R&D and the Market for Acquisitions

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COMMENTS WELCOME: First version January 10, 2010.

This Version: February 20, 2011

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ABSTRACT

We provide a new theory and empirical tests showing how an active acquisition market positively affects firm incentives to innovate and conduct R&D. Our model shows how the incentives of small firms to conduct R&D in order to innovate increase with competition, demand and the probability that they are taken over. In contrast, we show that large firms optimally may decide to purchase smaller innovative firms and conduct less R&D themselves. Empirically, we document that the R&D of small firms responds more than the R&D of larger firms to demand shocks and the probability of being an acquisition target. The results also show that firm R&D increases with product-market competition and with industry acquisition liquidity and that these effects are stronger for smaller firms.

1 Introduction

We examine how the market for merger and acquisitions affects the decision to conduct R&D and innovate. Our paper provides a new theory and evidence on mergers as a mechanism to acquire innovation as a substitute strategy for conducting R&D inside the existing firm. This motive is distinct from other motives for acquisitions that include neoclassical theories or agency theories of mergers[1] and is closest to recent theories and evidence by Rhodes-Kropf and Robinson (2008) and Hoberg and Phillips (2010) which emphasize asset complementarity and product market synergies. In our paper, we model the incentives of firms to acquire successful innovative firms and the effect this has on both small and large firms incentives to conduct R&D. Recent articles in Bloomberg and Forbes describe how acquisitions are often attempts to grow by buying innovation.[2] In fact, larger companies like CISCO, General Electric and Microsoft are cited as buying smaller companies for their successful innovations. This strategy has been referred to as the "Art of Acquiring Growth" by a recent Forbes article.[3] An additional recent example is Apple Computer's 2008 purchase of a chip maker, PA Semi, for $278 million. This firm specialized in making fast, low-power chips, now used in the IPAD.[4]

Our model shows that large firms optimally may decide to let small firms conduct R&D and innovate then subsequently acquire the companies that have successful innovated. We show that smaller firms' incentives to conduct R&D to innovate increase with the probability that they are taken over. This is consistent with evidence that post-acquisition large firms innovate less and with evidence large firms conduct less R&D per unit of firm size. Seru (2010) recently finds patenting goes down post-acquisition and concludes that large conglomerate firms stifle innovation, while noting that they are more likely to sign alliances and joint ventures - a fact consistent with the outsourcing of R&D. Our interpretation

[1] See Maksimoivc and Phillips (2001), and Jovonovic and Rousseau (2002) for neoclassical and q theories and Morck, Schleifer and Visny (1990) for an agency motivation for mergers.

[2] See: Bloomberg, February 29, 2008, "Innovation through Acquisition" and Forbes, Nov. 8, 2005, "Does Innovation Through Acquisition Work?"

[3] See article from Forbes published with this title on January 4, 2008.

[4] Apple also purchased Intrinsity, an Austin TX low power chip manufacturer, in April 2010. A NY Times article (April 28, 2010) claims the purchases were done to keep technology out of competitors' hands as well as to use in Apples products to increase the products attractiveness.

of the decrease in innovative activity is different. The existing literature has not taken into account the fact that some firms decide to buy other firms to gain access to successful innovations and may optimally decide to engage in less R&D. This acquisition potential in our model can also give stronger incentives for small firms to engage in R&D. A recent example consistent with our model and evidence is the obesity drugs under development by three small companies (Arena Pharmaceuticals Inc., Vivus Inc., Orexigen Therapeutics Inc.,) who explicitly mention the probability of an acquisition by a larger firm in the event of success.[5] These incentives to innovate and acquire other firms also vary with the state of demand.

Specifically, the model provides the following predictions. First, the model predicts that small firms' R&D is procyclical. Higher values of the demand shock make it more attractive for small firms to invest in R&D either to keep the innovation for themselves or to become an attractive acquisition target, if an acquisition is possible. Second we show that larger firms' R&D is less procyclical than small firms' R&D. Unlike small firms, large firms may find it disadvantageous to engage in an "R&D race" with small firms at intermediate states of demand, as they can obtain access to innovation by acquiring a small firm that succeeded in its R&D efforts. Third, the possibility of an acquisition induces innovation by both small and large firms, but especially for the small ones. The possibility of an acquisition amplifies the potential gain from innovation. Fourth, greater bargaining power of the small firm leads to more aggressive innovation by the small firm and to higher likelihood of an acquisition. Having the ability to capture a greater fraction of the acquisition surplus, the small firm will tend to invest in R&D more aggressively to increase the odds of being acquired by the larger firm. Lastly we show that market structure and competition are important. A higher number of small firms lead to more innovation by smaller firms and to less innovation by the larger firms.

We empirically examine these predictions of our model. We control for the fact that R&D and acquisition activity may both be affected by fundamentals and thus it may be fundamentals that are driving both acquisition probability and R&D. We also control for endogenous acquisition probability by estimating the probability of being an acquisition target using several different instruments that are plausibly exogenous. We estimate the probability of being an acquisition target, including as instruments institutional

[5] See the recent article by Reuters on September 9, 2010 at http://www.reuters.com/article/idUSTRE6885KA20100909./

ownership and also unexpected mutual fund flow into and out of stocks that can affect persistent firm valuation and thus acquisition activity but not affect firm fundamentals (see Edmans, Goldstein and Jiang (2009)).[6] We find that small firms' R&D respond more to demand shocks and the probability of being an acquisition target. We also find that R&D increases with competition and with industry acquisition liquidity - a measure of bargaining power of small firms in the acquisition market. We also find that larger firms in competitive industries conduct less R&D and in particular conduct less R&D than smaller firms when there are positive demand shocks.

Our research adds to the current academic literature in several areas. First, we provide a new theory that has not been explored in the literature. The existing literature has emphasized neoclassical models or q theories where highly productive firms buy less productive firms and has also emphasized managerial agency theories of mergers. It also adds to the theories that emphasize asset complementarity or product market synergies, by emphasizing that the complementary assets are new innovations produced through R&D that can be used by existing firms. Our paper directly examines the effect of acquisition probabilities, market structure and firm size on R&D.

Secondly, our model and evidence is consistent with large firms optimally reducing innovation, letting small firms innovate, and acquiring them later. This evidence is consistent with other recent papers which examine R&D and patents post acquisition. Seru (2010) finds conglomerate firms reduce innovation post acquisition. Hall (1999) finds no effect on R&D expenditures from mergers of public firms, while a reduction in R&D following going public transactions.[7]

Related literature looks at the relation between competition in product markets and innovation, without paying attention to acquisitions. Vives (2008) provides a detailed overview of theoretical and empirical work. The empirical evidence is favorable to the positive effect of competition on innovation including Porter (1990), Geroski (1990, 1994), Baily and Gersbach (1995), Nickell (1996), Blundell, Griffin, and Van

[6] See Edmans, Goldstein and Jiang (2009) for the description of and successful use of this instrument. We thank them for sharing this mutual fund flow instrument with us.

[7] Note our model and evidence is about small firms optimally deciding to sell out. We do not model agency conflicts nor anti-takeover amendments that are common for larger firms that may be subject to conflicts between managers and shareholder. See Atanassov (2009) and Chemmanur and Tian (2010) for articles that deal with anti-takeover devices or laws.

Reen (1999), Galdon-Sanchez and Schmitz (2002). However, most of these papers look at productivity rather than R&D. Theoretical work seems to support a negative relation between innovation and competitive pressure. Standard IO theory predicts that innovation should decline with competition, as more competition reduces the monopoly rents that reward successful innovators (see, for example, Dasgupta and Stiglitz, 1980.) Other theoretical papers suggest a positive (Aghion et al, 2001) or U-shaped relation (Aghion et al, 2002) between innovation and product market competition. We complement and extend this literature by focusing on the effect of a potential acquisition on a firm's innovation incentives.

Overall our contribution is to focus on the trade-off for large firms between innovating themselves or acquiring small firms that have successfully innovated. Acquiring firms that have successfully innovated can be a less expensive and more efficient path to obtaining innovation than innovating directly oneself. We illustrate this effect in a theoretical model and provide rigorous empirical tests. Second, we generate new empirical predictions regarding procyclicality of R&D investments and their relation to firm size, the effect of potential acquisitions on R&D, the link of R&D to industry structure, and the effect of bargaining power and asset liquidity on small firms' R&D decisions.

The remainder of the paper is organized as follows. In the next section we develop an illustrative model that endogenizes R&D and acquisition decisions in a simple 2-period framework. In section 3 we present out empirical hypotheses, describe our data and empirical methodology. Section 4 presents the results of our empirical tests. Section 5 summarizes and concludes.

2 The model

We present a simple illustrative model that allows us to draw empirical predictions about the relation between R&D, acquisitions and firm size. We setup the model with a simple utility function for consumers who value product variety but are willing to substitute between products. In the base version of the model we assume heterogenous products and price (Bertrand) competition.[8] Firms have a similar production

[8] In the appendix we consider alternative specifications of the utility function, competition, and innovation mechanism. Our major results are robust to these alternative specifications.

technology but we allow heterogeneity in the size of firms. We study one large firm and up to two small firms but the model can be extended to allow additional firms. We allow each firm to innovate and introduce a new product but allow firms also to choose to purchase other firms instead of innovating themselves.

Our model captures both heterogeneous products and the intensity of product market competition in a simple setting. We believe that this setting provides a realistic background for the issues of interest, as a positive effect of innovation by a small firm (e.g. a biotech or technology one) is likely to result in a shift in consumers' demand (an example is recent obesity drugs under development). For robustness we also consider various scenarios in which innovation results in cost savings, as well as alternative competition mechanisms (Cournot) and utility functions (constant elasticity) in the appendix.[9]

2.1 General Setup

Consumers We follow Vives (2000, 2008), and Bernile, Lyandres, and Zhdanov (2010), and consider an industry with n ($n \in \{2, 3\}$) firms. Originally, each product is produced by a single firm. There is a representative consumer, with a general quadratic utility function that allows for concavity in consumer utility as they consume more of any given product and also allows for differentiated products captured by the parameter γ, the degree of substitutability among the products.

$$U(\overrightarrow{q}) = x\sum_{i=1}^{n}\alpha_i q_i - \frac{1}{2}\left[\sum_{i=1}^{n}\beta_i q_i^2 + 2\sum_{j\neq i}\gamma_{ij}q_i q_j\right], \tag{1}$$

where $\alpha_i > 0$ represents consumer preferences for product i, β_i measure the concavity of the utility function, and γ_{ij} represents the degree of substitutability between products i and j. For simplicity we assume that $\beta_i = \beta$ and $\gamma_{ij} = \gamma$ for all i and j, and also that $\beta > \gamma > 0$,[10] In (1) q_i is consumption of good

[9] Under Cournot competition with similar competitors mergers will not take place as rival firms expand output after the merger - this is a well-known Cournot-merger paradox. (See, for example, Salant, Switzer adn Reynolds, 1983). However the literature (see Gaudet and Salant, 1992 and Zhou, 2008, among others) has shown that under Cournot competition with cost savings mergers will take place. In our setting if the innovation produces large cost savings, mergers will take place with positive demand shocks. Furthermore, we do not allow firms to change their capital stock post-merger.

[10] This assumption ensures that the utility function is concave. We also work out the results for a constant elasticity utility

i, n is the number of active firms in the industry, and, thus, the number of available products, and x is the stochastic shock to the representative consumer's utility. $\gamma > 0$ ensures that the products are (imperfect) substitutes. The higher the γ the more alike are the products and the more intense is competition in the industry. Furthermore we follow Vives (2008) and assume that in addition to the products above there is a numeraire good (or money), which represents the rest of the economy, and income is large enough, so that the income constraint never binds and all income effects are captured by consumption of the numeraire good. Parameters α_i, $i = 1, n$, reflect consumer's preferences for product i. $\alpha_i > \alpha_j$ implies that consumer prefers product i to product j, but still consumes both products as long as they are imperfect substitutes ($\gamma < \beta$). In what follows we normalize β to 1. (the results are insensitive to this normalization).

Production technology There are k ($k \in \{2, 3\}$) firms in the industry, each endowed with capital K_i. The firms' production functions are of the Cobb-Douglas specification with two factors:

$$q_i = \sqrt{K_i L_i}, \tag{2}$$

where q_i is the quantity produced by firm i, and L_i is the amount of the second factor (e.g. labor) employed by firm i.

The cost of one unit of labor is denoted p_l. The amount of capital is fixed, hence labor is the only variable input. Given this specification, firm i's cost of producing q_i units is

$$C_i(q_i) = \frac{q_i^2}{K_i} p_l. \tag{3}$$

This specification results in profit functions of the following from:

$$\pi_i = q_i p_i - C_i(q_i). \tag{4}$$

Firms are heterogeneous in the amount of capital. There is one big dominating firm with capital K_1

function and Cournot competition with a quadratic utility function in the appendix.

and one or two small firms with capital $K_{2(,3)} < K_1$ each. In what follows we assume that $p_l = 1$ (the results are insensitive to this assumption).

