula for each product group (adding a superscript indexing product group to all previous equations) defined by the Nielsen HomeScan database, and calculate the changes in the cost of living with or without adjustment for product turnover, denoted by $\Phi_{t-1,t,g}^{UPI}$ and $\Phi_{t-1,t,g}^{CG}$. More specifically,

$$\Phi_{t-1,t,g}^{UPI} = \left(\frac{\lambda_{t,t-1,g}}{\lambda_{t-1,t,g}}\right)^{\frac{1}{\sigma_g-1}} \left(\frac{\tilde{S_{t,g}^*}}{\tilde{S_{t-1,g}^*}}\right)^{\frac{1}{\sigma_g-1}} \left(\frac{\tilde{P_{t,g}^*}}{\tilde{P_{t-1,g}^*}}\right), \tag{14}$$

$$\Phi_{t-1,t,g}^{CG} = \left(\frac{\tilde{S_{t,g}^*}}{\tilde{S_{t-1,g}^*}}\right)^{\frac{1}{\sigma_g-1}} \left(\frac{\tilde{P_{t,g}^*}}{\tilde{P_{t-1,g}^*}}\right),$$

where g refers to product group g.

To aggregate the product turnover bias across product groups, I take a simple average of the price change in each product group weighted by the expenditure share of each product group at the beginning of the period,

$$\Phi_{t-1,t}^{UPI} = \sum_{g=1}^{G} \Phi_{t-1,t,g}^{UPI} S_{t-1,g}, \tag{15}$$

$$\Phi_{t-1,t}^{CG} = \sum_{g=1}^{G} \Phi_{t-1,t,g}^{CG} S_{t-1,g}.$$

An alternative aggregation approach using a nested CES structure is also considered and does not affect the results. Variable *variety* is the measure of mismeasurement in real consumption growth in this paper and defined as:

$$Turnover = \Phi_{t-1,t}^{CG} / \Phi_{t-1,t}^{UPI} - 1. \tag{16}$$

As is clear in (14), the product turnover adjustment to price growth comes from $\left(\frac{\lambda_{t,t-1,g}}{\lambda_{t-1,t,g}}\right)^{\frac{1}{\sigma_g - 1}}$. It is worth pointing out that the price index in Feenstra (1994) also includes this term, but instead of $\Phi_{t-1,t,g}^{CG}$ his benchmark measure of price growth is based on the Sato-Vartio formula (denoted by $\Phi_{t-1,t,g}^{SV}$), which imposes the restriction that $\phi_{kt} = \phi_{k,t-1} = \phi_k$. It is not an innocuous assumption because ϕ reflects quality change in existing goods ($\Omega_{t,t-1,g}$). Higher prices paid for certain goods may be justified by an increase in quality and we would like to measure quality-adjusted prices. As the product turnover bias is aggregated across product groups, it is important to make sure that the price growth benchmark is also chosen appropriately to avoid that the difference between $\Phi_{t-1,t,g}^{CG}$ and $\Phi_{t-1,t,g}^{SV}$ correlates with $\left(\frac{\lambda_{t,t-1,g}}{\lambda_{t-1,t,g}}\right)^{\frac{1}{\sigma_g - 1}}$, which can cause a bias in *turnover*.

The unknown elasticity of substitution parameter σ_g in (14) is estimated using the reverse-weighting estimator introduced by Redding and Weinstein (2017). The identifying assumption is to force the utility function to be money-metric, in the sense that we can make consistent welfare comparisons regardless of using preferences at the beginning of the period or at the end of period. The details of the estimation procedure using the Generalized Method of Moments (GMM) can be found in the appendix of Redding and Weinstein (2017).

4 Data

The change in the cost of living is calculated using data from the Nielsen HomeScan database (HMS), which contains price and quantity information of spending on over three million goods (bar codes). The HMS tracks purchases made by approximately 40,000-60,000 U.S. households across all retail outlets in the U.S. between 2004 and 2015. The sample of households is selected to be representative of the universe of households on key demographic characteristics, such as household size, income, education, and occupation. Consumer spending covered by the HMS constitutes a decent share of total spending. As shown in Lecznar and Smith (2017), per-capita spending recorded in the HMS accounts for 7 percent of per capita consumption in the Consumer Expenditure Survey and the two series grew within 0.3 percentage points of each other between 2005 and 2014.

