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# Product Differentiation and Systematic Risk: Theory and Empirical Evidence

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## Abstract

Firms producing differentiated products have high margins and therefore low risk. As a result firms invest more into developing differentiated products when they perceive risk is high. Higher risk also implies higher product skewness towards more differentiated products and therefore higher average markups. The model predicts endogenous systematic and idiosyncratic riskiness as well as endogenous intensity of competition: firms in high risk industries reduce their riskiness by competing less than firms in low risk industries. Empirical evidence on product differentiation, R&D expenses, B/M ratios, and market  $\beta$  is consistent with the model.

*Keywords: Stock Returns, Price Differentiation, Product Market Competition, Product Development, Idiosyncratic Volatility, Research and Development, Counter-Cyclical Markups, Price of Risk, Price-Cost Margin, Investment, Innovation*

*JEL Classification Codes: E32, E22; G12, G32; L11, L16, L25; O31;*

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# 1 Introduction

Firms often strive to differentiate their products from those of their competitors. Whether it be automobiles, smart-phones, clothing or even vegetables, firms often make an effort to get customers to know their products and how they are different from the rest. Both product development and marketing are areas of a firm's managerial activity that can be thought in part as being about product differentiation. Firms choose how much time and effort to spend in these activities. The resulting differentiation of a firm's products has implications for its total earnings, its profit margins and also for the sensitivity of the firm to shocks of different kinds. Since product differentiation potentially affects the firm's value, its systematic riskiness and therefore its expected returns it is logical to investigate product differentiation from an asset pricing perspective. How does differentiation affect stock returns? How do different systematic risk scenarios affect firm's differentiation decisions? How do investment, output, price-cost markups and profitability respond to changes in systematic risk or in the price of this risk?

Also, there's an important empirical controversy that demands more investigation. Hou and Robinson (2006), using Compustat data, find that more firms in more concentrated industries pay lower returns while instead Eli, Klasa, Yeung (2009), adding US Census data find that, for the case of manufacturing, firms in less concentrated industries *do not* pay higher returns. The results in Hou and Robinson (2006) are more consistent with the standard intuition for the relationship between competition and returns, the latter paper uses a data set that is more likely to capture the true competitiveness of individual industries and yet finds the opposite result. This empirical controversy can also be studied from the point of view of product differentiation.

We develop a model of product differentiation that lets me provide answers to some of these questions as well as bring more clarity to the controversy described above. In our model the firm chooses how many new product developments to engage in. After developing the products the firm can observe the characteristics of the market for these products in terms of

the market size and in terms of how 'different' the product is from that of the competition. It then chooses how much output to produce for the markets of each of the products it developed. While it is costly to develop more products, each new product development gives the firm an opportunity to find a really good market. Products that are more differentiated are good for the firm because they let it get high profit margins and therefore less risk. We analyze this problem by contrasting the optimal behavior of the firm given different levels of (or prices for) systemic risk.

The model predicts that firms produce relatively more of the more differentiated products when there is more systematic risk. We call this an increase in the skewness of the product mix. The intuition is that the profit stream from more differentiated products is less sensitive to systematic shocks and therefore when systematic risk increases the firm values the output from those products more and therefore produces relatively more for these markets. From a time series perspective, this is consistent with the large literature in macroeconomics that finds that markups are counter-cyclical under the assumption in a large part of the asset pricing literature that the price of risk is higher in recessions. Intuitively, more product differentiation is equivalent in the model to higher price-cost markups and so if the firm faces more risk it focuses more on more differentiated products. If a higher fraction of output is produced for highly differentiated products then the average markup will increase.

The model also predicts an effect of changes in systematic risk on the firm's product development decisions. The firm devotes more resources, relative to total production, to the development of new products if systematic risk is high than if it is low. This follows from the skewness prediction above. Skewness implies that the firm's value is more dependent on the single 'best' new product that it develops. This implies in turn that it devotes relatively more resources to finding this best product. We do not interpret this as an increase in innovation but instead as a search for market niches that are protected from competition.