R&D and Innovation Each firm in the industry has an option to invest in R&D to develop an innovation technology at a cost of RD_i. If one firm invests in R&D then it develops innovation with $\delta < 1$ percent certainty. (We allow for the possibility of failure even in the absence of competition). If multiple firms invest in R&D then each of them obtains the right to the innovative technology with probability

$$p = \frac{1 - (1 - \delta)^n}{n},$$

where n is the number of firms with active R&D programs[11]. Once firm i successfully develops innovation, the technology becomes inaccessible to the other firms in the industry (e.g. protected by a patent). If firm i wins the innovation contest then the only way for firm j to acquire access to innovation is through an acquisition of firm i, as described below.

The innovative technology, once developed, can be brought to the market through commercialization. Commercialization of the new technology requires a cost of I_1 for the big firm and I_2 for the small one. This cost is assumed to include any fixed costs which will also include advertising and investment in distribution facilities and also any fixed costs of raising financial capital. Brining to market the product based on this innovation results in a change of consumers' liking of the product(s) produced by the firm, as reflected in an increase of the parameter α_i from α_{i1} to α_{i2}, where $\alpha_{i1} < \alpha_{i2}$. For simplicity, we assume that $\alpha_{i1} = \alpha$ and $\alpha_{i2} = \alpha'$, $i \in \{1, 2, 3\}$.

The Acquisition Market The big firm, whether or not it has acquired the innovative technology, has an option to take over one small firm. We assume (for simplicity to focus on innovation) that there are no economies of scale and the merged firms utilize all the pre-merged firms capital and do not reallocate

[11]The probability that all firms fail in their R&D efforts is $(1 - \delta)^n$. Otherwise, each of them has an equal chance of succeeding.

capital between their production facilities (or that it is prohibitively costly to do so)[12]. Nevertheless, there are two consequences of an acquisition on the profit of the merged entity (and its competitors, if any). First, the two firms are now able to coordinate their pricing strategies, which leads to greater market power and increases equilibrium prices and profits. Second, the merged entity can apply innovation to its entire product line, resulting in an increase of consumer preference parameter from α to α' for all its products. We assume that an acquisition can be implemented at a fixed cost I_m.

We further assume that the target shareholders get a fraction η of the acquisition surplus, e.g. the price paid to the target shareholders is given by

$$P = V_t^s + \eta(V_m - V_t^s - V_b^s),$$

where V_m is the value of the merged entity if an acquisition is implemented, V_t^s and V_b^s are the stand-alone values of the target and the bidder. Parameter η reflects the relative bargaining power of the target shareholders.

The sequence of events is presented in figure 1.

Insert figure 1 here

2.2 Solution

The equilibrium prices and profits of firms in the industry depend on which firm has successfully innovated (if any), on whether an acquisition occurs and also on whether any firm decides to commercialize innovation. In the following subsections, we allow for a large firm and different numbers of small firms (one or two) and treat these two cases separately below. We start with a case when a merger is precluded and then proceed by incorporating a possibility of an acquisition.

[12] Incorporating production synergies results in greater benefits from the merger and, in general, produces consistent results.

Case 1: One small firm, one large firm and no acquisition is possible To find the equilibrium profits we first differentiate the utility function with respect to quantities and set the derivatives equal to prices. Solving the resulting system of equations for quantities gives the demand functions:

$$q_1 = \frac{x(\alpha_1 - \alpha_2\gamma) - p_1 + p_2\gamma}{1-\gamma^2}, \tag{5}$$

$$q_2 = \frac{x(\alpha_2 - \alpha_1\gamma) - p_2 + p_1\gamma}{1-\gamma^2}. \tag{6}$$

The inverse demand functions are linear in prices. We then substitute these functions into profit functions (4) , differentiate with respect to prices (firms maximize their profits by setting prices competitively), set the derivatives equal to zero, and solve the resulting system of equations. This produces equilibrium prices, provided in the appendix. We then substitute equilibrium prices into inverse demand functions to get equilibrium quantities, then into profit functions (4) to obtain equilibrium profits.

Figure 2 plots the equilibrium profit of a firm as a function of its "innovation parameter" α_i, that of its competitor, α_j, the relative size of the two firms, K_1/K_2, and the degree of product differentiation, γ. The comparative statics in figure 1 are based on the following parameter values: $K_1 = 10$, $K_2 = 1$, $\gamma = 0.5$, $\alpha_1 = 10$, $\alpha_2 = 10$. For each graph we compute the profits with these values but vary one of them as indicated on the x-axis. Consistent with intuition, equilibrium profit of one firm increases in its own innovation parameter α_i, and decreases with its product substitutability γ, its rival's capitalization K_j, and its innovation parameter α_j.

Insert figure 2 here

The optimal R&D and commercialization policies of each firm depend on the current state of the demand shock x and on the actions of its opponent. Each firm first decides whether it wants to invest in R&D. If neither firm invests then neither develops innovation and the profits of the two firms are given by $\pi_1(\alpha_1, \alpha_2)$ and $\pi_2(\alpha_1, \alpha_2)$. If only one firm invests in R&D, then it acquires the new technology with probability δ, it then decides whether or not it wants to commercialize its innovation (by incurring an additional commercialization fee). If both firms invest in R&D, then each of them has a $\frac{1-(1-\delta)^2}{2}$ chance of obtaining the patent. The successful firm then has an option to proceed to the commercialization stage. The values of the big and the small firms conditional on their innovation decisions are given in the appendix.

Figure 3 presents the equilibrium strategies of the two firms in the space (α', x). For ease of exposition we assume $\alpha_1 = \alpha_2 = \alpha$.

Insert figure 3 here

The results in figure 3 are based on the following set of parameter values: $K_1 = 10$, $K_2 = 1$, $\gamma = 0.5$, $\alpha = 10$, $\alpha' = 15, RD_1 = RD_2 = 15$, $\delta = 0.8$, $I_1 = 0$, $I_2 = 5$[13]. When the state of x is low, both firms find it optimal not to invest in R&D, because the potential benefit of innovation does not outweigh the cost of R&D at low states of demand. For sufficiently high states of x the big firm decides to invest in R&D. The effect of successful innovation on the profit of the small firm is lower, so the small firm stays aside. Finally, for even higher states of demand the benefit of innovation for the small firm becomes high enough so it joins the innovation race. As shown in figure 3, the incentive to invest in innovation for both firms is greater when the benefit of innovation α' is high.

Case 2: One small firm, one large firm, and acquisitions are possible We now assume that the big firm has an option to acquire the small one by incurring a restructuring cost I_m. A successful acquisition results in a single firm in the industry, which sets prices to maximize its total (monopoly) profits. If either the small or the big firm has developed innovation, then the merged firm can commercialize it by paying a cost I_1. Note that the merged entity still produces two separate products, and if it decides to commercialize, demand for each product will be characterized by the parameter $\alpha = \alpha'$. The profit of the merged entity is given in the appendix.

The equilibrium investment choices of firms are found similarly to the previous case by comparing expected firm values in different scenarios. When deciding whether or not to invest in R&D, the big firm now takes into account the possibility to acquire the small one if the latter develops innovation. Likewise,

[13]The small firms is likely to be financially constrained, therefore faces a higher commercialization cost. The results are insensitive to this assumption and robust to alternative specifications of parameter values.

the small firm incorporates the possibility of being acquired by the big one in its optimization problem.

Figure 4 presents the equilibrium innovation strategies of the two firms. There are two important differences between figures 3 and 4. First, innovation by the big firm starts at a lower state of the demand shock x, because the potential benefit of innovation is greater - the big firm has an option to acquire the small one and apply innovation to both its capacity and production *and* the production capacity acquired by the non-innovating small firm. Second, there is a region in which the small firm innovates, while the big firm does not. Rather than joining the small firm in the innovation race and having a rather low chance of winning the patent, the big firm prefers to let the small firm innovate and acquire it later.

Insert figure 4 here

Figure 5 plots the demand threshold, $\overline{x}$, at which the acquisition just becomes profitable - as a function of the acquisition cost I_m. Acquisition is optimal for the states of demand exceeding $\overline{x}$. As figure 5 shows, acquisitions are procyclical and acquisition thresholds increase in the cost of merger I_m. Note that in general there are two acquisition thresholds that divide the space (x, I_m) into three different regions. In the bottom region, acquisitions never occur. In the top region acquisitions occur with probability one. In the middle region an acquisition occurs only if the small firm has successfully developed innovation. Because of relatively large cost of an acquisition, the big firm does not find it optimal to acquire the small one if the former has accessed innovation through its own R&D program. It can commercialize without performing an acquisition. By contrast, if the small firm obtains the innovative technology, the big firm has more incentives to initiate an acquisition, because it will also result in gaining access to innovation.

Insert figure 5 here

Figure 6 shows the equilibrium R&D strategies of the firms when the small firm has greater bargaining power and captures a fraction of acquisition surplus $\eta = 0.5$. There are two important differences between figure 4 ($\eta = 0$) and figure 6 ($\eta = 0.5$). First, the region in which the small firm invests in R&D and the big firm does not is much wider. Since the small firm gets a share of the acquisition benefit it is more motivated to engage in R&D, so it could sell out to the big firm at a higher price. Because of a high potential payoff in the event of successful innovation and a subsequent acquisition, the small firm is motivated to pursue an aggressive R&D strategy. At relatively low states of demand the big firm prefers not to interfere and refrains from competing with the small one. Second, the boundary at which both firms decide to invest in R&D shifts down, again because the small firm is more willing to invest in R&D.

insert figure 6 here

We now move to an oligopoly setting and consider an industry with one big firm and two small firms.

Case 3: Two small firms, one large firm and acquisitions are possible The equilibrium profits computed analogously to the case with one small firm and are given in the appendix.

Initially, firms decide wether or not they want to invest in R&D to develop innovation. As discussed above, the probability of obtaining access to innovation equals $p = \frac{1-(1-\delta)^n}{n}$, where n is the number of firms engaged in the R&D process. Equilibrium firm values are computed similarly to those in subsection 1 and are available upon request.

As before, we assume that the big firm has an option to acquire one small firm at a cost I_m. It can take over a small firm that holds a patent to innovation (if one of the small firms obtained it) or a one without it. If an acquisition is consummated, then there remain two competing firms in the industry - the big merged entity and the small firm that has not been acquired. The equilibrium profit functions and firm values are found similarly to the previous cases.

Figure 7 provides the optimal R&D strategies of the three firms for the base set of parameter values.

Insert figure 7 here

By comparing figures 4 and 7, two results emerge. First, the aggregate investment in R&D is higher when there are two small firms in the industry than when there is only one small firm (figure 4). Second, and more importantly, the big firm is less motivated to invest when there are two small firms, because it has a lower probability of success facing competition with two firms, and prefers to let one of them develop innovation and consequently acquire the innovation through an acquisition. Likewise, a small firm has a stronger motivation to engage in R&D as it will stand a better chance of being acquired by the larger firm.

Case 4: Potential entry For robustness, we also consider the possibility of entry. In particular, we examine an industry with two incumbent firms (a big one endowed with capital K_1 and a small one with capital K_2) and one potential entrant with capital K_2. In order to enter the industry, an entry cost of I_E must be incurred. The cost of entry is not known initially but is distributed uniformly on a an interval $[0, E]$. Once R&D and acquisition decisions have been made by the incumbent firms, the potential entrant can observe its realization of the entry cost and then decide whether to enter or not. Obviously, it will enter as long as its equilibrium profit exceeds the entry cost. The entrant's equilibrium profit depends on whether innovation has been successfully developed, whether an acquisition took place and also on which (if any) incumbent firms decided to commercialize innovation. The effect of acquisition and innovation provide opposite incentives for entry: acquisition induces entry by making the industry more concentrated and increasing equilibrium profits of all industry participants, including the entrant. By contrast, innovation shifts consumer demand in favor of the firm that commercializes innovation and reduces the profit of the entrant.

Insert figure 8 here

Figure 8 shows the equilibrium profit of the potential entrant as a function of the gain from innovation (captured by the parameter α') for four different cases - 1) the baseline case when the two incumbent firms stay separate and do not innovate (the dash-dotted line), 2) the larger incumbent firm acquires the smaller one but does not commercialize innovation, 3) innovation is commercialized by the large firm, but no takeover takes place, 4) the large incumbent firm acquires the small one and commercializes innovation. The base set of input parameters is used to produce figure 8.

As follows from figure 8, the negative effect of innovation on the entrant's profits by far outweighs the positive effect of the merger (due to increased industry concentration), for reasonable values of innovation benefits. Thus, the larger firm may have additional incentives to commercialize innovation as it helps to deter potential entry. We also performed an analysis of equilibrium strategies of the two incumbent firms in the presence of potential entry. The results of this analysis are consistent with the results presented in figures 3-7 and are available upon request.

