Diversification to Capture R&D Spillovers Do Conglomerates Really Destroy Value?

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April 15, 2010

Abstract

In this paper we attempt to provide a rational explanation for conglomerate mergers: diversifying acquisitions occur in order to appropriate the returns from R&D activity. I propose a dynamic general equilibrium model where buyers are endogenously matched with target firms. The model predicts that the best managers will be the first to buy and the worst manager will be the first to sell. As time passes, the quality of the buyers falls and the quality of the sellers rises . The model generates a merger wave and predicts that buyers are hungry for targets and will pay an additional premium in order to merge early; the premium will fall over the wave.

1 Introduction

In 1952, Royal Little, founder and manager of Textron, decided to diversify the product offerings of his company; moving from the textile sector where Textron was operating, Little started acquiring relatively small firms in completely unrelated industries: automotive, radar antennas, mechanics, aircraft, pharmaceuticals. Textron was the world's first multi-industry company, becoming in few years a conglomerate of incredible proportions (for the time); it inaugurated the era of conglomeration, which took place during the 1960s, when thousands of acquisitions in unrelated activities were registered every year.
The purpose of this work is to explain economic motivations behind the conglomerate merger wave of the 1960s. "Why do conglomerate exist?" and "why were they so relevant in the past?" are questions that haven't found a clear answer yet. Standard models of horizontal mergers and vertical mergers cannot explain the variety of acquisitions observed in that period: while the former models predict mergers between firms in the same industry and the latter mergers between firms that share an "upward-seller, downward-buyer" relation, there is no clear reason why completely unrelated firms should merge in a single entity and why they should form a conglomerate. Still, diversification was the dominant firm strategy during the 60s: the conglomerate wave took off in the mid-1950s, and peaked during the "go-go" boom

of 1962-1969, when 90 percent of all mergers were of the conglomerate type. Medium-size companies that often got started in the rapidly expanding electronics industry or military contracting devoured firms in unrelated industries. International Telephone and Telegraph, Ling-Temco-Vought, Gulf and Western, and Litton Industries all made unrelated acquisitions totaling $1 billion or more.
The antitrust policy played an important role in shaping the merger wave: after the boom in merger activity in the 1950s, the Supreme Court - worried about the increasing concentration - provided the Department of Justice with a stringent interpretation of the Celler-Kefauver amendment to section 7 of the Clayton Act; as a consequence, horizontal and vertical mergers became rare. However, the euphoria for mergers continued to increase, boosted by the favorable economic conditions. The total amount of mergers - now primarily of the conglomerate type - reached record levels in the following years. The Federal Trade Commission and the Department of Justice, puzzled by the innovative business strategy and - along most of the economists - not able to judge its welfare effects, decided initially to abstain from taking action against conglomerate mergers.
The shift from related acquisitions to unrelated ones suggests the existence of a value from merging, a gain that goes beyond that predicted by horizontal or vertical models. Given the impossibility to collect this value with related acquisitions in the 1960s, the market turned to conglomerate mergers and continued “reaping the harvest” until it was profitable to do so: at the end of the decade, the Congress and the Nixon Administration decided to intervene presenting less favorable fiscal incentives to multi-industry firms; together with the long recession of the 1970s, this fact led to a decline in the merger wave (Matsusaka (1993) reports a favorable reaction of the market on the announcement of unrelated acquisitions during all the 1960s; this premium disappears during in the following decades). During the 1980s, the adoption of a looser interpretation of antitrust legislation by the FTC and the Justice Department and the availability of new financial tools for corporate businesses (e.g. leveraged buyout) made related acquisitions feasible once again and more efficient than unrelated ones (See Shleifer and Vishny, (1990), and Kaplan and Weisbach, (1992)).