Each unique good is assigned a bar code, and it is reasonable to assume product quality is constant for a bar code. Broda and Weinstein (2010) discuss incentives for manufacturer to keep a one-to-one mapping between bar codes and goods. The main advantage relates to inventory management. The HMS also reviews bar codes and documents changes to product characteristics, most of which are changes in size and occur infrequently. As a result, the HMS data are ideal for identifying new products available to consumers. Bar codes are categorized into product groups (e.g., pet food, tea, beer, books and magazines, and laundry supplies) by the HMS. The assumption of a CES utility function at the product group level seems appropriate considering the functional similarity of goods within a product group. I exclude product groups not tracked throughout the entire sample period and product groups of durable goods. My sample contains 102 product groups.

I choose to process the purchases data at a quarterly frequency. A higher frequency provides me with a longer time series for asset pricing tests but there is a better chance the timing of purchases and actual consumption is mismatched, which overestimates product turnover.

Table 1 reports the characteristics of product groups. The expenditure distribution across product groups is rather disperse, making it unlikely for a few product groups to drive the results. Pet food, carbonated beverages, and paper products make up the largest shares of total spending at below 4 percent. $\lambda_{t-1,t,g}$ and $\lambda_{t,t-1,g}$ are spending shares of goods (bar codes) that do not exit next period and those that exist last period within a product group. They measure the magnitudes of product destruction and creation, repectively. On average, 8 percent of spending within each product group comes from exiting goods every year and new goods account for 13 percent of spending. $\frac{\lambda_{t,t-1,g}}{\lambda_{t-1,t,g}}$ as shown in (14) measures product turnover within a product group. A lower value is associated with more product turnover and greater understatement of real consumption growth. The elasticity of substitution estimates for each product group are also presented, which on average are very close to those reported by Redding and Weinstein (2017) and Lecznar and Smith (2017).

Aggregate consumption data are obtained from the Bureau of Economic Analysis. For the period 2005 to 2015, the seasonally adjusted nominal consumption expenditure on nondurables and services is retrieved from National Income and Product Accounts (NIPA) Table 2.3.5, and the price deflator is from NIPA Table 2.3.4 following the literature. To calculate per-capita consumption growth, I obtain population figures from NIPA Table 2.6.

To tease out seasonal patterns in consumer spending, I measure changes in the cost of living on a year-over-year basis, i.e., comparing prices in the current quarter and the same quarter last year. Between 2005 and 2015, I obtain 44 quarterly observations of year-over-year price changes using alternative price indexes from (14) and (15), and calculate the bias in consumption growth due to product turnover as shown in (16). Table 2 reports the summary statistics of annual consumption growth on a per-capita basis in the data and after adjusting for product turnover using consumption. Consumption growth is calculated as the year-over-year change using quarterly consumption data, and reported by quarter in Table 2, given serial correlation of annual rates in a quarterly series. Annual consumption growth is significantly increased by three percentage points when product turnover is taken into consideration. However, the volatility of consumption growth is unchanged, making it difficult to resolve the equity premium puzzle. The skewness is more negative, which is relevant for models with non-lognormal consumption growth, especially models featuring disasters.

5 Empirical Analysis

As shown in Table 2, the sample moments of consumption growth are changed by adjusting for product turnover. Hence, I apply the approach introduced by Martin (2013) to study the implications for the equity premium and the risk free rate. Under Epstein-Zin preferences with i.i.d. consumption growth, the risk free rate is given by:

$$log(1 + R^f) = \rho - c(-\gamma) + c(1 - \gamma)(1 - 1/\theta), \qquad \theta = \frac{1 - \gamma}{1 - 1/\psi}, \tag{17}$$

and the equity premium is given by:

$$log[1 + E(\ R^m\ )] - log(1 + R^f) = c(1) + c(-\gamma) - c(1 - \gamma), \tag{18}$$

where $c(.)$ is the cumulant generating function; ρ is the time preference parameter; γ is the coefficient of risk aversion; and ψ is the intertemporal elasticity of substitution. The cumulant generating function can be approximated by a Taylor expansion using the first four cumulants. Assuming different values of risk aversion, Table 3 presents the model's predictions of the risk free rate and the equity premium. Using the adjusted sample moments of consumption growth increases the risk free rate prediction significantly while only slightly raising the equity premium. The high risk free rate and low equity premium predictions in both cases reflect the widely documented poor performance of a standard CCAPM. It should be noted that the time series of consumption growth used to calculate the sample moments is too short to generate robust estimates of the population moments, especially when a strand of literature argues that disasters are difficult to calibrate in a short sample.