In a general sense, the model allows the firm to explicitly devote resources to reducing its own riskiness in response to the environment's riskiness. This

intuition can potentially rationalize some of the existing evidence for the relationship between excess returns and product market competition. In our model firms *compete more* in industries (or periods of time) that are intrinsically less risky and *compete less* in industries (or periods of time) that are intrinsically more risky. In other words, firm decisions undo part of the differences in the environments that they face. This provides a new perspective on the relationship between returns and competition. Firms in high systemic risk industries will compete less, but will still be riskier, than firms in low systemic risk industries which compete more intensely. This reasoning can potentially explain why it is hard to find an empirical relationship between concentration and returns as Eli, Klasa and Yeung (2009) have shown.

Although a large body of empirical and theoretical literature studies cross sectional asset returns, relatively few papers look at product market competition and its implications for asset returns. Novy-Marx (2009) describes a model where industry competition is Cournot-type and based on different marginal costs. Firms, each one with a different productivity compete with other firms in their industry. This feature lets that model rationalize the finding that the main source of the value premium is within-industry value premium. Similarly, Aguerrevere (2009) finds a cyclical concentration premium in a model with Cournot-type competition based on differences in investment and capital utilization. In another related paper Bena and Garlappi (2011) model an innovation race where innovations create negative externalities on the rest of the firms. In their model returns decline when the firm invests and increase when other firms invest. In contrast to these works, in our model firms will be choosing how much to compete. They decide how much to concentrate on producing products that are highly differentiated and also they decide how much to spend on looking for highly differentiated products.

Also, there is a wealth of models built to describe the relationship between firms' actions or firms' characteristics and their stock returns which focus on the firms' investment behavior, given a set of shocks and frictions. Berk, Green and Naik (1999) for example describe the firm as a set of assets

in place and a set of options. At every period, firms' choice is whether to invest by exercising the option that matures then. Firms vary in terms of how many good options they have exercised which in turn implies that their returns have different sensitivities to the aggregate shocks and therefore different expected returns. In another example, Zhang (2005) shows that one way to rationalize the value premium is by modeling firms as facing different temporary productivity shocks which leads to different rates of investment. These different rates of investment imply that firms' returns have different sensitivities to aggregate shocks and therefore these firms have different expected returns. Other models with a similar structure in the sense that they focus on firm investment are for example Gomes, Kogan and Zhang (2003) and Carlson, Fischer, Giammarino (2004).

This literature, built in part upon the foundation of the q-theory of investment, has focused on describing a variety of mechanisms and frictions that make some firms more risky than others. Because of the focus on q-theory and its extensions, this literature has described firms mostly as making choices about investment in capital, intangible capital, installed labor, etc., in the presence of different frictions. These shocks and frictions paired with the nature of the systematic risk in the model determine investment dynamics, which in turn imply particular return dynamics and these then have implications about cross sectional return patterns. While these models and this line of research in general have improved our understanding of return determinants greatly, here we argue that a firm's investment choice is only one of many choices that these firms or their management teams make. They make all kinds of decisions that are not easily equated with investment, for example, having to do with marketing, with competition, with research and development, etc. Some of these choices have potentially *more direct* implications about the return dynamics of firms, and therefore about their expected returns, than the investment choice that is typically modeled.

This paper is also related to the literature that focuses on risk management, idiosyncratic volatility and stock returns. In a purely empirical paper, Gaspar (2006) for example finds that higher concentration or market power

leads to lower idiosyncratic volatility (consistent with the model we present below) and to lower information uncertainty for investors. Similarly Angel at. (2006) and Ang et al. (2009) find that high idiosyncratic volatility is related to low stock returns, also consistent with the model below. In a different track, Goyal and Santa-Clara (2003) find that idiosyncratic volatility matters in an aggregate sense: higher average idiosyncratic volatility is related to higher average stock returns. However, Bali, et al. (2005) dispute these results, showing they are not robust to a more standard weighting scheme, or to different data sources or periods. We contribute to this literature by proposing a model where firms' attempts to reduce their systematic riskiness have an effect on the idiosyncratic riskiness of their returns. The model predicts that firms that invest in R&D to mitigate the high systematic risk of their industry will have relatively low idiosyncratic return volatility.