2.3 Predictions of the model

Below we summarize the empirical predictions generated by the model. We test these predictions in the subsequent empirical section of the paper.

P1. *Acquisitions are procyclical.*

This result is illustrated in figure 5 and follows from the fact that equilibrium profits as well as the benefit of acquisitions are increasing in the demand shock x. This result is consistent with large theoretical literature on acquisitions (e.g. Lambrecht 2004, Morellec and Zhdanov 2005) and supported by empirical evidence (Mitchell and Mulherin, 1996, Maksimovic et al, 2001 and Harford, 2005).

P2. *Small firms' R&D is procyclical.*

This prediction is illustrated in figures 3,4,6,7. Higher values of the demand shock make it more attractive for small firms to invest in R&D either to keep innovation to themselves or to become an attractive acquisition target, if an acquisition is possible.

P3. *Big firms' R&D is less procyclical than small firms' R&D.*

Unlike small firms, large firms may find it disadvantageous to engage in an "R&D race" with small firms at intermediate states of demand, as they can obtain access to innovation by acquiring a small firm that succeeded in its R&D efforts.

P4. *Possibility of being acquired induces innovation (by both firms, but especially by the small one)*

This prediction follows from figures 3 and 4. Possibility of an acquisition amplifies the potential gain from innovation.

P5. *Greater bargaining power of the small firm leads to more aggressive innovation by the small firm and to higher likelihood of an acquisition. Empirically we capture this effect through asset liquidity and through past abnormal announcement returns to acquisition targets in the same industry. We expect smaller firms to be more likely to invest more in R&D when asset liquidity is high. This effect is expected to be more pronounced for inside, intra-industry liquidity. We also expect past announcement returns to be positively related to small firms' R&D intensities.*

Follows from figures 4 and 6. Having the ability to capture a greater fraction of the acquisition surplus, the small firm will tend to invest in R&D more aggressively to increase the odds of being acquired by the larger firm.

P6. *Increased product market competition leads to more innovation by smaller firms.*

Follows from figures 4 and 7. With more small firms in the industry, big firms become less motivated to invest in their own R&D programs (and face intense competition with small firms) and are more inclined to let small firms innovate and acquire those that innovate successfully.

3 Data and Empirical Methodology

3.1 Sample

Our data come from the Merged CRSP-Compustat Database, the Securities Data Corporation (SDC), the St. Louis Federal Reserve Economic Database (FRED), and the Census of Manufactures. We start with the Merged CRSP-Compustat Database and exclude companies in the financial (SIC codes 6000 to 6999) and utilities (SIC codes 4900 to 4999) industries. We also drop companies for which we are unable to compute acquisition liquidity or our main control variables. Our final sample includes 12,941 firms operating in 181 different three-digit SIC industries and 117,151 firm-year observations during the period

1984-2006. We merge to this data a sample of mergers and acquisitions from Securities Data Corporation (SDC) from the same period of time.

3.2 Industry Demand and Supply Variables

In our analysis, we use measures of fundamental industry demand and industry supply and liquidity conditions that we discuss in this section. To capture industry demand we use measures of downstream demand that we obtain from the Federal Reserve on the value of industrial production seasonally by industry, converted into 4 digit SIC codes. The industrial production data are publicly available series available at Federal Reserve based on data from Census Bureau.[14] We aggregate these measures to the three digit level and then calculate the annual change for each year. We then link these data to each industry by downstream industries using the input output matrix of the U.S. economy from the Bureau of Economic Analysis in the closest lagged census year (this matrix is published every five years) using the Bureau of Economic Analysis "use" tables.[15] Given most industries sell to multiple downstream industries, to construct our final demand shock measure we weight the percentage change of each downstream industry by the % sold to that industry at the 3 digit level. For industries that sell directly to consumers we use the change in consumer income in real dollars. For industries that sell directly to the government, we use the change in government military expenditures in real dollars as the downstream demand index. These demand indices are available directly from the authors. This procedure results in a binary demand shock variable, which we denote *Vexpand.*

Our main measure of asset liquidity follows Schlingemann, Stulz, and Walkling (SSW) (2002) and it captures the *historical liquidity* of a firm's assets using the value of past M&A activity in the firm's industry. Shleifer and Vishny (1992) argue that a high volume of transactions in an industry is evidence of high liquidity because the discounts that sellers must offer to attract buyers are smaller in more active resale markets. Consequently, we obtain the value of all M&A activity involving publicly traded targets in each

[14] These data are available at http://www.federalreserve.gov/releases/g17/table1_2.htm

[15] Input output tables are from Bureau of Economic Analysis web site and are publicly available at: http://www.bea.gov/industry/#io. We match this data into SIC codes using publically available correspondence tables.

three-digit SIC industry and in each year from the Securities Data Corporation (SDC). We include both mergers and acquisitions of assets. Acquisitions of assets are important conceptually and economically to our argument. Conceptually there are many firms who develop R&D in divisions and then sell that division. In our sample, overall acquisitions of assets are particularly important as they comprise approximately 75% of the total deals.

If SDC does not report corporate transactions in an industry-year, we set the value of transactions equal to zero. We then scale the value of transactions in the industry by the total book value of assets in the industry, and further average this ratio over the past five years. To compute the value of the assets in each industry, we sum the assets in the industry reported by single-segment firms and the segment level assets reported by multiple-segment firms in the Compustat Segment data, breaking up the multiple-segment firms into their component industries. Averaging over past years smooths the temporary ups and downs in M&A activity and allows us to better capture the intrinsic salability of an industry's assets. The resulting asset-liquidity measure we denoted *wSSW*.[16]

We further decompose our measure of asset liquidity to distinguish between inside buyers of assets – those who operate in the same three-digit SIC industry as the target – and outside buyers – those who do not currently operate in the industry. Again we use the Compustat Segment tapes to further refine this calculation. We classify a purchase as an inside purchase if the buyer has any segments with the same there-digit SIC code as the assets purchased – checking over each reported SIC code of the target if the target reports multiple SIC codes. *InsM&A* is the value of M&A activity in the industry involving acquirers that operate within the industry, scaled by the book value of the assets in the industry. *OutM&A* is the value of M&A activity in the industry involving acquirers that operate outside the industry, scaled by the book value of the assets in the industry. Both of these variables are averaged over the past five years.

Our measure of industry competition is based on the Census Herfindahls as updated and extended to nonmanufacturing industries by Hoberg and Phillips (2010a). The variable "compete" is equal to 1 minus the Herfindahl index. We also examine if our results are robust to the text-based industry concentration

[16] Our analyses based on this and related M&A measures are unaffected if we exclude from the sample firms that are undergoing M&A activity in a particular year.

measure developed in Hoberg and Phillips (2010b). This later measure is only avaiable for years 1997 onwards and thus these results are only available for a subset of our sample period. To capture the supply of capital, we use the spread between the rate on Commercial & Industrial (C&I) loans and the Fed Funds rate as a measure for aggregate liquidity following Harford (2005). Lown et al. (2000) find that this spread is strongly correlated with the tightening of liquidity measured from Federal Reserve Senior Loan Officer (SLO) survey. When credit spread is low, acquisitions become easier to finance and are more likely to be carried out.

In addition, several authors have also recently argued that a significant fraction of merger activity of public firms can be explained by misvaluation or unexplained valuation. For example, Rhodes-Kropf, Robinson and Viswanathan (2005) (RKRV) argue that while economic shocks might be fundamental determinants of merger activity, misvaluation by public markets may determine who buys whom and how mergers are clustered in time. We adopt a variant of the RKRV measure of firm- and industry-specific unexplained valuation and check whether the addition of this variable affects our findings. We label this variable in our tables UV, RKRV to indicate that it is unexplained valuation based on the RKRV model. To calculate the measures of unexplained valuation, we use model (3) from RKRV, as updated by Hoberg and Phillips (2010).[17] First, we regress log market value of equity on log book value of equity, net income, an indicator for negative net income and leverage ratio by industry using a historical 10-year rolling window. Following Hoberg and Phillips, we use only lagged data in the calculation of these coefficients to avoid any look ahead bias. Then, we use the estimated industry-specific regression coefficients to compute the predicted market value of equity assuming that a firm's market value at time t is a function of its current characteristics and the industry specific value of characteristics estimated from past years. The unexplained valuation measure is then the difference between the actual valuation and the predicted valuation both at time t. For robustness we also calculate a second unexplained valuation measure using the valuation model from the Pastor and Veronesi (2003) paper, model 1, as described in Hoberg and Phillips (2010). In our tables this variable is reported as UV, PV.

[17] As discussed by Rhodes-Kropf, Robinson, and Viswananthan (2005), the key to investigating these effects is obtaining a good measure of misvaluation. Measures of misvaluation are of necessity valuation anomalies relative to a model of market expectations. While intended to measure misvaluation they may also pick up the market's expectation of future performance. The discussion of the valuation models in general is beyond the scope of this paper.

4 Results

4.1 Summary Statistics

Table 1 presents the summary statistics of our main variable used in the second stage regressions, annual R&D expenditures scaled by sales, and also annual acquisition rate by different size groups. Panel A shows that the highest R&D activity as a percentage of sales is concentrated among firms with below median size. R&D for firms between the 25 and 50th percentile of market capitalization is 2.4 percent of sales. Given market capitalization reflects growth options and R&D may capture many growth options, the fact that R&D is very low at the lowest size decile is not surprising. At the highest size decile, R&D is also a low fraction of market capitalization consistent with many growth options being already exercised for these large firms. Panel B shows that the acquisition rate for firms below the median market capitalization.

Insert Table 1 here

Table 2 presents summary statistics for our sample of Compustat Firms.

Insert Table 2 here

Our demand variables are presented in the first group. We present the detrended annual percentage change (*Vdshock*) in the downstream industry and also its discretized version (*Vexpand*). To detrend the variable we regress it on industry and year indicator variables and then take the residual from this regression. The detrended variable represents the "shock" or unanticipated change to demand. We study the effect of both demand shock variables in our regressions

The second group of variables represent measures of the liquidity in the market for mergers. *wSSW* is the asset liquidity measure capturing the value of M&A activity in the industry. *Ins M&A* is the value of M&A activity involving acquirers from the same industry. *Out M&A* is the value of M&A activity involving acquirers operating outside the industry. *Abn. announcement return* is industry-level mean abnormal announcement returns to acquisition targets in the previous year. *Mfflow* is the mutual funds flow variable. *C&I spread* is the commercial and industrial loan spread.

The third group of variables is our unexplained valuation variables which may capture either future growth prospects or misvaluation. The last group of variables is our instruments for the first stage of our regression. These include institutional ownership and unexpected mutual fund flow - both from Edmans, Goldstein and Jiang (2009).

4.2 First stage target prediction

Before examining R&D directly, we first present our first stage regression where we predict mergers and acquisitions. We use the predicted value of R&D in our second stage regression when we examine how R&D responds to a firm's expectation of a possible acquisition and the liquidity in the market for assets. We use both fundamental demand and supply variables as well as two instruments that are independent of our second stage.

Our two independent variables that we use as instruments are institutional ownership and also unexpected mutual fund flow. The institutional ownership variable follows Edmans, Goldstein and Jiang (2009). We test in the next section whether the effect of these variables affects firm R&D only through the probability of acquisitions and find that this indeed the case and these variables are found to satisfy the exclusion restriction. The unexpected mutual flow variables is also from Edmans, Goldstein and Jiang (2009) and captures the pricing pressure from changes in mutual fund holdings that are caused by redemptions that causes the mutual fund to sell stocks.[18] This unexpected mutual fund flow has been shown to have persistent valuation effects that extend up to 24 months by Edmans, Goldstein and Jiang (2009). It is likely to be exogenous to fundamentals but may impact acquisition likelihood through a firm's discount from fundamentals as it captures deviations from predicted valuation that are caused by investors redeeming mutual fund shares that subsequently cause the mutual funds to sell stocks. The mutual fund flow instrument has been used successfully recently by Edmans, Goldstein and Jiang (2009) as an exogenous instrument that affects firm's acquisition probability through the discount or valuation channel.

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[18] We thank Edmans, Goldstein and Jiang for sharing this mutual fund flow data with us.

Our other variables follow the basic specification of Ambrose and Megginson (1992) and Harford (2005). Specifically, the dependent variable is the target dummy, equaling one if the firm was a target in an acquisition attempt in a given year, and zero otherwise. *Vdshock* is a detrended version of demand shock variable constructed from the input-output matrix. *Log(market value)* is the natural log of the market value of equity. *Log(cash/NA)* is the natural log of the ratio of cash to net assets. *Profitability* is the ratio of operating profit to net assets. *NWCNA* is net working capital divided by the value of net assets. *Tangibility* is the proportion of tangible assets. *P-E ratio* is the price-to-earnings ratio. *Institutional ownership* is the percentage of stock owned by institutional investors. *C&I spread* is the spread between the Commercial & Industrial (C&I) loans and the Fed Funds rate. *Firm-level UV, PV* is the firm-level unexplained valuation computed based on the Pastor and Veronesi (2003) (PV) model. *Firm-level UV, RKRV* is the firm-level unexplained valuation computed based on the Rhodes-Kropf, Robinson, and Viswanathan (RKRV) model. *Industry-level UV, RKRV* and *Industry-level UV, PV* are the industry-level unexplained valuation variables.