2 Conglomerate Mergers in the Literature

Conglomerate mergers constitute a puzzle for economic theory; as I mentioned above, textbook analysis of mergers cannot explain the motivations behind unrelated acquisitions. Several theories have emerged in the last forty years trying to fill that gap. The literature follows two lines of thought: the first one, which I will call *pessimistic*, argues that the creation of a conglomerate doesn’t correspond to the objective of maximizing the value for the shareholders: diversification is seen as a way for managers to pursue their personal goals; the second one, which can be addressed as *optimistic*, argues that unrelated acquisitions are a mean to increase the profits of the firm.

The *pessimistic* view is based on the idea that, because of diffuse ownership, individual shareholders lack the ability to monitor managers. As a consequence, managers have the opportunity to pursue their personal objectives, which may include empire building (hubris hypothesis, Roll (1986)), reducing the risk of their specific human capital (Amihud and Lev (1981)), entrenchment (Shleifer and Vishny (1989)). The common prediction of these models is the destruction of value arising from diversification; this prediction finds justification in Lang and Stulz (1994) and in Berger and Ofek (1995). The agency view can explain the diversification discount but is not consistent with the finding that investors bid up stock prices upon announcement of a diversified acquisition; moreover, it is not clear why shareholders would allow managers to invest in diversified activities when it is common knowledge that this would result in a loss in value.
On the other hand, the optimistic view argues that diversified acquisitions are rational, in the sense that they maximize profits. Diversified production may lead to risk diversification (Levy and Sarnat (1970)) and to formation of internal capital markets (Stein (1997)). Matsusaka (2001) develops a matching model to explain why conglomerates exist, based on the transfer of organizational capabilities across industries. Maksimovic and Phillips (2002) and Gomes and Livdan (2004) present neoclassical models where diversification creates synergies, and firms self select in such a way to recreate the diversification discount. Recent empirical works by Villalonga (2004 and 2004) and Campa and Kedia (2002) show that there is no diversification discount once endogeneity is accounted for in the estimating equation.
In this work, I am going to develop old intuitions from Nelson (1959) and Penrose (1959) and try to explain conglomerate mergers as an attempt by firms involved in R&D to capture spillovers induced by the activity itself. Following Penrose,

> *the Product of R&D is new knowledge ... the market for knowledge is imperfect. In order to appropriate the returns to knowledge, firms should diversify into new industries*

Research is risky but can produce significant breakthroughs. However, the results of a research project could be not directly related or applicable to the main area of activity of the sponsoring firm. Since the direction of a research project cannot be predicted a priori, the sponsoring firm could have the incentive to intensify its own area of activity; quoting Nelson

> *..the wider the area of diversification of a firm, the higher the probability that research - whatever direction it will take - will be of value to the firm itself*

Conglomerate mergers are a way to achieve the mentioned level of diversification. This view is consistent with the fact that, for most part of the 1960s, the acquiring companies were young and technologically advanced firms (ITT, Ling-Temco-Vought). Gort (1969) also documents an higher R%D intensity in more diversified firms.
I am going to assume that the outcome of an R&D project will be

applicable to different industries: as a consequence, since the cost of R&D is sunk, the firm will have incentives to enter new sectors in order to fully appropriate the returns of its investment. The firm cannot start an activity in a new sector from scratch; instead, it can enter the industry by purchasing the assets from an existing company (I assume that the acquiring firm eliminates the board of directors of the acquired company [1]). In order to induce the management of the target firm to leave, the buyer has to pay at least the reservation value. I present a dynamic general equilibrium model where manager self select into buyers and sellers, and I fully characterize the equilibrium price. In equilibrium, only firms that have invested in R&D will be buyers. Buyers are *hungry*, and will pay a premium in order to eat early, but the premium will fall over time.

3 The Model

I assume the presence of a continuous of industries. Each industry produces a completely differentiated product: that is, pricing decisions in one market don't affect price decisions in the remaining markets. Each firm in each industry acts as a price taker (I want to abstract from competition issues): I will normalize all the product prices to 1.

Managers' are heterogeneous in their ability to manage a firm (see Lucas (1978)): the identity of each manager (its type, z) is assumed to be perfectly observable. The ability z is stochastic and distributed according to a distribution F over a bounded support $Z = [0, z_h]$ (without loss of generality I normalize the lower bound to zero).