Next, I move on to a cross-sectional test of a linear factor model. The standard CCAPM model assuming time separable power utility developed by Breeden (1979) has the following Euler equation:

$$E_t[\, e^{-\rho} \left(\frac{c_{t+1}}{c_t} \right)^{-\gamma} R^e_{t+1} \,] = 0, \tag{19}$$

where c is the real consumption per capita and R^e is the excess return. As I argue that the real consumption is mismeasured in the data for using a price deflator ignoring product turnover, the above Euler equation can be written as:

$$E_t[\, e^{-\rho} \left(\frac{c^*_{t+1}}{c^*_t} \right)^{-\gamma} \left(\frac{\Phi^*_{t,t+1}}{\Phi_{t,t+1}} \right)^{-\gamma} R^e_{t+1} \,] = 0, \tag{20}$$

where c^* is the observed consumption, Φ^* is the gross price change using the current price index, and Φ is the true gross price change, which accounts for product turnover. $\frac{\Phi^*_{t,t+1}}{\Phi_{t,t+1}}$ is proxied using factor *turnover* constructed in (16). I work with the unconditional version of (20) and linearize it similarly to Breeden, Gibbons, and Litzenberger (1989):

$$E[\, R^e_{i,t+1} \,] \approx \gamma e^{-\rho} R^f \left[Cov\Big(\frac{c^*_{t+1}}{c^*_t},\, R^e_{i,t+1} \Big) + Cov\Big(\frac{\Phi^*_{t,t+1}}{\Phi_{t,t+1}},\, R^e_{i,t+1} \Big) \right]. \tag{21}$$

I estimate the above model in the following form:

$$E[\, R^e_i \,] = \beta_{\Delta c,i} \lambda_c + \beta_{to,i} \lambda_{to}, \tag{22}$$

where $\beta_{\Delta c,i}$ and $\beta_{to,i}$ are the multiple regression coefficients of excess returns on consumption growth and turnover, respectively. Although the model requires that the consumption beta and the turnover beta be equal, I consider an unrestricted version. In the first step, I run time series regressions of excess returns asset-by-asset to obtain the consumption beta and turnover beta for each asset:

$$R^e_{i,t} = a_i + \beta_{\Delta c,i} \Big(\frac{c^*_{t+1}}{c^*_t} \Big) + \beta_{to,i}\, turnover_t + \epsilon_{i,t}. \tag{23}$$

Next, I estimate the factor risk premia λ_c and λ_{to}:

$$\overline{R_i^e} = \beta_{\Delta c,i}\lambda_c + \beta_{to,i}\lambda_{to} + \alpha_i, \tag{24}$$

where $\overline{R_i^e} = \frac{1}{T}\sum_{t=1}^{T} R_{i,t}$. To account for serial correlation in errors, I use GMM to estimate the model. Table 4 shows the results from the cross-sectional regressions using the 25 Fama-French size and book-to-market portfolios as test assets. All models are rejected based on the hypothesis that pricing errors are zero. The Fama-French model has the lowest pricing errors at 2.754%. Including the turnover factor does not affect the price of risk for consumption beta and slightly decreases the pricing errors. More importantly, the price of risk for the turnover factor is negative and insignificant. Table 5 reports the results for an alternative set of test assets, which includes 10 industry portfolios in addition to the 25 Fama-French size and book-to-market portfolios. The product turnover factor remains insignificantly negative. Table 6 reports the results measuring consumption as spending on nondurables, motivated by the fact that the turnover factor is estimated using data on purchases of nondurables. The factor price of product turnover is virtually zero and price errors do not shrink by much, although the significance of consumption beta increases. It is fair to conclude that accounting for changes in product variety in the consumer market does not lead to improvements in the performance of a plain-vanilla CCAPM.

6 Conclusion

The empirical literature finds that product turnover accounts for a large share of aggregate output. Conceptually, by Schumpeter (1942)'s argument, product turnover results from creative destruction, which implies technological innovations and quality upgrading. The price index constructed by the statistics bureau is based on a fixed basket of goods and disregards the important implication of product turnover for consumer welfare, leading to an upward bias in price growth. Motivated by the evidence that product turnover is procyclical, I test whether real consumption growth is calculated using inflation figures that do not account for product turnover is the reason that the standard CCAPM performs poorly. Bias in price growth due to product turnover is calculated using a comprehensive dataset that contains detailed information on household purchases, applying the approach introduced by Redding and Weinstein (2017).