Insert Table 3 here

Table 3 shows that coefficients of most variables appear to have expected signs. The coefficient for Vdshock is positive and marginally significant in regressions with no year dummies. Vdshock is an annual measure, so inclusion of year dummies makes it insignificant. Size is positively related to the probability of being taken over, however, size interacted with shock is negative - small firms have a relatively higher probability of acquisition at high industry states. Industry-level unexplained valuation is positive perhaps reflecting industries that are viewed as having positive future cashflows or that industries that are more positively "misvalued" may have higher acquisition intensity. However, within industries, firm-level unexplained valuation is negative, as acquirers target relatively undervalued firms. These facts are consistent with RKRV and also Maksimovic and Phillips (2001). The coefficient on C&I spread is negative as expected as low spreads make debt capital very accessible. Institutional ownership is positive consistent with institutional owners facilitating acquisition. Institutional ownership appears a valid instrument as it does not affect R&D directly but is significant in the acquisition prediction variable. (It is insignificant in the second-stage regressions discussed later). Our other instrument Mfflow is also positive and significantly related to the probability of an acquisition.

4.3 Second stage (R&D) regressions

We now turn to our main results where we examine firm level R&D. We examine both R&D scaled by sales and R&D scaled by assets. We include variables capturing size, demand shocks and also variables capturing both the liquidity and competitiveness of industries. We test the predictions outlined earlier in section 2 from our model. We examine two different demand shock variables, including in Panel A discretized version of demand shocks we term "Vexpand". The variable Vexpand equals one when the downstream demand increases for an industry. In Panel B we include the previously discussed continuous vertical demand shocks,"Vdshock". We interact these demand variable with firm size to test Prediction 2 and Prediction 3.

Insert Table 4 here

Table 4 shows that R&D increases with demand but less so for large firms as evident by the negative coefficient on the demand shock interacted with size. Thus small firms' R&D is more sensitive to demand. The table also shows that M&A activity increases firm R&D in several ways. The variable "wSSW" follows Stulz, Schliglemnan and Walking (2002) measuring the liquidity of the merger and acquisition market by summing up all value of M&A activity at the three digit SIC code and dividing it by the total firm value in that industry, as described above. Inspection of the results in Table 4 reveal that the value of M&A activity increases firm R&D as shown by the positive coefficients on the SSW liquidity measure in the regression specifications. We also find the interaction variable of the SSW liquidity variable with size is negatively related to firm R&D. Thus, large firms increase their R&D less than small firms in industries with high acquisition activity. These results are consistent with our Prediction 5 that greater bargaining power increases firm R&D and in particular for small firms.

Our second set of tests examine Predictions 4 and 6 where we examine the effect of acquisition expectations, competition in the M&A market and the effect of market concentration and competitiveness. We first discuss Prediction 4 that the probability of an acquisition increases firm R&D. We test this prediction by including the predicted probability of an acquisition from our first-stage target prediction regression. We find in every specification that the probability of being a target increases firm R&D.

Our final test is to examine Prediction 6 that product market competition increases firm R&D and more so for small firms. We test this prediction by including the variable "Compete" and then interact it with firm size. Compete is measured as one minus industry Census Herfindahl index. We find that product market competition increases firm R&D but less so for large firms. The intuition is that firms have to do more R&D to stay current in competitive industries and that small firms incentive to increase R&D is particular large - either because they can sell out to larger firms or it enables them to survive in the longer run.

In addition to the Herfindahl-based competition measure we also use the text-based industry concentration measure developed in Hoberg and Phillips (2010b). This measure is only available since 1997, so we use it for the subsample starting in 1997 (resulting in a significant loss of observations) and we also extrapolate it over the whole sample. The results are robust with text-based concentration measures being significant in all regression specifications. These results are available upon request.

Table 5 extends these results by examining an alternative to the SSW liquidity variable to test Prediction 5 that the bargaining power of target firms increases firm R&D. We examine the industry-average cumulative abnormal return to acquisition announcements in the previous year. To construct this measure we take the -250 to + 30 target abnormal returns surrounding previous year merger announcements and cumulate them over this period. We then average these firm specific abnormal returns for a given industry-year. Abnormal announcement returns are likely to be related to the share of the acquisition surplus captured by the target and are correlated with the probability a firm is a target and we thus do not include the probability a firm is a target directly. The idea is that following periods of high abnormal returns in their industries, target shareholders may naturally anticipate high returns to their firms and higher bargaining power in the event of an acquisition. This anticipation encourages potential target firms to intensify their R&D programs in an effort to create a successful innovation and attract potential bidders.

Insert Table 5 here

Inspection of Table 5 shows that we find strong support for Prediction 5. The bargaining power of target firms strongly increases firm R&D as shown by the significant positive coefficients on the lagged cumulative abnormal returns. The table also shows that this effect is larger for smaller firms as the coefficient on the interaction variable of "Abn. AR" with firm size is negative. Overall this table supports the conclusion that small firms' R&D increases strongly when their bargaining power in acquisitions increases.

We now extend our results further by examining whether the type of merger liquidity affects firm R&D. We further decompose the SSW measure of asset liquidity to distinguish between inside buyers of assets – those who operate in the same three-digit SIC industry as the target – and outside buyers – those who do not currently operate in the industry. Shleifer and Vishny (1992) model how inside asset liquidity causes firms to loose less value in asset sales as these inside buyers are better informed about the asset value and can operate the asset at closer to its optimal way. The idea we are testing is whether firms will invest more in R&D given that they anticipate there is a more active inside industry market in which to sell the firm. We use the Compustat Segment tapes to further refine this calculation. We classify a purchase as an inside purchase if the buyer has any segments with the same there-digit SIC code as the assets purchased – checking over each reported SIC code of the target if the target reports multiple SIC codes. *InsM&A* is the value of M&A activity in the industry involving acquirers that operate within the industry, scaled by the book value of the assets in the industry. *OutM&A* is the value of M&A activity in the industry involving acquirers that operate outside the industry, scaled by the book value of the assets in the industry. Both of these variables are averaged over the past five years. In general, we expect that successful innovation is more likely to attract acquirers with similar product lines and operating in the same industry, thus the *InsM&A* liquidity measure is expected to affect R&D intensity more strongly than the *OutM&A* measure.

Insert Table 6 and 7 here

Table 6 presents the specification including inside industry asset liquidity and Table 7 presents the results for outside asset liquidity. Table 6 shows that inside asset liquidity, *InsM&A.* positively and strongly affects firm R&D. The results also show that this effect is larger for smaller firms as the coefficient on inside liquidity interacted with firms size is negative. These results are significant in nearly all specifications in Table 6. By contrast, the coefficients on *OutM&A* in Table 7 are insignificant. The results are consistent with the conclusion that firms invest more in R&D when there is an active merger market with high liquidity and particularly when inside industry liquidity is high and thus the presence of an inside industry buyer is more likely.

Insert Table 8 here

Table 8, our final table, examines the effect of using our second instrument mutual fund flow, "Mfflow", in the first stage target prediction regression. We use the predicted probability from specification 6 that includes mfflow from Table 3. Overall the results are very similar to the ones presented earlier despite these regressions having only about 60% of the observations as the specifications where institutional ownership is used as the instrument. Firms invest more in R&D when the predicted probability of being acquired is higher. Firms invest more in R&D when there are positive demand realizations, particularly so for small firms. Firms also invest more in R&D when inside industry asset liquidity is higher and in more competitive industries. The interaction variables with firm size show that the effects are stronger for small firms than for large firms as the size interaction variables are negative and significant.

5 Conclusions

In this paper we examine how merger and acquisition activity and competition affect the decision to conduct R&D and innovate. Our theory shows the importance of the acquisition market for the decision to conduct R&D. We model the incentives for large and small firms to conduct R&D based on their size, the gains of commercialization and the potential for firms to merge or acquire other firms post innovation. Our model and evidence shows that large firms optimally may decide to let small firms conduct R&D and innovate and then subsequently acquire these small innovative companies. Unlike small firms, large firms may find it disadvantageous to engage in an "R&D race" with small firms at intermediate states of demand, as they can obtain access to innovation by acquiring small innovate firms.

Our theory and evidence shows that the possibility of an acquisition amplifies the potential gains from innovation - particularly so for smaller firms. We show that smaller firms' incentives to conduct R&D to innovate increase with the probability that they are taken over. These incentives to innovate and acquire other firms also vary naturally with the state of demand. The probability a firm is a target varies positively with industry demand and R&D varies positively with both industry demand and also with the predicted probability a firm is an acquisition target.

We also show that greater bargaining power of small firms and more inside asset liquidity in the M&A market leads to more aggressive innovation by the small firms and to higher likelihood of acquisition. Having the ability to capture a greater fraction of the acquisition surplus, the small firm will tend to invest in R&D more aggressively to increase the odds of being acquired by the larger firm. Lastly we show that market structure and competition are important. A higher number of small firms leads to more innovation by smaller firms and to less innovation by larger ones.

We conclude that merger and acquisition activity strongly increases firms' incentives to conduct R&D, particularly so for small firms as then the small firms have a more likely potential buyer for their technology in the event that they wish to sell. Competition also increases incentives for firms to conduct R&D and especially so again for small firms - either because they need to innovate to survive as an independent entity or because they have a higher likelihood that they can sell out to larger firms to monetize their investments in R&D.

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Appendix

1. Equilibrium profit functions

One small firm, no acquisition: equilibrium profits The inverse demand functions (5) and (6) are linear in prices. We then substitute these functions into profit functions (4) , differentiate with respect to prices (firms maximize their profits by setting prices competitively), set the derivatives equal to zero, and solve the resulting system of equations. This produces equilibrium prices:

$$p_1 = \left(-2 + \left(-1+\gamma^2\right) K_1\right) \left(\alpha_2 \gamma K_2 + \alpha_1 \left(-2 + \left(-2+\gamma^2\right) K_2\right)\right) \kappa x,$$

$$p_2 = \left(-2 + \left(-1+\gamma^2\right) K_2\right) \left(\alpha_1 \gamma K_1 + \alpha_1 \left(-2 + \left(-2+\gamma^2\right) K_1\right)\right) \kappa x,$$

where

$$\kappa = \left[4 - 2\left(-2+\gamma^2\right) K_2 + K_1 \left(\gamma^4 K_2 + 4(1+K_2) - \gamma^2(2+5K_2)\right)\right]^{-1}$$

We then substitute equilibrium prices into inverse demand functions (5) and (6) to get equilibrium quantities, then into profit functions (4) to obtain profits.

The equilibrium profits of the two firms are given by:

$$\pi_1(\alpha_1, \alpha_2) = x^2 \kappa K_1 (1 + (1-\gamma^2) K_1)(\alpha_2 \gamma K_2 + \alpha_1((\gamma^2 - 2)K_2 - 2)^2,$$

$$\pi_2(\alpha_1, \alpha_2) = x^2 \kappa K_2 (1 + (1-\gamma^2) K_2)(\alpha_1 \gamma K_1 + \alpha_2((\gamma^2 - 2)K_1 - 2)^2.$$

One small firm, no acquisition: firm values The value of the big firm conditional on its own innovation strategy and that of the small firm are given by the following expressions. α' represents the new post commercialization innovation parameter. :

$$V_1(x, B = I, S = NI) = \delta \max\{\pi_1(\alpha', \alpha_2) - I_1, \pi_1(\alpha_1, \alpha_2)\} + (1-\delta)\pi_1(\alpha_1, \alpha_2) - RD_1,$$

$$V_1(x, B = NI, S = I) = \pi_1(\alpha_1, \alpha_2) 1_{\{\pi_2(\alpha_1, \alpha') - I_2 < \pi_2(\alpha_1, \alpha_2)\}} + [\delta \pi_1(\alpha_1, \alpha') + (1-\delta)\pi_1(\alpha_1, \alpha_2)] 1_{\{\pi_2(\alpha_1, \alpha') - I_2 > \pi_2(\alpha_1, \alpha_2)\}},$$

$$V_1(x, B = I, S = I) = \frac{1-(1-\delta)^2}{2} [\pi_1(\alpha_1, \alpha_2) 1_{\{\pi_2(\alpha_1, \alpha') - I_2 < \pi_2(\alpha_1, \alpha_2)\}} + \pi_1(\alpha, \alpha') 1_{\{\pi_2(\alpha_1, \alpha') - I_2 > \pi_2(\alpha_1, \alpha_2)\}}] + \frac{1-(1-\delta)^2}{2} \max\{\pi_1(\alpha', \alpha_2) - I_1, \pi_1(\alpha_1, \alpha_2)\} + (1-\delta)^2 \pi_1(\alpha_1, \alpha_2) - RD_1,$$

$$V_1(x, B = NI, S = NI) = \pi_1(\alpha_1, \alpha_2).$$

The value of the small firm is found similarly. A Nash equilibrium of the game is a pair of strategies $s^* \in \{I, NI\}$, such that for $i = 1, 2$ $V_i(s_i^*, s_j^*) \geq V_i(s_i, s_j^*)$. To simplify the analysis, we focus on pure strategy equilibria.