Time is continuous and the horizon is infinite: at time 0 each manager must decide if investing in a risky project or not. If he decides to invest in R&D then he is committed to pay a sum $B > 0$ each period until the arrival date of the innovation. The riskiness of the project is modeled as a stochastic arrival date of innovation: the stochastic process governing the arrival date is assumed to be negative exponential, with parameter λ:

$$Pt(\tau \leq t) = 1 - e^{-\lambda t} \quad , \qquad \lambda > 0$$

I assume that λ is constant over time and across managers.

The innovation is modeled as an increase in productive efficiency. I assume that the innovation contains elements of tacit knowledge and organizational capital: therefore the innovation can be transferred only from buyers to target firms and not vice-versa. That is, a firm cannot buy an innovation from its target (Faria (2002) assumes the opposite). There is evidence that supports this assumption.

From time 0 on, each firm can bid for another company or it can sell its own assets. The equilibrium timing of this decision is endogenous and will depend on the managerial ability.

[1] This is consistent with evidence. Consider the case of Textron, where the acquired companies were taken as divisions and not as subsidiaries.

I assume that managers are risk neutral and discount profits at the instantaneous rate r.

3.1 The Profit Function

I index the instantaneous profit function by the ability of the manager, z, the state of the R&D project and the number of assets controlled by the firm:

$$\pi_t(z, R\&D \text{ state}, \text{Conglomerate Size})$$

"$R\&D$ state" takes the value to 0 if the firm has decided not to invest in research, it is equal to B if the firm is investing in research but the research project has not produced any result yet (B is the instantaneous investment cost in R&D), and it is equal to A if the firm has invested in R&D and the research project has produced results. Innovation is represented as an increase in productive efficiency, $A > 1$. I assume that every firms involved in R&D will receive the same innovation. The key assumption of the paper is that innovation affects all the assets owned by the manager: this is particularly true for the ones who have been added through acquisitions (R&D spillovers). Research is firm specific, there are no spillover effects across firms.

"Conglomerate Size" represents the number of assets controlled by the managers. I assume that no firm can acquire more than one company (think of Antitrust limits to the dimension of a conglomerate): this assumptions considerably simplifies the model.

For simplicity I assume that there are no inputs other than managerial ability and that the production function exhibits constant returns to scale in managerial ability, z.

The instantaneous profit function when the manager has ability z, has not invested in R&D and controls only his own firm is given by: $\pi_t(z, 0, 1) = z$. The profit when the manager has invested in R&D and the project has produced results is $\pi_t(z, A, 1) = Az$ (A enters multiplicatively in the production function). When the firm whose R&D project has proven successful decides to acquire another firm the profit function changes in $\pi_t(z, A, 2) = \phi(Az, 2)$: once a new entity is formed, the product of innovation extends to the assets of the acquired firm as well; the spillover assumption is captured by the function ϕ. I assume that the function $\phi(x, y)$ is such that $\phi_x > 0, \phi_y > 0$ (the higher the ability of the manager the higher the profits; the same relationship holds for the number of assets controlled by the manager); $\phi_{yy} < 0$ (additional assets to the firm have decreasing returns), $\phi_{xy} > 0$ (the additional benefit from adding one asset over the control of the manager increases with the ability of the manager), and $\phi(x, 1) = x$ and $\phi(x, y) \geq yx \quad \forall y > 1$ (these are just normalizations).

If the R&D project has not given result yet and the manager controls just one asset, the profit function is $\pi_t(z, B, 1) = z - B$: I assume that the firm has to pay the investment cost, B, every period until innovation arrives. On the other hand, if the firm controls more than one asset, the profit will be $\pi_t(z, B, 2) = \phi(z, 2) - B$.

ASSUMPTION: $B < \frac{\lambda(A-1)}{r} F^{-1}(1/2)$.