The rest of this paper proceeds as follows: Section 1 describes the intuition of the paper by presenting a real world example to focus on and by describing the basic intuition for the relationship between product differentiation and returns; Section 2 describes the model in detail and solves for some features of the optimal behavior of the firm; Section 3 describes the model predictions; Section 4 describes the empirical exercise by explaining the source of data on product differentiation and the empirical findings; Section 5 concludes.

## **2 Intuition**

### **2.1 Real World Example**

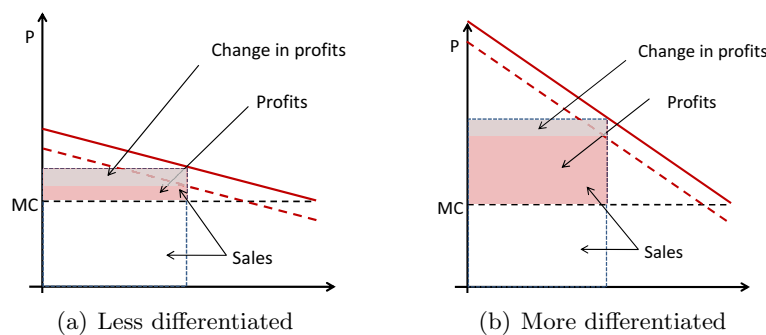
A good real world example to focus on for the type of problem described by the model is that of a car manufacturer like General Motors and its decisions of how many new car models to develop and how many units to produce of each one. In reality, among other strategic decisions GM will decide how much time and effort to devote to new car model development. Each model will have a market of different size, each will elicit more or less brand loyalty, each will face more or less competition from existing or potential new models

and so on. It is costly to develop these products. Automotive firms typically create a concept car and show that around the world before actually defining the product and producing it. Once GM develops a concept car it can then gauge the size of the market for that product as well as how different or unique it is viewed by car consumers, i.e. its degree of differentiation. After it has found out the features of the market for each of its new products it decides on production for each of them. This production is constrained by how much total car production it can manage, say because it has a limited number of plants. After it chooses the production level for each model GM produces these cars and sells them at a price that has a systematic random component in it.

In this story, because different products will have different price-cost markups, the combination of products that GM ends up producing will determine the systematic risk of future GM cash flows and profits. Therefore GM's development decisions are made in part based on their effect on the riskiness of the firm's cash flows. This in turn implies that the mix of car models that GM brings to the market each year and the quantities that it produces of each is in part a reflection of how much systematic risk GM perceives there to be.

## 2.2 Differentiation and Riskiness

Figure 1: Product differentiation



Intuitively, a firm's product is more 'differentiated' if the price elasticity



of demand is low. The two panels of Figure 1 show two linear demand schedules with different slopes but the same price 0 demand level. They also show the effect on profits of a fall in demand. All else equal, the sales and profits from the more differentiated products have lower price elasticity in the sense that a level or proportional change in price has a larger proportional impact on the profits coming from the less differentiated product.

In analytical terms, if demand  $D$  is a decreasing function of prices  $P$ , for example if

$$D(P) = kP^{-\epsilon}$$

then the price elasticity of demand is

$$e^D = -PD'(P)/D(P) = \epsilon.$$

Also, if there's a unit cost of production  $C$ , then price elasticity of profits is

$$e^\pi = -P\pi'(P)/\pi(P) = -\left[\frac{P(1-\epsilon) - \epsilon C}{P - C}\right].$$

Therefore high differentiation (or low  $\epsilon$ ) implies low 'riskiness' of profits in the sense that their price elasticity is also lower.