The profit of the merged firm The profit of the merged firm is obtained by optimizing over the product prices and is given by

$$\pi_m(x,\alpha_m) = \frac{\alpha_m^2 x^2\left[-2\gamma K_1 K_2 + (1+K_1)K_2 + (1+K_2)K_1\right]}{-4(1+K_2)+4K_1((\gamma^2-1)K_2-1)}, \tag{7}$$

where $\alpha_m = \alpha'$ if the merged entity commercializes innovation and $\alpha_m = \alpha$ otherwise.

Two small firms, equilibrium profits For ease of exposition we assume $\alpha_1 = \alpha_2 = \alpha_3 = \alpha$. When there are two small firms the profit functions are computed analogously to the case with one small firm and are given by (for $K_1 = 10, K_2 = 1$) :

$$\pi_1(\alpha,\alpha,\alpha) = -5\alpha^2 x^2(1+\gamma)(4-3(-1+\gamma)\gamma)^2(-11+\gamma(-11+20\gamma))\kappa_1,$$

$$\pi_2(\alpha,\alpha,\alpha) = \pi_3(\alpha,\alpha,\alpha) = -2\alpha^2 x^2(11+3(2-5\gamma)\gamma)^2(-1-2\gamma+\gamma^3)\kappa_1,$$

where

$$\kappa_1 = (44-3\gamma(-33+\gamma(2+27\gamma)))^{-2}$$

if neither firm innovates;

$$\pi_1(\alpha',\alpha,\alpha) = 5x^2(1+\gamma)(-11+\gamma(-11+20\gamma))(2\alpha\gamma(1+\gamma)+\alpha'(-4+(-5+\gamma)\gamma))^2\kappa_1,$$

$$\pi_2(\alpha',\alpha,\alpha) = \pi_3(\alpha',\alpha,\alpha) = -2x^2(-1-2\gamma+\gamma^3)(5\alpha'\gamma(1+\gamma)+\alpha(-11+\gamma(-11+10\gamma)))^2\kappa_1,$$

if the big firm innovates; and

$$\pi_1(\alpha,\alpha',\alpha) = -2.5x^2(1+\gamma)(-11+\gamma(-11+20\gamma))(\alpha'\gamma(1+\gamma)+2\alpha(-2+(-2+\gamma)\gamma))^2)\kappa_1,$$

$$\pi_2(\alpha,\alpha',\alpha) = (\alpha\gamma(1+\gamma)(-31+3\gamma(-7+10\gamma))+\alpha'(44+\gamma(88+\gamma(-23+3\gamma(-24+5\gamma)))))^2\kappa_2,$$

where

$$\kappa_2 = \frac{-2(-1-2\gamma+\gamma^3)}{(4-3(-1+\gamma)\gamma)^2}\kappa_1$$

$$\pi_3(\alpha,\alpha',\alpha) = (11+3(2-5\gamma)\gamma)^2(\alpha'\gamma(1+\gamma)+2\alpha(-2+(-2+\gamma)\gamma))^2\kappa_2,$$

if one small firm (firm 2) innovates.

2. Alternative specifications

In this section we consider alternative specifications of the utility function and innovation mechanism. The results from these alternative specifications are consistent with those obtained in our base case framework and are available upon request.

1. Cournot competition, cost savings, quadratic utility For the case of Cournot competition with homogenous products (and quadratic utility), the representative consumer's utility function becomes

$$U(q) = x\alpha q - \frac{1}{2}q^2,$$

which results in the following inverse demand functions

$$p(q) = x\alpha - q$$

The profit of firm j is then given by

$$\pi_j = q_j p_j - c_j(i)\frac{q_j^2}{2K_j},$$

where the cost parameter c_j depends on whether the firm has access to the innovation, $c_j(i=1) < c_j(i=0)$, innovation results in cost savings.

Below are the equilibrium profits of firms in the two- and three-firm cases:

Two firms, no merger:

$$\pi_1(c_1, c_2) = x^2\alpha^2 K_1(K_1 + c_1)(K_2 + 2c_2)^2\kappa_3,$$
$$\pi_2(c_1, c_2) = x^2\alpha^2 K_2(K_2 + c_2)(K_1 + 2c_1)^2\kappa_3,$$

where

$$\kappa_3 = [K_1(3K_2 + 4c_2) + 4(K_2 + c_2)c_1]^{-2}$$

Two firms, merger:

$$\pi_m(c) = \frac{x^2\alpha^2(K_1 + K_2)}{4(K_1 + K_2 + c)}.$$

Three firms, no merger, the bigger firm innovates ($c_1 = c_i$; $c_2 = c_3 = c$); the profit of the bigger firm:

$$\pi_1(c_i, c, c) = x^2\alpha^2 K_1(K_2 + 2c)^2(K_1 + c_i)\kappa_4,$$

where

$$\kappa_4 = 0.25(2K_1(K_2 + c) + (3K_2 + 2c)c_i)^{-2}.$$

Three firms, no merger, the bigger firm innovates ($c_1 = c_i$; $c_2 = c_3 = c$); the profit of the smaller firm:

$$\pi_2(c_i, c, c) = x^2\alpha^2 K_2(K_1 + 2c_i)^2(K_2 + c)\kappa_4.$$

Three firms, no merger, the smaller firm innovates ($c_1 = c_3 = c$; $c_2 = c_i$); the profit of the bigger firm:

$$\pi_1(c, c_i, c) = x^2\alpha^2 K_1(K_1 + c)(K_2 + 2c)^2(K_2 + 2c_i)^2\kappa_5,$$

where

$$\kappa_5 = 0.25(K_2(2K_1K_2 + 3(K_1 + K_2)c + 4c^2) + (4c(K_2 + c) + K_1(3K_2 + 4c))c_i)^{-2}.$$

Three firms, no merger, the smaller firm innovates ($c_1 = c_3 = c$; $c_2 = c_i$); the profit of the smaller firm:

$$\pi_2(c, c_i, c) = x^2\alpha^2 K_2(K_2 + c_i)(K_2 + 2c)^2(K_1 + 2c)^2\kappa_5.$$

Three firms, merger, the merged firm innovates, the profit of smaller firm:

$$\pi_2(c_i, c_m) = x^2\alpha^2 K_2(K_2 + c)(K_1 + K_2 + 2c_i)^2\kappa_6,$$

where

$$\kappa_6 = ((K_1 + K_2)(3K_2 + 4c) + 4(K_2 + c)c_i)^{-2}.$$

Three firms, merger, the merged firm innovates, the profit of merged firm:

$$\pi_m(c_i, c_m) = x^2\alpha^2 K_2(K_2 + 2c)^2((K_1 + K_2)^2 - 2cK_2 + (K_1 + 2K_2)c_i)\kappa_6.$$

2. Bertrand heterogeneous products competition, cost savings, quadratic utility Here we assume heterogeneous products Bertrand competition (and quadratic utility), as in our base case, with innovation resulting in cost savings. Innovation does not affect consumer's utility directly ($\alpha_1 = \alpha_2$), but affects the cost functions of both firms, which has the form $c_j(i)\frac{q_j^2}{2K_j}$.

The inverse demand functions are now given by

$$q_1 = \frac{x\alpha(1-\gamma) - p_1 + p_2\gamma}{1-\gamma^2}, \tag{8}$$

$$q_2 = \frac{x\alpha(1-\gamma) - p_2 + p_1\gamma}{1-\gamma^2}. \tag{9}$$

The equilibrium profit functions in case of two firms and no merger are

$$\pi_1(c_1, c_2) = \frac{x^2\alpha^2 K_1(K_1\gamma^2 - c_1 - K_1)(c_1 K_2(\gamma^2+\gamma-2) - 2c_2)^2}{[K_2(-2c(\gamma^2-2) + K_1(4-5\gamma^2+\gamma^4)) + (4(K_1+\alpha) - 2K_1\gamma^2)c_2]^2}$$

$$\pi_2(c_1, c_2) = \frac{x^2\alpha^2 K_2(K_2\gamma^2 - c_2 - K_2)(c_2 K_1(\gamma^2+\gamma-2) - 2c_1)^2}{[K_2(-2c(\gamma^2-2) + K_1(4-5\gamma^2+\gamma^4)) + (4(K_1+\alpha) - 2K_1\gamma^2)c_2]^2}$$

Equilibrium profits in the remaining scenarios can also be obtained in closed form (but are more complex algebraically) and are available upon request.

3. Bertrand heterogeneous products competition, cost savings, constant elasticity utility function The representative consumer has a utility function of the following specification:

$$U(q, x) = x\left(\sum_{i=1}^{n} q_i^\beta\right)^\phi,$$

and the inverse demand functions are

$$p_i(q) = x\beta\phi\left(\sum_{i=1}^{n} q_i^\beta\right)^{\phi-1} q_i^{\beta-1}.$$

In this case equilibrium profits have to be computed numerically.

Figure 1. Sequence of events This figure presents the sequence of events and the nature of the game. Initially, firms observe a realization of the demand shock and decide whether or not they want to invest in R&D. Competition in R&D then results in each participating firm developing innovation with probability $p = \frac{1-(1-\delta)^n}{n}$. The larger firm then decides whether or not to acquire a smaller one (regardless of which firm, if any, has developed innovation). At the next step the firm with access to innovation (acquired either through its own R&D program or through an acquisition of another firm that successfully innovated) decides if it wants to commercialize it. Finally, equilibrium profits are earned by the firms.

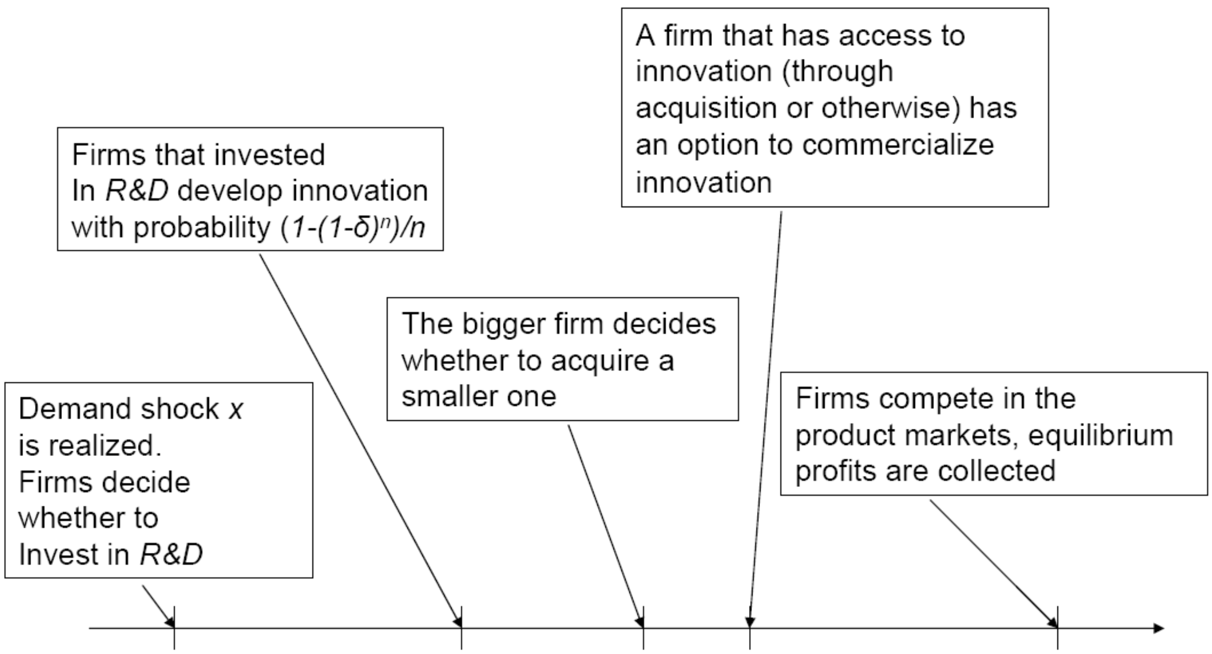

Figure 2. Equilibrium profits - 2 firms, no acquisition possible

This figure presents the equilibrium profit of a firm as a function of its "innovation parameter" α, the capital ratio of the firms K_1/K_2, and the degree of product differentiation, γ, for the following set of input parameters: $K_1 = 10$, $K_2 = 1$, $\gamma = 0.5$, $\alpha_1 = 10, \alpha_2 = 10$. For each graph we compute the profits with these values but vary one of them as indicated on the x-axis. Consistent with intuition, equilibrium profit of one firm increases in its own innovation parameter α_i, and decreases with its product substitutability γ, its rival's capitalization K_j, and its innovation parameter α_j.