I require that the investment cost is not too high: this restriction is sufficient (but not necessary) for existence and uniqueness of an equilibrium, moreover it allows for a "nice" representation of the equilibrium. I want to focus on the case where benefits from innovation are "sufficiently" high compared to the costs: this would be the case for major innovations, that is, innovations that are more likely to lead to mergers. This assumption guarantees a sufficient mass of bidders.

Anytime a firm wants to acquire another one, it must pay a price to the acquired firm. I focus on the case where a firm can acquire only one other firm. Suppose firm $\tilde{z}$ wants to acquire firm z at time t. Then it has to pay to the latter a price $p(z, \tilde{z}, t)$. In equilibrium there will be only one such price for each period, $p(t)$: I will show that the time t is a sufficient statistics to describe the identity of both parties. Hence, the pricing function is just a function of t. I show that the price function $p(t)$ is continuous and decreasing over time. I develop a dynamic general equilibrium model where firms act as price taker.
I will also show that in equilibrium only the firms that have decided to start a research project will be Buyers. And only firms with no project will be targets for the acquisition.

3.2 Research

Before introducing the model, I will spend a little time trying to explain how to setup the problem of the firm. For simplicity, suppose that no mergers are allowed, but that a particular firm has decided to invest in R&D. Assume that the research project produces results at time τ and that this date is known. Then the value for the firm at time 0 will be

$$V(z, R; \tau) = \int_0^{\tau} (z - B)e^{-rt} \mathrm{d}t + \int_{\tau}^{+\infty} Aze^{-rt} \mathrm{d}t$$

This is the value of the firm at time 0 when the research project becomes productive at time τ with certainty. The firm gets its profit, z, and sustain the investment cost, B, each time before innovation has occurred. After time τ the firm benefits for the increase in productivity forever.
The value of the firm at time 0 when the date of arrival of innovation is uncertain is just given by the expectation of the value of the firm over all possible values of τ:

$$\mathbb{E}_{\tau}[V(z, R; \tau)] \equiv V(z, R) = \int_0^{+\infty} \left\{ \int_0^{\tau} (z - B)e^{-rt} dt + \right.$$
$$\left. + \int_{\tau}^{+\infty} Aze^{-rt} \right\} \lambda e^{-\lambda\tau} \mathrm{d}\tau$$

3.3 The Problem of the Firm

At time 0, each firm z must to decide whether to invest in R&D or not. If it does then it can decide whether to acquire another firm and when. If it doesn't then it can decide whether to sell its assets and when. The fact that only those that invest in R&D qualify as buyers, and that only those that do not invest in R&D qualify as sellers, is a feature of the equilibrium.

Given the sequential component of the problem, I will solve it backward. Each firm solves the optimal value for a buyer and the optimal value for a seller and then chooses the highest of these values. The equilibrium is solved by looking for a price schedule that clears the market, given that everyone is maximizing its value.

3.3.1 The Problem of the Buyer

Each firm that invests in R&D can decide wether to bid for another firm or not. The buyer must decide the exact moment, t^b, when to bid for a target company, taking as given prices $\{p(t)\}$. The decision is made at time 0.

$$V^B(z,R) = \max_{t^b} \int_0^{t^b} \left\{ \int_0^{\tau} (z-B)e^{-rt}\mathrm{d}t + \int_{\tau}^{t^b} Aze^{-rt}\mathrm{d}t + \right. \tag{1}$$

$$\left. + \int_{t^b}^{+\infty} \phi(Az,2)e^{-rt}\mathrm{d}t \right\} \lambda e^{-\lambda\tau}\mathrm{d}\tau +$$

$$\int_{t^b}^{+\infty} \left\{ \int_0^{t^b} (z-B)e^{-rt}\mathrm{d}t + \int_{t^b}^{\tau} (\phi(z,2)-B)e^{-rt}\mathrm{d}t + \right.$$

$$\left. + \int_{\tau}^{+\infty} \phi(Az,2)e^{-rt}\mathrm{d}t \right\} \lambda e^{-\lambda\tau}\mathrm{d}\tau - p(t^b)e^{-rt^b} \tag{2}$$

Under the first integral in equation (1) ($\int_0^{t^b}$) I consider the case in which τ is drawn to fall before the date t^b: the terms under the integral report the profit of the firm from 0 to τ (which is just $z-B$), the profit from τ to t^b (after τ the research project starts giving benefits), the price for the acquisition and the profit of the new entity, respectively.