In a calibration exercise following Martin (2013), I find that consumption growth increases significantly and becomes more negatively skewed after accounting for product turnover. However, changes in the moments of consumption growth from product turnover adjustment increase the equity premium only slightly, while causing an increase in the risk free rate. The cross-sectional analysis also shows that the product turnover factor does not command a positive price of risk.

In summary, not measuring consumption properly by ignoring product turnover is not responsible for the failure of the standard consumption-based model. But it by no means suggests that product turnover is not relevant for asset prices. In a general equilibrium setting where firms' innovation and investment decisions are also modeled, it is possible for product turnover to appear in a pricing kernel.

Table 1: Summary of Product Groups

Table 1 summarizes characteristics of product groups. S_g represents the average expenditure share of a product group in total spending. $\lambda_{t-1,t,g}$ is the ratio of spending on goods (bar codes) within a product group that do not exit next period to total spending on the product group. $\lambda_{t,t-1,g}$ is the ratio of spending on goods (bar codes) within a product group that exist last period to total spending on the product group. $\frac{\lambda_{t,t-1,g}}{\lambda_{t-1,t,g}}$ measure product turnover within a product group. σ_g is the estimate of elasticity of substitution using the reverse-weighting estimator. The sample period is 2002-2015.

Product group	S_g (%)	$\lambda_{t-1,t,g}$	$\lambda_{t,t-1,g}$	$\frac{\lambda_{t,t-1,g}}{\lambda_{t-1,t,g}}$	σ_g	Product group	S_g (%)	$\lambda_{t-1,t,g}$	$\lambda_{t,t-1,g}$	$\frac{\lambda_{t,t-1,g}}{\lambda_{t-1,t,g}}$	σ_g
BABY FOOD	0.44	0.92	0.86	0.94	4.58	DOUGH PRODUCTS	0.37	0.95	0.92	0.96	3.26
CANDY	2.35	0.91	0.82	0.90	4.31	EGGS	0.72	0.97	0.97	0.99	3.25
FRUIT - CANNED	0.38	0.96	0.94	0.98	3.51	MILK	2.84	0.97	0.96	0.99	2.14
GUM	0.24	0.95	0.83	0.88	5.78	PUDDING, DESSERTS-DAIRY	0.08	0.92	0.84	0.91	3.88
JAMS, JELLIES, SPREADS	0.58	0.96	0.92	0.96	3.28	SNACKS, SPREADS, DIPS-DAIRY	0.25	0.91	0.87	0.96	3.09
JUICE, DRINKS - CANNED, BOTTLED	2.51	0.95	0.91	0.95	3.79	YEAST	0.00	0.94	0.93	1.00	2.78
PET FOOD	3.69	0.94	0.86	0.92	3.76	YOGURT	1.07	0.94	0.84	0.90	3.23
PREPARED FOOD-READY-TO-SERVE	1.09	0.97	0.94	0.97	3.48	DRESSINGS/SALADS/PREP FOODS-DELI	2.12	0.92	0.87	0.94	2.59
PREPARED FOOD-DRY MIXES	1.06	0.97	0.92	0.95	3.79	PACKAGED MEATS-DELI	2.94	0.95	0.92	0.97	3.64
SEAFOOD - CANNED	0.41	0.96	0.92	0.95	3.14	FRESH MEAT	0.60	0.94	0.90	0.97	3.44
SOUP	1.09	0.98	0.93	0.95	3.70	FRESH PRODUCE	2.96	0.97	0.93	0.96	1.67
VEGETABLES - CANNED	0.96	0.98	0.96	0.98	3.12	DETERGENTS	1.41	0.93	0.79	0.85	6.30
BAKING MIXES	0.42	0.97	0.91	0.94	4.47	DISPOSABLE DIAPERS	0.63	0.77	0.64	0.83	4.66
BAKING SUPPLIES	0.53	0.97	0.94	0.97	3.62	FRESHENERS AND DEODORIZERS	0.47	0.88	0.69	0.78	4.57
BREAKFAST FOOD	0.90	0.94	0.83	0.88	4.87	HOUSEHOLD CLEANERS	0.66	0.95	0.87	0.91	4.29
CEREAL	2.08	0.96	0.87	0.90	4.12	HOUSEHOLD SUPPLIES	0.78	0.91	0.85	0.94	3.76