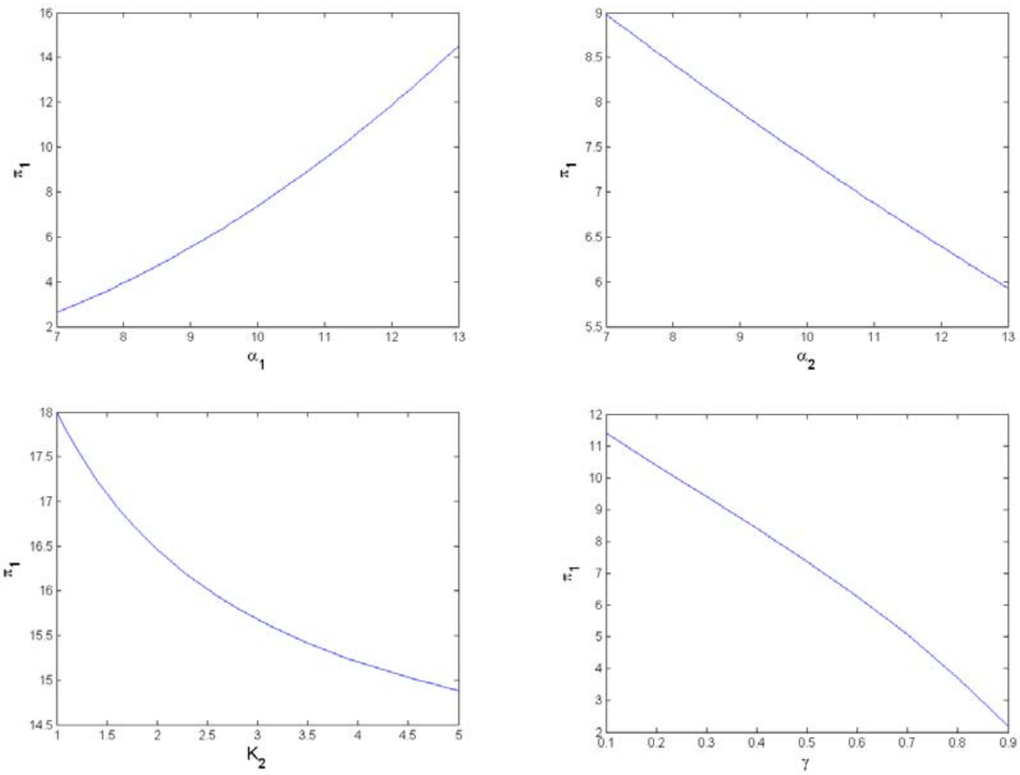

Figure 3. Equilibrium strategies - two firms, no acquisition possible
This figure presents the equilibrium investment thresholds of the two firms in the case when an acquisition is precluded, as functions of the innovation parameter α'. Above the upper threshold both firms find it optimal to invest in R&D, between the upper and the lower thresholds only the big firm invests, while no firm invests below the lower threshold. The set of input parameters is as follows: $K_1 = 10$, $K_2 = 1$, $\gamma = 0.5$, $\alpha_1 = \alpha_2 = 10, \alpha' = 15, RD_1 = RD_2 = 15, I_1 = 0, I_2 = 5$, $\delta = 0.8$.

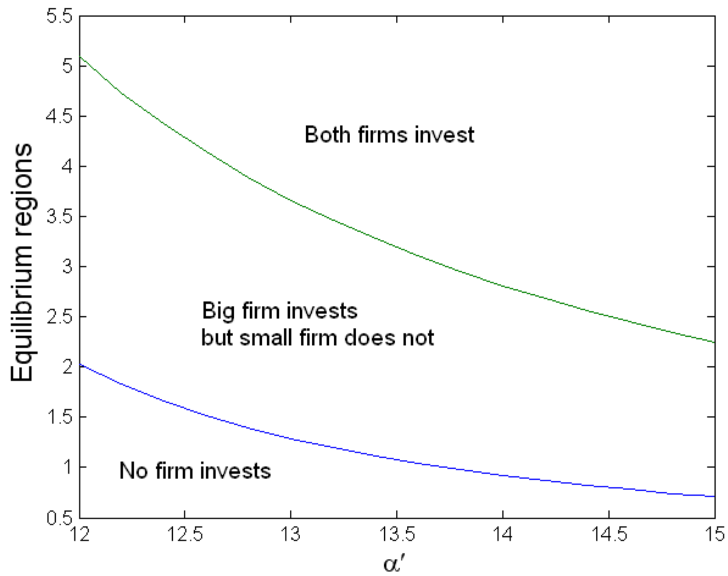

Figure 4. Equilibrium strategies - two firms, an acquisition is possible
This figure presents the equilibrium investment thresholds of the two firms in the case when an acquisition is possible, as functions of the innovation parameter α'. The set of input parameters is as in figure 3. In addition, the relative bargaining power of target shareholders $\eta = 0$. At low states of the demand shock x both firms prefer not to invest in R&D. For sufficiently high states of x the big firm decides to invest in R&D. For even higher states of demand the benefit of innovation for the small becomes high enough and it decides to invest in R&D while the larger firm backs out from investing, as it has an option to acquire the small firm.

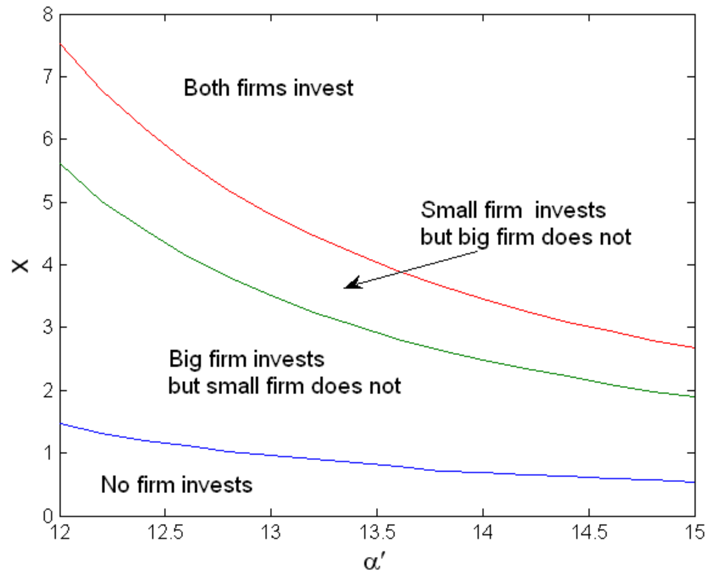

Figure 5. Acquisition thresholds This figure presents the equilibrium acquisition strategy as a function of the demand shock x. The set of input parameters is as in figure 3. Above the higher boundary, an acquisition occurs with certainty. Between the lower and the upper thresholds, an acquisition is optimal only if the small firm obtains the innovation. Below the lower threshold acquisition never occurs. Thus, the probability of an acquisition is positively related to the state of the demand shock x and acquisitions are procyclical.

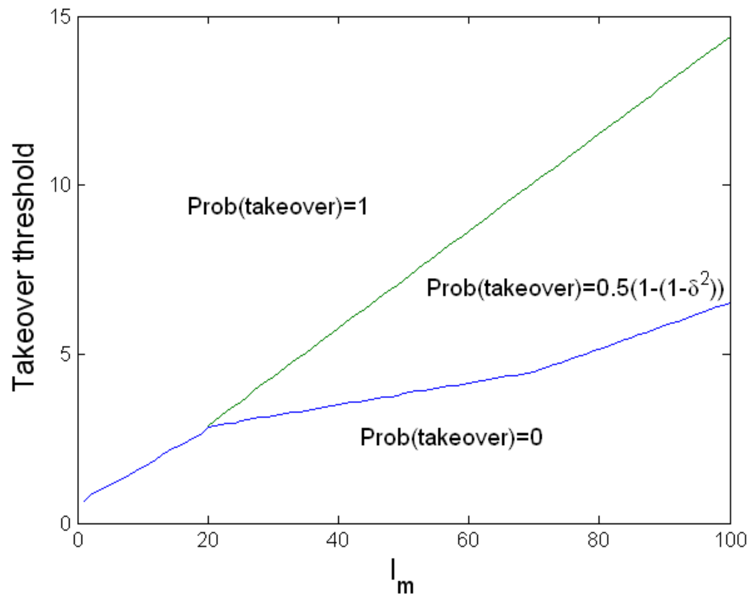

Figure 6. Equilibrium strategies - 2 firms, an acquisition possible This figure presents the equilibrium investment thresholds of the two firms in the case when an acquisition is possible, as functions of the innovation parameter α'. The set of input parameters is as in figure 3. In addition, the relative bargaining power of target shareholders $\eta = 0.5$. There are four different regions in figure 6, similarly to figure 4. It follows from comparing figures 6 and 4 that greater bargaining power of the potential target (small firm) substantially increases its innovation incentives.

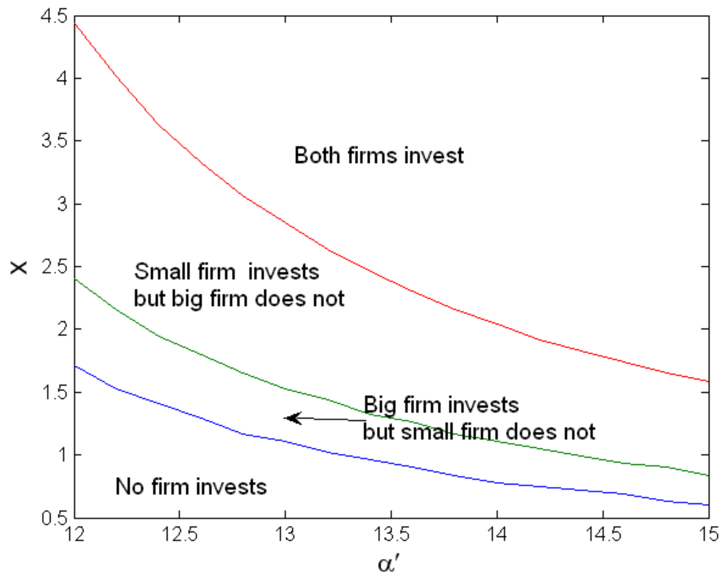

Figure 7. Equilibrium strategies, one big firm, two small firms, an acquisition is possible This figure presents the equilibrium investment thresholds of the two firms in the case when an acquisition is possible, as functions of the innovation parameter α'. The set of input parameters is as in figure 3. In addition, the relative bargaining power of target shareholders $\eta = 0$. In region I no firm invests in R&D, in region II only a big firm invests, in region III the two small firms invest, while in region IV all three firms invest in R&D. The big firm is less motivated to invest when there are two small firms, because it has a lower probability of success facing intensified R&D competition, and prefers to let one of the small firms develop innovation and consequently acquire it. Likewise, a small firm has a stronger motivation to engage in R&D as it stands a better chance of being acquired by the larger firm.

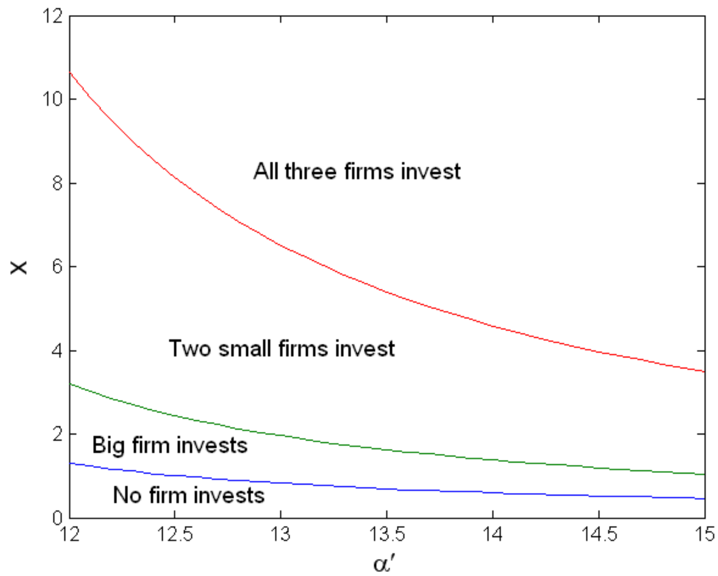

Figure 8. Equilibrium profit of the potential entrant This figure presents the equilibrium profit of the potential entrant into an in industry with two incumbent firms, one large and one small as a function of the innovation benefit α'. The dash-dotted line corresponds to the base-line case of no merger and no innovation. The dashed line provides the profit when a merger occurs but the merged entity does not commercialize innovation. The dotted line corresponds to the case of a takeover and innovation, while the solid line to the case when the large firm commercializes innovation but does not acquire the small one.