The second part of the equation considers the case where τ falls after t^b (the integral $\int_{t^b}^{+\infty}$); the terms under the integral denote the profits up to merger $(z-B)$, the profits of the new entity until the technological innovation arrives and profit of the new entity after the innovation has arrived. The last term is the merger price at time 0.

The first order conditions of this problem is:

$$\underbrace{rp(t^b) - p'(t^b)}_{\text{Marginal Benefit}} \geq \underbrace{(\phi(Az,2) - Az)\left(1 - e^{-\lambda t^b}\right) + (\phi(z,2) - z)\, e^{-\lambda t^b}}_{\text{Marginal Cost}} \tag{3}$$

The FOC has a nice interpretation: the left hand side represents the marginal benefits from postponing the acquisition for an instant (the firm saves the money today and tomorrow will pay a lower price); the

right hand side represents marginal costs from delaying the acquisition: costs are expressed as a weighted average of foregone incremental earnings (profit with merger minus profit with no merger) for the case of a successful innovation arriving in the period or earlier and for the case of no innovations arrived yet; the weights are the probabilities that an innovation occurred in the past and that an innovation hasn't occurred yet, respectively.
For interior solutions (i.e. when $\tilde{z} < \infty$), the FOC holds with equality; when MB > MR the optimal rule for the firm is to never enter a merger: I define this case by setting $t^b = +\infty$. Notice that the optimal timing doesn't depend on the research cost. The second order conditions are

$$rp'(t^b) - p''(t^b) - \lambda \left[(\phi(Az, 2) - Az) - (\phi(z, 2) - z) \right] e^{-\lambda t^b} \leq 0$$

The term in the square bracket is positive, $p(t)$ is increasing over time while $p''(t)$ is negative. The overall sign depends on the magnitude of the term in bracket, which in turn depends on the magnitude of $\phi_{xy}(A_1)$ (this is an approximation to the term in bracket): I assume that this element is sufficiently large to satisfy the following condition:

$$rp'(t^b) - \lambda[\phi_{xy}(z, 1)(A - 1)]e^{-\lambda t^b} \leq p''(t^b) < 0 \tag{4}$$

I proceed now with the characterization of the identity of the buyers: the FOC implicitly defines the ability of the manager who enters the merger at time t^b:

Proposition 1: The function $t_b : Z \to \mathbb{R}$ is decreasing. The set $B(t) = \{z \in Z | t^b(z) = t\}$ is single-valued for every finite t.

This result implies that every time that a merger takes place, there is only one (type of) manager who successfully bids for the target. Every time we observe a merger, the identity of the acquirer is perfectly determined. Moreover, managers with high ability bid early; managers with low ability bid late. As time passes, the ability of the managers who bid falls: more formally, the function $t^b(z)$ is continuously decreasing in z.

3.3.2 The Problem of the Seller

Each manager not involved in R&D can decide whether to sell its firm or not. The seller must decide the optimal timing t^s, taking prices $\{p(t)\}$ as given.

$$V^S(z, NR) = \max_{t^s} \int_0^{t^s} z e^{-rt} \mathrm{d}t + p(t^s) e^{-rt^s}$$

The first order condition becomes:

$$\underbrace{z}_{\text{Marginal Benefit}} \geq \underbrace{rp(t^s) - p'(t^s)}_{\text{Marginal Cost}} \tag{5}$$

The FOC has again a natural interpretation: for interior solutions (that is, for $t^s < \infty$), marginal benefits from delaying the merger (that is, profits from another period of production) must equate marginal costs (a reduction in price tomorrow plus the lost interest on today price).
The second order conditions are:

$$p''(t^s) < rp'(t^s) \qquad (< 0)$$

Notice that this condition makes the marginal cost from waiting for the seller increasing at a decreasing rate. This condition is satisfied in equilibrium.
As before, I can perfectly characterize the identity of the manager who sells its firm at time t^s

Proposition 2: the function $t^s : Z \to \mathbb{R}$ is increasing. The set $S(t) = \{z \in Z | t^s(z) = t < \infty\}$ is single-valued for every finite t.