COFFEE	1.28	0.95	0.86	0.90	4.31	LAUNDRY SUPPLIES	0.79	0.93	0.83	0.89	4.33
CONDIMENTS, GRAVIES, AND SAUCES	1.45	0.97	0.93	0.97	3.24	PAPER PRODUCTS	3.32	0.91	0.72	0.79	5.37
DESSERTS, GELATINS, SYRUP	0.48	0.97	0.93	0.96	4.01	PERSONAL SOAP AND BATH ADDITIVES	0.67	0.90	0.77	0.86	4.47
FLOUR	0.13	0.98	0.96	0.98	2.60	PET CARE	1.31	0.88	0.78	0.89	3.72
FRUIT - DRIED	0.38	0.91	0.81	0.89	3.77	TOBACCO & ACCESSORIES	2.99	0.94	0.93	0.99	4.26
NUTS	0.87	0.92	0.86	0.94	4.03	WRAPPING MATERIALS AND BAGS	0.83	0.94	0.88	0.93	4.34
PACKAGED MILK AND MODIFIERS	0.63	0.97	0.92	0.96	4.54	BEER	1.49	0.97	0.95	0.98	1.95
PASTA	0.39	0.96	0.93	0.97	2.96	LIQUOR	1.21	0.93	0.89	0.96	3.19
PICKLES, OLIVES, AND RELISH	0.38	0.95	0.94	0.99	3.16	WINE	1.21	0.91	0.89	0.97	3.46
SALAD DRESSINGS, MAYO, TOPPINGS	0.72	0.97	0.92	0.95	3.96	BATTERIES AND FLASHLIGHTS	0.65	0.93	0.85	0.91	4.79
SHORTENING, OIL	0.55	0.96	0.93	0.97	2.56	CANNING, FREEZING SUPPLIES	0.03	0.98	0.82	0.83	3.14
SPICES, SEASONING, EXTRACTS	0.53	0.94	0.91	0.97	2.80	CHARCOAL, LOGS, ACCESSORIES	0.10	0.90	0.79	0.87	3.08
SUGAR, SWEETENERS	0.50	0.98	0.95	0.97	2.82	FLORAL, GARDENING	0.25	0.90	0.84	0.93	2.82
TABLE SYRUPS, MOLASSES	0.16	0.96	0.93	0.97	3.04	GRT CARDS/PARTY NEEDS/NOVELTIES	0.02	0.60	0.53	0.89	2.07
TEA	0.69	0.95	0.89	0.94	3.58	INSECTICDS/PESTICDS/RODENTICDS	0.28	0.93	0.87	0.94	3.62
VEGETABLES AND GRAINS - DRIED	0.21	0.94	0.93	0.98	1.82	PHOTOGRAPHIC SUPPLIES	0.28	0.46	0.32	0.71	2.79
BREAD AND BAKED GOODS	3.29	0.93	0.90	0.97	3.17	STATIONERY, SCHOOL SUPPLIES	1.18	0.82	0.74	0.90	3.01
CARBONATED BEVERAGES	3.45	0.98	0.95	0.97	4.26	BABY NEEDS	0.23	0.72	0.67	0.93	3.15
COOKIES	1.11	0.91	0.83	0.90	3.50	COSMETICS	0.50	0.81	0.68	0.85	2.85
CRACKERS	0.84	0.95	0.87	0.91	4.17	COUGH AND COLD REMEDIES	0.86	0.92	0.80	0.88	3.49
SNACKS	3.28	0.88	0.76	0.87	4.10	DEODORANT	0.34	0.93	0.82	0.88	5.13
SOFT DRINKS-NON-CARBONATED	1.28	0.95	0.89	0.93	3.92	DIET AIDS	0.15	0.91	0.79	0.89	5.22
BAKED GOODS-FROZEN	0.38	0.96	0.92	0.96	3.61	ETHNIC HABA	0.03	0.91	0.90	0.99	2.17
BREAKFAST FOODS-FROZEN	0.54	0.95	0.87	0.92	4.17	FEMININE HYGIENE	0.06	0.92	0.87	0.95	3.85
DESSERTS/FRUITS/TOPPINGS-FROZEN	0.27	0.95	0.89	0.94	2.84	FIRST AID	0.37	0.91	0.85	0.93	3.06
ICE	0.03	0.94	0.94	1.00	2.72	FRAGRANCES - WOMEN	0.18	0.55	0.45	0.81	2.84
ICE CREAM, NOVELTIES	1.53	0.94	0.89	0.95	3.19	GROOMING AIDS	0.18	0.78	0.69	0.89	2.97
JUICES, DRINKS-FROZEN	0.12	0.97	0.95	0.98	2.73	HAIR CARE	1.02	0.91	0.80	0.88	4.36
PIZZA/SNACKS/HORS DOEURVES-FRZN	1.19	0.94	0.88	0.93	4.50	MEDICATIONS/REMEDIES/HEALTH AIDS	2.38	0.92	0.85	0.93	3.33
PREPARED FOODS-FROZEN	3.13	0.95	0.88	0.92	4.85	MEN'S TOILETRIES	0.07	0.64	0.53	0.81	3.74
UNPREP MEAT/POULTRY/SEAFOOD-FRZN	1.09	0.92	0.89	0.97	2.98	ORAL HYGIENE	0.93	0.94	0.83	0.88	4.55
VEGETABLES-FROZEN	1.02	0.96	0.92	0.96	3.33	SANITARY PROTECTION	0.35	0.94	0.86	0.92	4.24
BUTTER AND MARGARINE	0.74	0.98	0.96	0.97	3.40	SHAVING NEEDS	0.44	0.94	0.81	0.87	4.60
CHEESE	2.74	0.96	0.94	0.97	3.16	SKIN CARE PREPARATIONS	0.69	0.88	0.74	0.83	3.81
COT CHEESE, SOUR CREAM, TOPPINGS	0.56	0.97	0.96	0.99	3.31	VITAMINS	2.08	0.88	0.80	0.91	2.56
Mean	0.98	0.92	0.85	0.93	3.60	Median	0.66	0.94	0.87	0.94	3.51