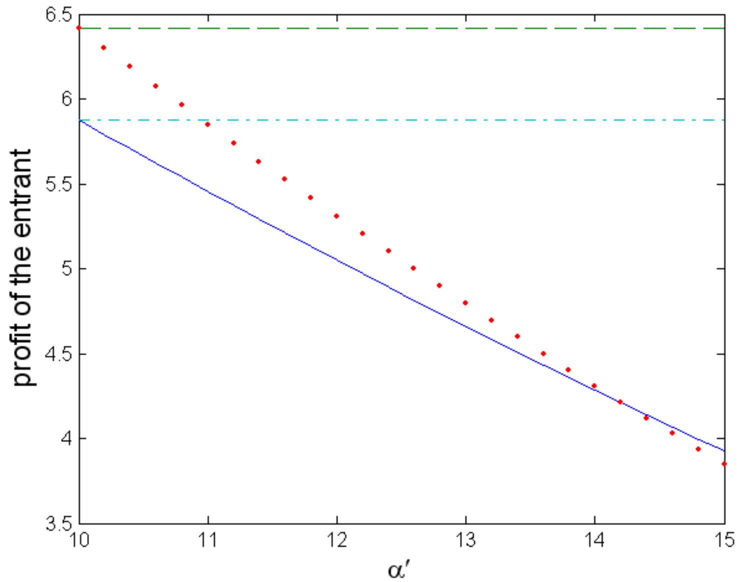

Table 1: R&D and Acquisition summary statistics

Table 1 reports summary statistics for R&D scaled by sales and number of acquisitions by year for different size groups. Size is defined as the log of the market equity value.

PANEL A - R&D/Sales

Variable	**Mean**	**Median**	**Std. Dev.**	**N**
R&D/Sales, size < 10%	0.266	0.000	1.716	7348
R&D/Sales, 10 % < size < 25%	0.487	0.016	2.793	11018
R&D/Sales, 25 % < size < 50%	0.669	0.024	3.125	18381
R&D/Sales, 50 % < size < 75%	0.450	0.015	2.324	18381
R&D/Sales, 75 % < size < 90%	0.153	0.001	1.063	11019
R&D/Sales, 90% < size < 100%	0.056	0.004	0.271	7348

PANEL B - Acquisition rate

Variable	**Mean**	**Median**	**Std. Dev.**	**N**
Annual acquisition rate, size < 10%	0.162	0.186	0.087	23
Annual acquisition rate, 10 % < size < 25%	0.099	0.098	0.026	23
Annual acquisition rate, 25 % < size < 50%	0.095	0.097	0.026	23
Annual acquisition rate, 50 % < size < 75%	0.086	0.080	0.025	23
Annual acquisition rate, 75 % < size < 90%	0.070	0.071	0.034	23
Annual acquisition rate, 90% < size < 100%	0.055	0.051	0.028	23

Table 2: Summary statistics

Table 2 reports summary statistics of the main variables. *Vdshock* is a de-trended demand shock variable constructed from the input-output matrix. *Vexpand* is a discretized version of *Vdshock* . *wSSW* is the asset liquidity measure constructed following Schlingemann, Stulz and Walkling (2002). *Ins M&A* is the value of M&A activity involving acquirers from the same industry. *Out M&A* is the value of M&A activity involving acquirers operating outside the industry. *Abn. announcement return* is industry-level mean abnormal announcement returns to acquisitions in the previous year. *Mfflow* is the mutual funds flow variable. *C&I spread* is the commercial and industrial loan spread. *Firm level UV, PV* is the firm-level unexplained valuation computed from the Pastor and Veronesi (PV) model. *Firm level UV, RKRV* is the firm-level unexplained valuation computed from the Rhodes-Kropf, Robinson, and Viswanathan (RKRV) model. *Industry-level UV, RKRV* and *Industry-level UV, PV* are the industry-level unexplained valuation variables. *Inst. Ownership* is the percentage of common equity owned by institutional investors. *Compete* is a measure of industry competitiveness equalling one minus the Herfindahl index.

Variable	**Mean**	**Median**	**Std. Dev.**	**Min.**	**Max.**	**N**
			Demand and supply variables			
Vdshock	0.050	0.047	0.069	-0.270	0.903	84472
Vexpand	0.823	1.000	0.382	0.000	1.000	84472
			Liquidity variables			
wSSW	0.044	0.185	0.078	0.000	1.840	81060
Ins M&A	0.016	0.005	0.030	0.000	0.214	81060
Out M&A	0.027	0.009	0.067	0.000	1.840	81060
C &I spread	1.597	1.632	0.252	1.160	2.120	81531
Abn. announcement return	0.126	0.115	0.152	-0.887	3.715	84472
Mfflow	-1.032	-0.167	2.996	-319.331	0.000	41120
			Valuation variables			
Firm level UV, RKRV	0.070	0.063	0.853	-4.795	7.511	58788
Firm level UV, PV	0.069	0.058	0.827	-6.157	13.241	57186
Ind. level UV, RKRV	0.077	0.109	0.318	-1.652	1.783	77899
Ind. level UV, PV	0.077	0.111	0.306	-2.102	1.601	77849
			Concentration and ownership variables			
Inst. Ownership	20.804	9.829	24.818	0.000	99.995	84472
Compete	-5.219	-4.784	1.774	-22.166	-3.147	75771

Table 3: Target prediction regressions

The dependent variable is the target dummy, equaling one if the firm was a target in an acquisition attempt in a given year, and zero otherwise. *Vdshock* is a de-trended version of demand shock variable constructed from the input-output matrix. *Log(market value)* is the natural log of the market value of equity. *Log(cash/NA)*is the natural log of the ratio of cash to net assets. *Profitability* is the ratio of operating profit to net assets. *Net Work. Capital* is net working capital scaled by total assets. *Tangibility* is the ratio of tangible assets. *P-E ratio* is the price-to-earings ratio. *Divd dummy* is a dummy variable equalling one for dividend paying firms and zero otherwise. *Sales Growth* is the annual growth in sales. *Inst. Ownership* is the percentage of common equity owned by institutional investors. *C&I spread* is the commercial and industrial loan spread. *Firm-level unexplained valuation PV* is the firm-level unexplained valuation computed from the Pastor and Veronesi (PV) model. *Firm-level unexplained valuation RKRV* is the firm-level misvalutation computed from the Rhodes-Kropf, Robinson, and Viswanathan (RKRV) model. *Industry-level unexplained valuation RKRV* and *Industry-level unexplained valuation PV* are the industry-level unexplained valuation variables.

Independent Variable	*Dependent variable - Target dummy*					
Vdshock	0.053	0.120*	0.054	0.121*	0.087	0.195
	(0.061)	(0.063)	(0.062)	(0.063)	(0.123)	(0.124)
Log(equity value)	0.033***	0.033***	0.031***	0.032***	0.039***	0.039***
	(0.002)	(0.002)	(0.002)	(0.002)	(0.003)	(0.003)
Vdshock*Log(equity value)	-0.019	-0.023*	-0.019	-0.023*	-0.026	-0.032
	(0.012)	(0.012)	(0.012)	(0.012)	(0.021)	(0.022)
Log(Cash/NA)	-0.011***	-0.012***	-0.011***	-0.012***	-0.016***	-0.016***
	(0.001)	(0.001)	(0.001)	(0.001)	(0.002)	(0.002)
Profitability	0.003	0.003	0.003	0.003	0.002	0.002
	(0.003)	(0.003)	(0.003)	(0.003)	(0.005)	(0.005)
Leverage	0.037***	0.037***	0.036***	0.036***	0.050***	0.052***
	(0.008)	(0.008)	(0.008)	(0.008)	(0.012)	(0.012)
Net Work. Capital	-0.039***	-0.039***	-0.040***	-0.040***	-0.056***	-0.054***
	(0.008)	(0.008)	(0.008)	(0.008)	(0.012)	(0.012)
Tangibility	-0.069***	-0.069***	-0.069***	-0.069***	-0.095***	-0.092***
	(0.009)	(0.010)	(0.009)	(0.010)	(0.015)	(0.015)
P-E ratio	-0.000***	-0.000***	-0.000***	-0.000***	-0.000***	-0.000***
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
Divd dummy	0.012**	0.011**	0.012**	0.010**	0.006	0.009
	(0.005)	(0.005)	(0.005)	(0.005)	(0.007)	(0.007)
Sales growth	-0.051***	-0.049***	-0.053***	-0.050***	-0.074***	-0.068***
	(0.004)	(0.005)	(0.004)	(0.005)	(0.008)	(0.008)
Inst. Ownership	0.001***	0.001***	0.001***	0.001***	0.001***	0.001***
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
Firm level UV, RKRV	-0.035***	-0.035***				
	(0.003)	(0.003)				
Ind. level UV, RKRV	0.038***	0.031***				
	(0.007)	(0.007)				
C&I spread		-0.046***		-0.044***		-0.084***
		(0.007)		(0.007)		(0.011)
Firm level UV, PV			-0.032***	-0.032***	-0.045***	-0.044***
			(0.003)	(0.003)	(0.005)	(0.005)
Ind. level UV, PV			0.037***	0.029***	0.045***	0.040***
			(0.007)	(0.007)	(0.011)	(0.010)
Mfflow					0.004**	0.003**
					(0.002)	(0.002)
Observations	55,987	50,867	55,898	50,786	31,716	29,649
Year dummies	Yes	No	Yes	No	Yes	No
Errors clustered by	firm	firm	firm	firm	firm	firm

Table 4: R&D regressions, IO-matrix based demand shock

Table 4 reports estimates from *R&D* regressions. The dependent variable is *R&D* expense scaled by sales in the previous year. *Vdshock* is a de-trended demand shock variable constructed from the input-output matrix. *Vexpand* is a discretized version of *Vdshock* . *Log(net assets)* is the log of the asset value. *wSSW* is the asset liquidity measure. *Ptarget* is the estimated probability of an acquisition transaction. *Compete* is a measure of industry competitiveness equalling one minus the Herfindahl index. *C&I spread* is the commercial and industrial loan spread. *Firm level UV, RKRV* is the firm-level misvalutation computed based on the Rhodes-Kropf, Robinson, and Viswanathan (RKRV) model. *Ind level UV, RKRV* is the industry-level unexplained valuation variable. Standard errors are clustered by industry-years.

PANEL A

Independent Variable	*Dependent variable - R&D expenditures scaled by sales*						
Vexpand	0.350***	0.329***	0.659***	0.574***	0.514***	0.509***	0.421***
	(0.100)	(0.096)	(0.136)	(0.125)	(0.117)	(0.118)	(0.107)
Log(net assets)		-0.133***	-0.072***	-0.061***	-0.125***	-0.115***	-0.257***
		(0.019)	(0.011)	(0.009)	(0.044)	(0.043)	(0.053)
Vexpand*Log(net assets)			-0.075***	-0.065***	-0.053***	-0.055***	-0.041***
			(0.019)	(0.018)	(0.015)	(0.015)	(0.012)
wSSW				0.690	0.475	0.639*	0.475
				(0.501)	(0.301)	(0.330)	(0.345)
wSSW*Log(net assets)				-0.108*	-0.069	-0.128***	-0.069*
				(0.057)	(0.047)	(0.046)	(0.042)
Ptarget					0.356*	0.376*	0.613***
					(0.194)	(0.196)	(0.208)
Compete						0.047***	0.134***
						(0.009)	(0.022)
Compete*Log(net assets)							-0.015***
							(0.003)
Firm level UV, RKRV							0.213***
							(0.029)
Ind. level UV, RKRV							-0.199*
							(0.111)
C&I spread							0.735**
							(0.329)
Observations	84,471	84,471	84,471	81,059	49,049	48,674	48,665
R^2	0.017	0.032	0.033	0.033	0.029	0.032	0.031
Adj. R^2	0.0165	0.0319	0.0326	0.0332	0.0288	0.0310	0.0311
Year dummies	Yes	Yes	Yes	Yes	Yes	Yes	No

PANEL B

Independent Variable	*Dependent variable - R&D expenditures scaled by sales*						
Vdshock	0.561 (0.435)	0.279 (0.437)	1.051* (0.597)	1.113** (0.524)	0.364 (0.505)	0.480 (0.515)	0.400 (0.505)
Log(net assets)		-0.134*** (0.019)	-0.126*** (0.020)	-0.104*** (0.016)	-0.170*** (0.051)	-0.159*** (0.049)	-0.296*** (0.060)
Vdshock*Log(net assets)			-0.181* (0.099)	-0.208** (0.083)	-0.073 (0.074)	-0.104 (0.074)	-0.046 (0.072)
wSSW				0.749 (0.500)	0.509* (0.300)	0.677** (0.331)	0.520 (0.341)
wSSW*Log(net assets)				-0.111* (0.057)	-0.071 (0.046)	-0.133*** (0.045)	-0.071* (0.042)
Ptarget					0.379* (0.199)	0.398** (0.201)	0.631*** (0.214)
Compete						0.050*** (0.010)	0.141*** (0.024)
Compete*Log(net assets)							-0.016*** (0.003)
Firm level UV, RKRV							0.216*** (0.030)
Ind. level UV, RKRV							-0.145 (0.108)
C&I spread							0.740** (0.331)
Observations	84,471	84,471	84,471	81,059	49,049	48,674	48,665
R^2	0.014	0.030	0.030	0.031	0.026	0.029	0.029
Adj. R^2	0.0142	0.0298	0.0299	0.0303	0.0258	0.0284	0.0287
Year dummies	Yes	Yes	Yes	Yes	Yes	Yes	No

Table 5: R&D and abnormal announcement returns

Table 5 reports estimates from *R&D* regressions. The dependent variable is *R&D* expense scaled by sales in the previous year. *Vdshock* is a de-trended demand shock variable constructed from the input-output matrix. *Vexpand* is a discretized version of *Vdshock* . *Log(net assets)* is the natural log of the asset value. *Abn. AR* is industry-level mean abnormal announcement returns to acquisition targets in the previous year. *Compete* is a measure of industry competitiveness equalling one minus the Herfindahl index. Standard errors are clustered by industry-years.