This result parallels the one presented above. Every time that a merger takes place the identity of the target is perfectly determined, in the sense that in each such period there is only one manager who will offer her own firm. Managers with low ability will sell early, managers with high ability will sell late.

3.3.3 The Investment Decision

Once the problem for the buyer and the seller have been solved, each manager must decide whether to invest in R&D or not at time 0. Investing in R&D will qualify him for being a buyer; on the other hand, not investing will qualify him as a potential target. Each manager z solves the following problem:

$$V(z) = \max_{\{\text{R,NR}\}} \{V(z,R), V(z,NR)\} \tag{6}$$

3.4 The Equilibrium

At this point it is possible to define the equilibrium:

Definition An *equilibrium* is:

1. an allocation of managers $\{S^*, B^*\}$, where $S^* = \{z \in Z | z \text{ doesn't invest in R\&D }\}$ and $B^* = \{z \in Z | z \text{ invests in R\&D }\}$
2. two optimal timing functions $t^b : B^* \longrightarrow \mathbb{R}_+ \cup \{+\infty\}$ and $t^s : S^* \longrightarrow \mathbb{R}_+ \cup \{+\infty\}$
3. a price function $p : \mathbb{R}_+ \cup \{+\infty\} \longrightarrow \mathbb{R}_+$

such that

- given prices, the allocation of managers is optimal: $\{S^*, B^*\}$ is such that $\forall z \; V(z) = \max_{\{\text{R,NR}\}} \{V(z,R), V(z,NR)\}$
- given prices, $t^b(\cdot)$ and $t^s(\cdot)$ solve the FOC for the buyers and the sellers respectively

- Market Clearing: at each point in time, prices are such that total demand of firms, $Q^d(t)$, equal total supply, $Q^s(t)$; where

$$Q^d(t) = \int_{\tilde{B}(t)} \mathrm{d}F(z) \qquad \text{and} \qquad Q^s(t) = \int_{\tilde{S}(t)} \mathrm{d}F(z) \qquad (7)$$

where $\tilde{B}(t) = \{z \in B^* | t^b(z) \leq t\}$ and $\tilde{S}(t) = \{z \in S^* | t^s(z) \leq t\}$, $\forall t$

3.4.1 Characterization of the Equilibrium: The Allocation

The allocation is characterized by a cutting point rule: I denote z^* the cutting point. All managers with ability over the cutting point will invest in R&D, and all managers with ability below z^* will not invest in R&D.

Proposition 3 : there is only one z^* such that $V(z^*, R) = V(z^*, NR)$, and $\forall z > z^*$ we have $V(z, R) > V(z, NR)$; on the other hand $\forall z < z^*$ we have $V(z, NR) > V(z, R)$.

To describe the rule that matches buyers and sellers in each particular merger, I label the buyer and the seller in that particular merger as b and s (formally, $b = B(t)$ and $s = S(t)$). Assume for simplicity that the profit function is constant returns to scale with respect to the managerial ability (this assumption is not necessary). Then it is easy to see that the equilibrium timing function for mergers that matches buyers and sellers, $T(b, s)$, is homogenous of degree zero. Define $x = b/s$.

Proposition 4 : $T(x, 1)$ is decreasing in x

This proposition confirms that the first managers to enter a merger are z_h (as a buyer) and z_l (as a seller): in fact, it is in this case that the ratio x is the largest possible; z_h and z_l will merge at time 0. Since there is no other reason to wait to merge than a decrease in prices, it must be that $T(z_h, z_l) = 0$.