Table 2: Summary of Consumption growth

Table 2 reports the summary statistics of real consumption growth on a per-capita basis. Consumption growth is measured by the year-over-year change in expenditure on nondurables and services. The top panel reports unadjusted consumption growth using NIPA data. The bottom panel reports consumption growth adjusted for product turnover using the approach described in Section III. The sample period is 2005-2015.

Quarter	Mean	Standard deviation	Skewness	Kurtosis
Consumption growth before adjustment				
1	0.016	0.014	-0.370	2.112
2	0.016	0.015	-0.829	3.345
3	0.016	0.014	-0.624	2.466
4	0.016	0.013	-0.398	1.839
Consumption growth adjusted for product turnover				
1	0.043	0.016	-0.589	1.988
2	0.046	0.016	-0.788	2.782
3	0.045	0.014	-0.687	2.357
4	0.046	0.013	-0.709	2.716

Table 3: Predicted Equity Premium and Risk Free Rate

Table 3 reports the model predictions of the risk free rate and the equity premium in Martin (2013) assuming a standard CCAPM setting with Epstein-Zin preferences. ρ is the time preference parameter. ψ is the intertemporal elasticity of substitution. γ is the coefficient of risk aversion. Parameters are assumed following Martin (2013).

Preference parameters						
ρ	0.03					
ψ	1.5					
γ	4		10		20	
Predictions						
	Unadjusted	Adjusted	Unadjusted	Adjusted	Unadjusted	Adjusted
Risk free rate (%)	4.01	5.93	3.9	5.81	3.72	5.6
Equity premium (%)	0.08	0.09	0.2	0.24	0.42	0.49

Table 4: Estimation of Linear Factor Models with the Fama-French Portfolios

Table 4 reports estimates of the factor prices for the CCAPM, the CCAPM with the product turnover factor, and the Fama-French 3-factor model. Test assets include the 25 Fama-French size and book-to-market portfolios. MAPE is the mean absolute price error. R.m.s is the root mean squared pricing error. The associated p-value is for testing the null hypothesis that pricing errors are jointly zero. Estimation is implemented using GMM. Returns are measured in percentage points.