### 3 The Model

In this section we introduce our formal model and analyze product development, investment, markups and returns. In particular we solve for the optimal output in each market as a fraction of total firm output. Then we analyze how the firm's decisions respond to changes in the amount of systematic risk faced by the firm.

### 3.1 The Firm

The firm maximizes the present, discounted value of profits net of investment:

$$\max E[M\Pi] - \delta K - \phi N$$

Here,  $M$  is the discount factor with which the firm values future cash flows in different states of the world,  $K$  is the capital necessary for production and  $\delta$  is its depreciation rate,  $\Pi$  are the firm's total profits,  $\phi$  is the cost of 'developing' new products and  $N$  is the number of new products developed.

The firm's profits are the sum of output times price across different products that the firm produces:

$$\Pi = \sum_{i=1..N} P_i(Y_i, \zeta, \xi) Y_i$$

where  $Y_i$  is the output level of a particular product  $i$ ,  $\zeta$  is an idiosyncratic shock affecting the firm,  $\xi$  is a shock affecting the firm's industry which we call the industry's systematic shock. We assume that  $\zeta$  and  $\xi$  are uncorrelated. Also, we assume that  $\zeta$  is uncorrelated with the discount factor  $M$  and therefore that it represents diversifiable risk and that  $\xi$  is correlated with  $M$  and therefore it represents un-diversifiable or systemic risk.

#### 3.1.1 Product Development

There is an infinite number of potential product markets indexed by  $i = 1..\infty$ , each characterized by the parameters of the demand for that product ( $A_i, \epsilon_i$ ) such that that product's price function is:

$$P_i(Y_i, \zeta, \xi) = A_i \frac{\epsilon_i}{\epsilon_i - 1} (Y_i)^{-1/\epsilon_i} (\xi \zeta)$$

where  $P_i$  are prices and  $A_i$  and  $\epsilon_i$  are constants determining the size and price elasticity of that market.  $\{A_i\}$  and  $\{\epsilon_i\}$  are both iid series with support on  $(1, \infty)$  with distributions  $G$  and  $F$ . In this setup a high value for  $EM, \xi$  implies low systemic risk since it implies the market values cash flows

that are correlated with  $\xi$  as highly valuable. We interpret  $\xi$  as describing the amount of systematic risk in a industry during a period time. Also, without loss of generality we assume that  $E[\xi] = E[\zeta] = 1$ .

### 3.1.2 Capital and Output

For each portfolio of new products that it has developed, the firm chooses levels of production  $Y_i$  in each industry. The firm's total output is then the sum of the individual product outputs:

$$Y = \sum_1^N Y_i$$

There's a single type of capital and the firm sets the capital level to produce this total output  $Y$  using a decreasing returns to scale function

$$Y = (K)^\alpha$$

with  $\alpha < 1$  of capital.