Proposition 5 : in equilibrium $z^* = \frac{rB}{\lambda(A-1)}$.
Moreover, $t^b(z^*) = \infty$ and $t^s(z^*) < \infty$. When $z^* = F^{-1}(1/2)$, $t^s(z^*) = t^b(z^*) = t^* < \infty$ (where t^* is defined implicitly by setting $V(F^{-1}(1/2), R) = V(F^{-1}(1/2), NR)$).

The last proposition tells us the following: the higher is the instantaneous cost for R&D the more the managers who decide not to invest. The same effect holds for higher values of the interest rate: the opportunity cost of money becomes more burdensome: it is optimal to invest in R&D only if the return is sufficiently high, i.e. only for managers whose ability is high enough; the earlier the rate of arrival of innovations, λ, the more the managers that will invest in R&D; the

higher the gain from a successful innovation, $A-1$, with respect to normal profits, the higher the number of investors.
An excess of investors over targets implies that the marginal manager, in case he decides to invest, will never be able to acquire a target firms because all the other bidders have higher valuations for targets: in equilibrium it will be optimal to him to set $t^b(z^*) = \infty$. The marginal seller instead will sell the firm at a $t^s(z^*) < \infty$.
If the marginal seller falls exactly at the median then the marginal buyer will be finally able to bid for a target firm: from proposition 5 we can see that the marginal buyer will buy the marginal seller (z^* will buy a z^*-firm). In this case $t^s(z^*) = t^b(z^*)$, and this value must be finite. Call it t^*: t^* must solve the buyer problem and set the value equal to that of the marginal seller.
It is important to notice that it is the riskiness of the R&D activity that generates the merger wave.

Proposition 6 : if z^* falls before the median, there is an "inaction" region. All firms with $z \in [z^*, \underline{z}_b]$ invest in R&D but never enter any merger.

Investors in this area will never bid for firms which are developing their own R&D activity: if they did they would have to pay a much higher price, moreover the R&D of the target firm as no effect on the buyer's profit (there is no duplication of benefits if both firms innovate; that is, we don't have $\pi = 2Azg(2)$ but only $\pi = Azg(2)$). Since it is not profitable for them to merge with not-investors, it will not be profitable to merge with investors.