Factor price	CCAPM	CCAPM with turnover	Fama-French
Consumption growth	1.821	1.321	
	(1.385)	(1.485)	
Turnover		-0.487	
		(-1.616)	
Market			7.949
			(2.049)
SMB			0.918
			(0.695)
HML			-0.210
			(-0.116)
R2	0.826	0.865	0.914
MAPE	2.973	2.991	2.215
r.m.s	3.914	3.445	2.754
(p)	0.000	0.000	0.000

Table 5: Alternative Test Assets: Fama-French Portfolios and Industry Portfolios

Table 5 reports estimates of the factor prices for the CCAPM, the CCAPM with the product turnover factor, and the Fama-French 3-factor model. Test assets include the 25 Fama-French size and book-to-market portfolios and 10 industry portfolios. MAPE is the mean absolute price error. R.m.s is the root mean squared pricing error. The associated p-value is for testing the null hypothesis that pricing errors are jointly zero. Estimation is implemented using GMM. Returns are measured in percentage points.

Factor price	CCAPM	CCAPM with turnover	Fama-French
Consumption growth	1.849	1.613	
	(1.438)	(1.682)	
Turnover		-0.322	
		(-0.902)	
Market			8.876
			(2.294)
SMB			-0.941
			(-0.645)
HML			-0.394
			(-0.200)
R2	0.817	0.842	0.901
MAPE	3.232	3.036	2.324
r.m.s	4.019	3.736	2.954
(p)	0.000	0.000	0.000

Table 6: Alternative Consumption Measure: Consumption on Nondurables

Table 6 reports estimates of the factor prices for the CCAPM and the CCAPM with the product turnover factor model. Consumption is calculated as the expenditure on nondurables only, excluding services. Test assets include the 25 Fama-French size and book-to-market portfolios. MAPE is the mean absolute price error. R.m.s is the root mean squared pricing error. The associated p-value is for testing the null hypothesis that pricing errors are jointly zero. Estimation is implemented using GMM. Returns are meausred in percentage points.

	CCAPM	CCAPM with turnover
Consumption growth	1.447	1.480
	(1.756)	(1.973)
Turnover		0.000
		(0.000)
R2	0.878	0.879
MAPE	2.698	2.622
r.m.s	3.260	3.245
(p)	0.000	0.000

References

[1] Abel, Andrew B., 1990, Asset prices under habit formation and catching up with the Jones, *American Economic Review* 80, 38-42.

[2] Axarloglou, Kostas, 2003, The cyclicality of new product introductions, *Journal of Business* 76, 29-48.

[3] Balduzzi, Pierluigi, and Tong Yao, 2007, Testing heterogeneous-agent models: an alternative aggregation approach, *Journal of Monetary Economics* 54, 369-412.

[4] Bansal, Ravi, A. Ronald Gallant, and George Tauchen, 2007, Rational pessimism, rational exuberance, and asset pricing models, *Review of Economic Studies* 74, 1005-1033.

[5] Bansal, R. and Amir Yaron, 2004, Risks for the long run: a potential resolution of asset pricing puzzles, *Journal of Finance* 59, 1481-1509.

[6] Bernard, Andrew B., Stephen J. Redding, and Peter K. Schott, 2010, Multiple-product firms and product switching, *American Economic Review* 100, 70-97.

[7] Brav, Alon, George M. Constantinides, and Christopher C. Geczy, 2002, Asset pricing with heterogeneous consumers and limited participation: empirical evidence, *Journal of Political Economy* 110, 793-824.

[8] Breeden, Douglas, 1979, An intertemporal asset pricing model with

stochastic consumption and investment opportunities, *Journal of Financial Economics* 7, 265-296.

[9] Breeden, Douglas, Michael Gibbons, and Robert Litzenberger, 1989, Empirical test of the consumption-oriented CAPM, *Journal of Finance* 44, 231-262.

[10] Broda, Christian, and David E. Weinstein, 2010, Product creation and destruction: evidence and price implications, *American Economic Review* 100, 691-723.

[11] Campbbell, John Y., 1996, Understanding risk and return. *Journal of Political Economy* 104, 298-345.

[12] Campbell, John Y., and John H. Cochrane, 1999, By force of habit: a consumption-based explanation of aggregate stock market behavior, *Journal of Political Economy* 107, 205-251.

[13] Chen, Xiaohong, and Sydney C. Ludvigson, 2009, Land of addicts? An empirical investigation of habit-based asset pricing models, *Journal of Applied Econometrics* 24, 1057-1093.

[14] Cogley, Timothy, 2002, Idiosyncratic risk and the equity premium: evidence from the consumer expenditure survey, *Journal of Monetary Economics* 49, 309-334.