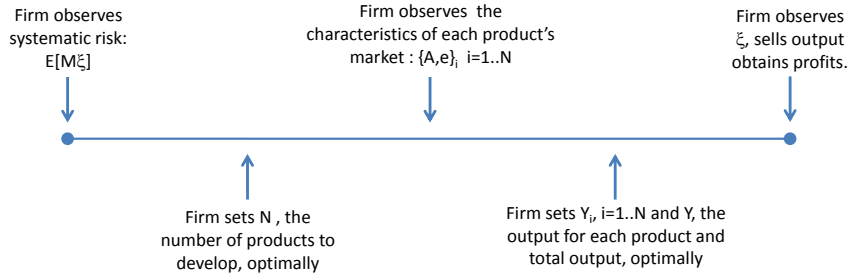
### 3.1.3 Sequence of Events

The sequence of events is illustrated in figure 2. The firm starts without knowing any of the product market characteristics  $A$  and  $\epsilon$ . It knows the quantity of systematic risk in the price of its products in the sense that it knows the present discounted price of the shock  $\xi$  of its industry,  $E[M\xi]$ . Based on this information the firm then chooses how many and which new products to discover by choosing  $N$ . It spends  $\phi$  in discovering each of the products and in exchange it finds out  $\{A_i\}$  and  $\{\epsilon_i\}$  for the market of each of the products. The firm then chooses how much to produce of each product,  $Y_i$ , and how much to invest  $K$  to produce total output  $Y = \sum^N Y_i$ . It chooses  $K$  and all  $Y_i$ 's jointly: since there are decreasing returns to scale in the production of output  $Y$ , then the optimal  $Y_i$ 's and  $K$  are all jointly determined.

Finally, after producing its output, the firm sells it and obtains profits

that depend on the realization of  $\xi$  and on  $\zeta_i$  for  $i = 1..N$ .

Figure 2: Sequence of Events



### 3.2 First Order Conditions

The main intuition of the model can be derived from the first order conditions of the firm's product-level optimal output decision problem. This is the problem the firm faces *after* it has chosen how many products to develop and has found  $A_i$  and  $\epsilon_i$  for each of them. For each product that it has developed the firm invests to equalize the marginal benefit and the marginal cost of each output unit. The marginal benefit for each product is the discounted expected value of profits from the sale of one extra unit of that product. Note that this expected value is determined in part by the price elasticity of demand for that product  $\epsilon_i$ :

$$MB = E[MA_i(Y_i)^{-\frac{1}{\epsilon_i}} \xi] \quad \forall i = 1..N.$$

The marginal cost is the depreciation of the increased capital necessary to produce that extra unit of output. It can be written in terms of the total output of the firm as:

$$MC = \frac{\delta}{\alpha} Y^{\frac{1-\alpha}{\alpha}}. \quad (1)$$

This in turn implies that given  $Y^*$ , the optimal output of a developed

product  $i$  is:

$$Y_i^* = \left( \mu \frac{A_i \alpha}{Y^{*\frac{1-\alpha}{\alpha}}} \right)^{\epsilon_i}$$

where we have written  $\mu = E[M\xi]$  and  $Y_i^* = Y_i^*(A_i, \epsilon_i, \mu, Y^*)$  to simplify the notation. Note that  $\zeta$  disappears since we assumed that  $E[M\zeta] = 0$ .

### 3.3 Number of Products Developed

The number of products developed is

$$N^* = \arg \max_N \left( E_{\{A\}, \{\epsilon\}} \left[ \sum_{i=1..N} E_{\xi, \zeta} [P_i(Y_i^*)Y_i^*] \right] - \delta K^* - \phi N \right).$$

The decreasing returns to scale assumption over production, which makes the marginal costs in 1 above an increasing function of  $Y^*$ , implies that  $N^*$  is well defined in that  $N^* < \infty$ .

## 4 Predictions

These first order conditions show that the model is consistent with basic intuition in the sense that an increase in the size of the market for product  $i$ , ( $A_i \uparrow$ ) results in an increase in the optimal output in that market. Similarly an increase in one product's differentiation ( $\epsilon_i \downarrow$ ) implies that the firm's output in that industry increases as well. Moreover, decreasing returns to scale in total output imply the opportunity cost of output increases when one of the  $\epsilon_i$  decreases, which in turn implies that all else equal the production of the other goods declines. Another basic prediction is that the firm will invest less in producing all products if it perceives higher risk. Intuitively, the firm is maximizing value and when risk increases the value of the risky output that it produces declines while the costs of producing that output do not.

Beyond these basic predictions, the model provides more interesting predictions about how the firm will react to changes in the riskiness it perceives.

We focus on these predictions in the rest of the paper:

**Proposition 1:** Given a set of potential products, more systematic risk leads to a higher 'output skewness' in the sense that the firm focuses proportionally more of its output on the most differentiated products.