Independent Variable	*Dependent variable - R&D expenditures scaled by sales*			
Vexpand	0.221*** (0.061)	0.138** (0.054)		
Log(net assets)	-0.021*** (0.008)	-0.108*** (0.015)	-0.046*** (0.008)	-0.130*** (0.020)
Vexpand*Log(net assets)	-0.044*** (0.011)	-0.035*** (0.010)		
Abn. announcement return	0.731** (0.308)	0.648** (0.257)	0.728** (0.304)	0.649** (0.258)
(Abn. AR)*Log(net assets)	-0.104** (0.044)	-0.094** (0.039)	-0.104** (0.044)	-0.095** (0.040)
Compete		0.156*** (0.019)		0.157*** (0.020)
Compete*Log(net assets)		-0.014*** (0.002)		-0.015*** (0.003)
Vdshock			0.986* (0.559)	0.686 (0.489)
Vdshock*Log(net assets)			-0.215*** (0.064)	-0.178*** (0.060)
Observations	84,471	75,770	84,471	75,770
R^2	0.124	0.132	0.124	0.132
Adj. R^2	0.123	0.131	0.123	0.131
Industry dummies	Yes	Yes	Yes	Yes

Table 6: R&D regressions with inside liquidity

Table 6 reports estimates from *R&D* regressions. The dependent variable is *R&D* expense scaled by sales in the previous year. *Vdshock* is a de-trended demand shock variable constructed from the input-output matrix. *Vexpand* is a discretized version of *Vdshock* . *Ins M&A* is the value of M&A activity involving acquirers from the same industry. *Ptarget* is the estimated probability of an acquisition transaction. *Compete* is a measure of industry concentration equalling one minus the Herfindahl index. *Firm level UV, RKRV* is the firm-level misvalutation computed from the Rhodes-Kropf, Robinson, and Viswanathan (RKRV) model. *Industry-level unexplained valuation RKRV* is the industry-level unexplained valuation variable. *C&I spread* is the commercial and industrial loan spread. Standard errors are clustered by industry-years.

PANEL A

Independent Variable	*Dependent variable - R&D expenditures scaled by sales*				
Vexpand	0.555*** (0.122)	0.540*** (0.124)	0.479*** (0.117)	0.478*** (0.118)	0.384*** (0.107)
Log(net assets)	-0.058*** (0.009)	-0.053*** (0.009)	-0.120*** (0.043)	-0.113*** (0.043)	-0.245*** (0.053)
Vexpand*Log(net assets)	-0.067*** (0.018)	-0.064*** (0.018)	-0.052*** (0.015)	-0.054*** (0.015)	-0.038*** (0.012)
Ins M&A	4.220** (1.954)	6.641** (2.953)	6.560** (2.601)	6.350** (2.654)	5.325* (2.794)
Ins M&A * Log(net assets)		-0.583** (0.284)	-0.458* (0.236)	-0.545** (0.231)	-0.389 (0.239)
Ptarget			0.372* (0.194)	0.386** (0.196)	0.614*** (0.206)
Compete				0.037*** (0.009)	0.113*** (0.024)
Compete*Log(net assets)					-0.013*** (0.003)
Firm level UV, RKRV					0.213*** (0.029)
Ind. level UV, RKRV					-0.176 (0.118)
C&I spread					0.712** (0.327)
Observations	81,059	81,059	49,049	48,674	48,665
R^2	0.036	0.036	0.033	0.035	0.034
Adj. R^2	0.0358	0.0361	0.0327	0.0340	0.0341

PANEL B

Independent Variable	*Dependent variable - R&D expenditures scaled by sales*				
Vdshock	1.106**	1.028**	0.271	0.351	0.215
	(0.516)	(0.520)	(0.503)	(0.515)	(0.513)
Log(net assets)	-0.102***	-0.095***	-0.163***	-0.156***	-0.281***
	(0.014)	(0.015)	(0.050)	(0.049)	(0.059)
Vdshock*Log(net assets)	-0.234***	-0.213**	-0.073	-0.093	-0.027
	(0.081)	(0.083)	(0.073)	(0.074)	(0.072)
Ins M&A	4.542**	7.095**	7.015***	6.772**	5.680**
	(1.972)	(2.951)	(2.602)	(2.656)	(2.767)
Ins M&A * Log(net assets)		-0.615**	-0.490**	-0.581**	-0.413*
		(0.278)	(0.231)	(0.226)	(0.238)
Ptarget			0.395**	0.408**	0.632***
			(0.199)	(0.201)	(0.211)
Compete				0.039***	0.119***
				(0.009)	(0.025)
Compete*Log(net assets)					-0.014***
					(0.003)
Firm level UV, RKRV					0.216***
					(0.030)
Ind. level UV, RKRV					-0.122
					(0.115)
C&I spread					0.715**
					(0.329)
Observations	81,059	81,059	49,049	48,674	48,665
R^2	0.034	0.034	0.031	0.032	0.032
Adj. R^2	0.0334	0.0337	0.0303	0.0317	0.0321

Table 7: R&D regressions with outside liquidity

Table 7 reports estimates from *R&D* regressions. The dependent variable is *R&D* expense scaled by sales in the previous year. *Vdshock* is a de-trended demand shock variable constructed from the input-output matrix. *Vexpand* is a discretized version of *Vdshock* . *Out M&A* is the value of M &A activity involving acquirers operating outside the industry. *Ptarget* is the estimated probability of an acquisition transaction. *Compete* is a measure of industry concentration equalling one minus the Herfindahl index. *Firm level UV, RKRV* is the firm-level misvalutation computed from the Rhodes-Kropf, Robinson, and Viswanathan (RKRV) model. *Industry-level unexplained valuation RKRV* is the industry-level unexplained valuation variable. *C&I spread* is the commercial and industrial loan spread. Standard errors are clustered by industry-years.

PANEL A

Independent Variable	*Dependent variable - R&D expenditures scaled by sales*				
Vexpand	0.578***	0.578***	0.516***	0.511***	0.427***
	(0.123)	(0.123)	(0.116)	(0.117)	(0.106)
Log(net assets)	-0.066***	-0.064***	-0.126***	-0.117***	-0.257***
	(0.009)	(0.009)	(0.044)	(0.043)	(0.052)
Vexpand*Log(net assets)	-0.065***	-0.065***	-0.053***	-0.056***	-0.042***
	(0.018)	(0.018)	(0.015)	(0.015)	(0.012)
Out M&A	-0.488	-0.054	0.086	0.192	0.056
	(0.333)	(0.419)	(0.240)	(0.262)	(0.266)
Out M&A * Log(net assets)		-0.119**	-0.126**	-0.161***	-0.111***
		(0.056)	(0.049)	(0.051)	(0.041)
Ptarget			0.356*	0.376*	0.615***
			(0.194)	(0.196)	(0.209)
Compete				0.048***	0.135***
				(0.009)	(0.021)
Compete*Log(net assets)					-0.015***
					(0.003)
Firm level UV, RKRV					0.214***
					(0.030)
Ind. level UV, RKRV					-0.203*
					(0.110)
C&I spread					0.736**
					(0.327)
Observations	81,059	81,059	49,049	48,674	48,665
R^2	0.034	0.034	0.029	0.032	0.031
Adj. R^2	0.0332	0.0333	0.0289	0.0313	0.0313

PANEL B

Independent Variable	*Dependent variable - R&D expenditures scaled by sales*				
Vdshock	1.111** (0.527)	1.107** (0.527)	0.364 (0.506)	0.460 (0.518)	0.407 (0.508)
Log(net assets)	-0.110*** (0.015)	-0.108*** (0.015)	-0.171*** (0.050)	-0.161*** (0.049)	-0.297*** (0.059)
Vdshock*Log(net assets)	-0.210** (0.083)	-0.210** (0.083)	-0.075 (0.074)	-0.104 (0.075)	-0.048 (0.072)
Out M&A	-0.490 (0.342)	-0.047 (0.428)	0.097 (0.243)	0.204 (0.269)	0.080 (0.269)
Out M&A * Log(net assets)		-0.121** (0.056)	-0.130*** (0.050)	-0.166*** (0.052)	-0.114*** (0.041)
Ptarget			0.380* (0.199)	0.398** (0.201)	0.633*** (0.215)
Compete				0.051*** (0.009)	0.143*** (0.023)
Compete*Log(net assets)					-0.016*** (0.003)
Firm level UV, RKRV					0.216*** (0.030)
Ind. level UV, RKRV					-0.148 (0.107)
C&I spread					0.742** (0.330)
Observations	81,059	81,059	49,049	48,674	48,665
R-squared	0.031	0.031	0.026	0.029	0.029
Adj. R-squared	0.0304	0.0304	0.0259	0.0286	0.0288

Table 8: R&D with predicted target from mutual fund flow

Table 8 reports estimates from *R&D* regressions with *Ptargetm* obtained from logistic regressions with mfflow. The dependent variable is *R&D* expense scaled by sales in the previous year. *Ins M&A* is the value of M &A activity involving acquirers from the same industry. *Out M&A* is the value of M &A activity involving acquirers operating outside the industry. *Log(net assets)* is the log of the asset value. *wSSW* is the asset liquidity measure. *Ptargetm* is the estimated probability of being acquired. *Compete* is a measure of industry competitiveness equalling one minus the Herfindahl index. *C&I spread* is the commercial and industrial loan spread. *Firm level UV, RKRV* is the firm-level misvalutation computed from the Rhodes-Kropf, Robinson, and Viswanathan (RKRV) model. *Ind level UV, RKRV* is the industry-level unexplained valuation variable. *C&I spread* is the commercial and industrial loan spread. Standard errors are clustered by industry-years.

Independent Variable	*Dependent variable - R&D expenditures scaled by sales*					
Vexpand	0.921***	0.707***	0.921***	0.709***	0.875***	0.667***
	(0.245)	(0.190)	(0.242)	(0.188)	(0.243)	(0.192)
Log(net assets)	-0.143**	-0.382***	-0.147**	-0.383***	-0.136**	-0.359***
	(0.062)	(0.090)	(0.062)	(0.088)	(0.061)	(0.089)
Vexpand*Log(net assets)	-0.115***	-0.084***	-0.116***	-0.084***	-0.112***	-0.080***
	(0.028)	(0.023)	(0.028)	(0.022)	(0.029)	(0.023)
wSSW	0.416	-0.192				
	(0.767)	(0.860)				
wSSW*Log(net assets)	-0.089	0.028				
	(0.102)	(0.094)				
Ptargetm	0.584*	0.860***	0.583*	0.863***	0.595*	0.861***
	(0.304)	(0.326)	(0.304)	(0.326)	(0.304)	(0.323)
Compete	0.048***	0.210***	0.048***	0.211***	0.037***	0.183***
	(0.010)	(0.039)	(0.010)	(0.037)	(0.010)	(0.042)
Compete*Log(net assets)		-0.027***		-0.027***		-0.024***
		(0.005)		(0.005)		(0.005)
Firm level UV, RKRV		0.220***		0.221***		0.220***
		(0.046)		(0.046)		(0.045)
Ind. level UV, RKRV		-0.219		-0.223*		-0.189
		(0.135)		(0.134)		(0.139)
C&I spread		0.958**		0.958**		0.944**
		(0.439)		(0.437)		(0.438)
Out M&A			-0.736	-1.092*		
			(0.583)	(0.629)		
Out M&A * Log(net assets)			-0.008	0.066		
			(0.081)	(0.068)		
Ins M&A					7.688*	4.628
					(4.496)	(4.857)
Ins M&A * Log(net assets)					-0.735	-0.299
					(0.520)	(0.558)
Observations	28,240	28,238	28,240	28,238	28,240	28,238
R-squared	0.039	0.040	0.040	0.040	0.042	0.042
Adj. R-squared	0.0382	0.0392	0.0388	0.0399	0.0412	0.0412