[15] Constantinides, George M. , 1990, Habit formation: a resolution of the equity premium puzzle, *Journal of Political Economy* 98, 519-543.

[16] Constantinides, George M., and Darrell Duffie, 1996, Asset pricing with heterogeneous consumers, *Journal of Political Economy* 104, 219-240.

[17] Devereux, Michael B., Allen C. Head, Beverly J. Lapham, 1996, Aggregate fluctuations with increasing returns to specialization and scale, *Journal of Economic Dynamics and Control* 20, 627-656.

[18] Dunn, Kenneth B., and Kenneth J. Singleton, 1986, Modeling the term structure of interest rates under non-separable utility and durability of goods, *Journal of Financial Economics* 17, 27-55.

[19] Dunne, Timothy, Mark J. Roberts, and Larry Samuelson, 1988, Patterns of firm entry and exit in U.S. manufacturing industries, *The Rand Journal of Economics* 19, 495-515.

[20] Epstein, Larry G. and Stanley E. Zin, 1989, Substitution, risk aversion, and the temporal behavior of consumption and asset returns: a theoretical framework, *Econometrica* 57, 937-969.

[21] Epstein, Larry G. and Stanley E. Zin, 1991, Substitution, risk aversion, and the temporal behavior of consumption and asset returns: an empirical analysis, *Journal of Political Economy* 99, 263-286.

[22] Fama, Eugene F., and Kenneth R. French, 1993, Common risk factors in the returns on stocks and bonds, *Journal of Financial Economics* 33, 3-56.

[23] Feenstra, Robert C., 1994, New product varieties and the measurement of international prices, *American Economic Review* 84, 157-177.

[24] Hansen, Lars Peter, and Kenneth J. Singleton, 1982, Generalized instrumental variables estimation of nonlinear rational expectations models, *Econometrica* 50, 1269-1286.

[25] Jagannathan, Ravi, and Yong Wang, 2007, Lazy investors, discretionary consumption, and the cross-section of stock returns, *Journal of Finance* 62, 1623-1661.

[26] Lecznar, Jonathon, and Arthur V. Smith, 2017, Geographic aggregation and the measurement of real consumption growth and volatility, Working paper, Boston University.

[27] Lucas, Robert E., Jr., 1978, Asset prices in an exchange economy, *Econometrica* 46, 1429-1445.

[28] Mankiw, Gregory N., and Matthew D. Shapiro, 1986, Risk and return: consumption beta versus market beta, *Review of Economics and Statistics* 68, 452-459.

[29] Mankiw, Gregory N., and Stephen P. Zeldes, 1991, The consumption of stockholders and nonstockholders, *Journal of Financial Economics* 29, 97-112.

[30] Mehra, Rajnish, Edward C. Prescott, 1985, The equity premium, *Journal of Monetary Economics* 15, 145-161.

[31] Martin, Ian, 2013, Consumption-based asset pricing with higher cumulants, *Review of Economic Studies* 80, 745-773.

[32] Parker, Jonathan A., Christian Julliard, 2005, Consumption risk and the cross section of expected returns, *Journal of Political Economy* 113, 185-222.

[33] Redding, Stephen J., and David E. Weinstein, 2017, A unified approach to estimating demand and welfare, Working paper, Princeton University.

[34] Savov, Alexi, 2011, Asset pricing with garbage, *Journal of Finance* 66, 177-201.

[35] Schumpeter, Joseph A., 1942, *Capitalism, socialism, and democracy*, (Harper, New York).

[36] Shleifer, Andrei, 1986, Implementation cycles, *Journal of Political Economy* 94, 1163-1190.

[37] Storesletten, Kjetil, Chris I. Telmer, and Amir Yaron, 2004, Cyclical dynamics in idiosyncratic labor market risk, *Journal of Political Economy* 112, 695-717.

[38] Vissing-Jorgensen, Annette, 2002, Limited asset market participation and the elasticity of intertemporal substitution, *Journal of Political Economy* 110, 825-853.

[39] Yogo, Motohiro, 2006, A consumption-based explanation of expected stock returns, *Journal of Finance* 61,539-580.

Disclaimers

”Researcher(s) own analyses calculated (or derived) based in part on data from Nielsen Consumer LLC and marketing databases provided through the NielsenIQ Datasets at the Kilts Center for Marketing Data Center at The University of Chicago Booth School of Business.”

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