**Proof:** This can be seen in the first order conditions above by noting that output depends on  $E[M\xi]$  to the power of  $\epsilon_i$ . Higher  $\epsilon_i$  leads to a higher response of output to changes in risk. In the limit, as the riskiness of the firm goes to infinity, the firm will only produce its most differentiated product. This is a key implication of the model: when systematic risk is high firms endogenously choose a product mix with a higher average differentiation.

**Corollary 1:** Under the (typical) assumption that the level of risk is counter-cyclical, firms have higher markups during bad times than during good times, consistent with the evidence in for example Rotemberg and Saloner (1986).

**Corollary 2:** Firms engage in less product market competition if systematic risk is high than if it is low.

**Proposition 2:** If systematic risk is high firms will invest relatively more on finding products that are differentiated.

**Proof:** This is a direct result of the skewness result above. Higher skewness implies that firms' value is more dependent on having a few good products. Then taking a step back, the firm that is deciding how many products to develop will spend relatively more on developing products in a setting of high risk than in a setting of low risk because the value of finding a single good product is higher than when risk is low. Note that this is a relative statement: firms are not predicted to develop more products if systematic risk is high, instead they are predicted to invest relatively more on research and development than on production capacity in this situation.

**Proposition 3:** Under the assumption that firms' exogenous idiosyncratic risk is homogenous, firms with more systematic risk will appear to have less idiosyncratic risk. In other words, the model predicts a negative correlation

between measures market and idiosyncratic risk.

**Proof:** In the model firms with more systematic risk will invest more in reducing their riskiness and therefore the same level of exogenous idiosyncratic risk will lead to lower measures idiosyncratic risk.

## 5 Evidence

### 5.1 Returns Data and Accounting Data

For returns and accounting data we follow the standard in the literature and use the CRSP and Compustat databases. We use data from 1980 to 2010 for results that do not involve product differentiation and data form 1996 to 2008 for those that do.

### 5.2 Product Differentiation Data

In this paper we use the product differentiation data of Hoberg and Phillips (2010). This data is publicly available from the author’s website. It is built from by using the 10k statements that are electronically available , (1996-2008) to obtain a word count description of what the firm states that it produces. These word count vectors are then compared to each other by finding the ‘angle’ between them in the sense of the dot product scaled by the vectors magnitudes. The public data consists of a set of concentration indicators that are calculated at industry and at firm level. Industry level indicators are constructed by first creating data defined industries that are fixed over time and then calculating Herfindahl-Hirschman indexes for these industries. Firm-level concentration are built by ‘measuring’ which firms are close to the firm and then calculating the HH index using these firm’s sales.

This data has several advantages over other product market data sets. First, the industry classifications are data driven rather than being artificially created by a government agency. Concentration in this setting implies that there are few firms *producing very similar set of products*. for example two firms that produce luxury, weather-proof, designer deck chairs, one

of which produces them out of wood and one that produces them out of steel, might end up in completely different industries in the standard SIC or NAICS but would be very close competitors in the Hoberg-Phillips methodology.

Another advantage of this dataset is that it provides firm level competition indexes. This fact implies that tests of competition are much more likely to have statistical power. In the SIC/NAICS setup analysts at S&P or at the BEA classify a firm into an industry and make many compromises in doing so. If three firms are in the same industry but two of them are not competing against each other although they are competing against the third, the standard classification methods will wrongly lead us to a single HH index based on the sales of the three firms.

### 5.3 Results - Systematic Risk and R&D Expenditures

Proposition 2 above suggests that firms with higher systematic risk will engage in more R&D. This is true in the data in the following sense: sorting firms on the ratio of R&D to CapEx or sorting them on market  $\beta$  produces very similar portfolios. Table 1 presents the results of regressing the R&D to CapEx ration on the firm's market  $\beta$  and the firm's B/M ratio. We include the B/M ratio as a way to capture the HML 'risk factor' of Fama and French (1993). It shows that indeed, market beta is a very significant predictor of R&D expenditure relative to expenditure in productive capacity which we proxy for with CapEx. This ratio is negatively related to B/M contrary to the joint assumption that B/M is a good proxy for the risk factor known as HML and that the firm invests in R&D to reduce its sensitivity to this risk. In this setting the size of the firm is also negatively correlated to R&D expenditures. Under the assumption that the firm's market capitalization is an inverse proxy for risk factor known as SML, the negative coefficient is consistent with the theory above: larger firms that have lower SML risk invest less in R&D relative to CapEx.



Table 1: Regression analysis: R&D and Systematic Risk  
This table presents a firm level regression of the average ratio of R&D expenditures to CapEx, to the average market  $\beta$ , the average Book to Market Ratio and the average size of the firm (Market Equity). We have deleted all observations that have their R&D expenditures missing in Compustat. On column two we present the results of running the regression with Winsorized variables at the 0.5 % and 99.5 % levels.

Variable	Non-Winsorized	Winsorized
Beta	0.050	1.168
t-stat	0.19	5.73
BM	-0.011	-0.078
t-stat	-0.51	-2.72
ME	-0.0002	-0.0004
t-stat	-1.16	-4.55
R-square	0.02%	0.68%

#### 5.4 Results - Product Differentiation

Table 2 describes the main empirical results of this paper. It shows that there is not a clear pattern in the returns across firms with different product market competition. This replicates the findings of Eli, Klasa and Yeung using this very different product market competition data set.

We interpret these results as saying that systematic risk is highest for the firms with the most differentiation. Under that assumption, the patterns in terms of Book/Market, Earnings/Sales and R&D/Investment conform to the theory suggested above:

- First, consistent with Proposition 1, firms in more concentrated industries obtain higher margins, i.e. their earnings to sales ratios are higher. Interpreting this fact through the model, it says that firms in higher risk industries will focus more of their production on highly differentiated products and have high average markups. This is also consistent with the higher book to market values of firms that are in a very competitive industry. More generally, this is consistent with Corollary 2: firms in higher risk industries will engage in less competition.

- Second, consistent with Proposition 2, firms in high systematic industries devote relatively more resources to finding differentiated products. The data is consistent with that prediction in the sense that it shows that firms with more systematic risk are those with more product differentiation. These are also those doing more research and development relative to the amount of investment in productive capacity that they are doing consistent with the regression results in table 1.

Table 2: Concentration, Returns, Profitability and Product Development

This table describes the characteristics and returns of 5 portfolios of firms over the 12 years of the sample 1996-2008. Assets are total assets. Size is market capitalization calculated as stock price times outstanding stocks. B/M is the ratio of Asset and Size. Earnings is net operating income before interest and depreciation. Investment is capital expenditures. Stock returns are yearly values, calculated for a holding period of one year starting in June of the year after portfolio formation. Returns are equally weighted total returns. HHIV is the HH concentration index based on product differentiation.

#	$R$	$\beta$	Asset	Size	B/M	Earnings /Sales	R&D /Investment	HHIV
1	9.59	0.87	13330	2806	0.69	0.01	0.2	0.02
2	11.47	1.2	4758	4288	0.47	0.04	0.2	0.05
3	12.29	1.4	2648	2636	0.45	0.05	0.8	0.09
4	9.93	1.4	2380	2173	0.49	0.06	0.6	0.19
5	9.31	1.5	2088	1758	0.51	0.05	1.2	0.46

## 5.5 Results - Total Return Volatility

Tables 3 through 5 describe the exercise of separating firms into portfolios according to their return volatilities. They also show the result of separating recession and expansion periods. These tables are consistent with the theory described above in the sense that:

- First, as Proposition 2 predicts, in the three tables it can be observed that firms that face higher risk as described by the portfolio's  $\beta$  are firms that perform on average more R&D expenditures relative to their CapEx expenditures.

- Second, as Corollary 1 predicts, comparing tables 4 and 5 it can be seen that during recessions firms invest relatively more on R&D (column 4) despite the fact that they invest less as a fraction of their market capitalization (column 7).

Table 3: Volatility, Returns, Profitability R&D

This table describes the characteristics and returns of 5 portfolios of firms over the period 1970-2010. Size is market capitalization calculated as stock price times outstanding stocks. B/M is the ratio of Assets and Size. Stock returns are yearly values, calculated for a holding period of one year starting in June of the year after portfolio formation. Investment represents CapEx. Market Beta is the regression coefficient of stock returns on market returns over a 2 year window.

#	R	$\beta$	R&D /Investment	B/M	Size	Investment /Size
1	0.006	0.84	0.36	0.74	927.3	0.074
2	0.007	1.27	0.46	0.78	254.6	0.071
3	0.008	1.46	0.85	0.72	125.4	0.060
4	0.009	1.70	1.62	0.66	72.4	0.051
5	0.004	1.82	2.53	0.56	37.5	0.037

Table 4: Volatility, Returns, Profitability R&D: Expansions

This table describes the characteristics and returns of 5 portfolios of firms over the period 1970-2010. Size is market capitalization calculated as stock price times outstanding stocks. B/M is the ratio of Assets and Size. Stock returns are yearly values, calculated for a holding period of one year starting in June of the year after portfolio formation. Investment represents CapEx. Market Beta is the regression coefficient of stock returns on market returns over a 2 year window. Business cycle data is from the NBER.

#	R	$\beta$	R&D /Investment	B/M	Size	Investment /Size
1	-0.002	0.83	0.35	0.83	1128.5	0.099
2	-0.006	1.30	0.41	0.85	279.8	0.093
3	-0.007	1.47	0.67	0.76	136.6	0.085
4	0.004	1.77	1.41	0.63	72.7	0.073
5	0.000	1.85	2.13	0.44	33.5	0.041

Table 5: Volatility, Returns, Profitability R&D: Recessions  
This table describes the characteristics and returns of 5 portfolios of firms over the period 1970-2010. Size is market capitalization calculated as stock price times outstanding stocks. B/M is the ratio of Assets and Size. Stock returns are yearly values, calculated for a holding period of one year starting in June of the year after portfolio formation. Investment represents CapEx. Market Beta is the regression coefficient of stock returns on market returns over a 2 year window. Business cycle data is from the NBER.

#	R	$\beta$	R&D /Investment	B/M	Size	Investment /Size
1	0.007	0.85	0.36	0.72	902.2	0.071
2	0.009	1.26	0.50	0.88	244.0	0.066
3	0.010	1.46	0.87	0.72	124.1	0.057
4	0.009	1.69	1.64	0.67	72.4	0.049
5	0.004	1.82	2.52	0.57	37.8	0.036

## 6 Conclusions

We develop a model of a firm that affects its systematic risk directly through its product differentiation decisions. In the model the firm decides how many products to develop and then how much of each of the products to produce. The firm’s development and production decisions are related to systematic risk in a way that implies the firm reacts to more systematic risk by making a larger effort to reduce its riskiness. This insight lets us rationalize the fact that firms in seemingly more concentrated industries and which therefore should be less risky, do not pay their investors higher returns. Empirical findings from a product market competition data-set that is closely aligned with the model’s product differentiation description of competition provide consistent empirical results. The model predicts firms with high systematic risk to have high concentration ratios and high R&D investment and this is what the data shows when taking market  $\beta$  as the measure of systematic risk. Also, firms in more risky industries have higher earnings/sales ratios and lower B/M ratios, again consistent with the theory. Finally, as the model predicts, firms are shown to have higher R&D/ to CapEx investment ratios during recessions despite having lower investment.

More generally the paper describes a firm that directly affects its risk-

iness through the choice of investment in product development, and in a the choice of what products to concentrate most of its production in, in a way that is distinct from the standard models of how investment affects firm's riskiness. In the model systematic risk, idiosyncratic risk and product market competition become jointly endogenous, a feature that potentially explains a number of otherwise surprising facts in the literature.

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