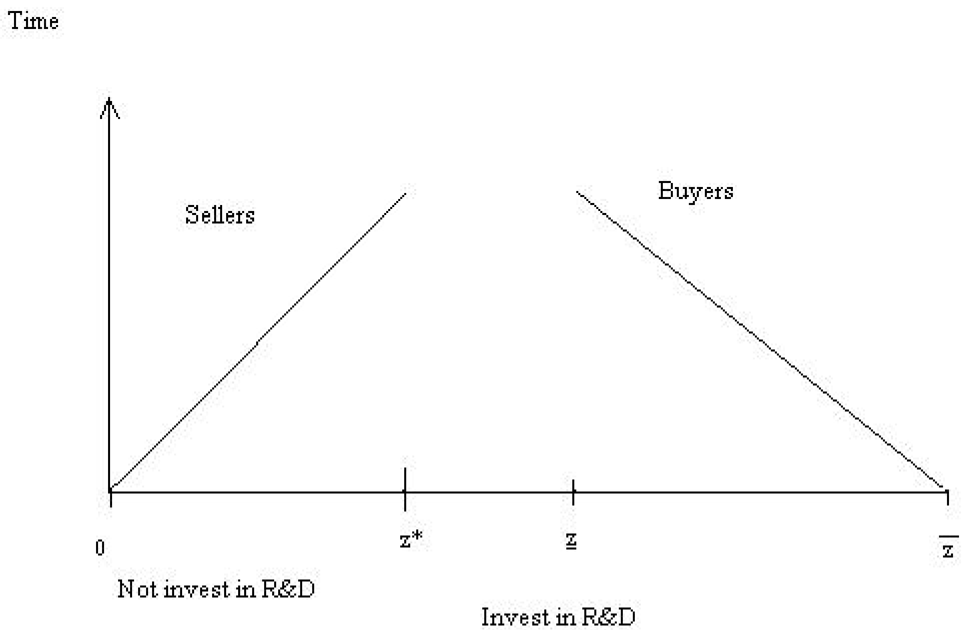

Figure 1: Equilibrium Allocation

The following condition must hold in order to have market clearing; the lowest ability investor (which I define $\underline{z_b}$) to enter a merger must be the one that satisfies $F(z^*) = 1 - F(\underline{z_b})$, or $\underline{z_b} = F^{-1}\left(1 - F\left(\frac{rB}{\lambda(A-1)}\right)\right)$. Since $\underline{z}$ and z^* will be matched in equilibrium, it must be $t^b(\underline{z_b}) = t^s(z^*) \equiv \tilde{t}$. This value is determined by making $\underline{z_b}$ indifferent between investing and buying z^* at $\tilde{t}$, and investing and never buying.

$$\tilde{t} = \text{argzero } V\left(F^{-1}\left(1 - F\left(\frac{rB}{\lambda(A-1)}\right)\right), R \middle| \text{buy at } \tilde{t}\right) - \\ -V\left(F^{-1}\left(1 - F\left(\frac{rB}{\lambda(A-1)}\right)\right), R \middle| \text{never buy}\right)$$

At each moment t, by taking ratios of both types' FOCs we get:

$$s(t) = (\phi(Ab(t), 2) - Ab(t))\left(1 - e^{-\lambda t}\right) + (\phi(b(t), 2) - b(t))\, e^{-\lambda t} \quad (8)$$

where $s(t) \in S(t)$ represents the identity of the seller, and $b(t) \in B(t)$ represents the identity of the buyer.
Now, for each period t where a merger occurs, market clearing imposes:

$$F(s(t)) = 1 - F(b(t)) \quad (9)$$

Substituting $s(t)$ in the above expression gives an equation in $b(t)$:

$$F(b(t)) + F\left([\phi(Ab(t), 2) - Ab(t)]\left(1 - e^{-\lambda t}\right) + \right. \\ \left. +[\phi(b(t), 2) - b(t)]e^{-\lambda t}\right) = 1 \quad (10)$$

This equation uniquely determines $b(t)$; substituting above we get $s(t)$. The equilibrium allocation is perfectly characterized: the sets $\{S(t), B(t)\}$ are determined. Equation (10) defines a function $b = f(s)$; it easy to see that $\mathrm{d}b/\mathrm{d}s < 0$: the first to buy are the highest quality managers and their targets are the lowest ability managers; the last to buy are the lower ones among the high quality managers and their targets are the best among the low quality managers. The equilibrium generates an endogenous matching function between buyers and sellers which exhibits negative sorting.

3.4.2 Characterization of the Equilibrium: the Price Function

From the Seller FOC we have

$$rp(t) - p'(t) = s(t) \quad (11)$$

This must hold every instant t. Solving and substituting for $s(t)$ we get

$$p(t) = \int_t^\infty e^{-r(\tau - t)} s(\tau)\mathrm{d}\tau \quad (12)$$

where $s(\tau) = z$ when $z \in S(\tau)$ for $\tau < t^*$ (where t^* stands for the last period in which a merger occurs) and $s(\tau) = z^*$ for $\tau \geq t^*$. Notice that

these are time t prices.
The timing functions are invertible over $\mathbb{R}$, by virtue of Proposition 1 and 2: $B : \mathbb{R}_+ \longrightarrow B^*$ as $B(t^b(z)) = z$; similarly, $S : \mathbb{R}_+ \longrightarrow S^*$ as $S(t^s(z)) = z$. We can rewrite the price function substituting the function $s(\tau) = z^*$ for $\tau \geq z^*$ and integrating by parts. The price function simplifies to

$$p(t)e^{-rt} = \underbrace{\frac{s(t)}{r}e^{-rt}}_{\text{continuation value for } t \text{ in case it didn't sell}} + \underbrace{\frac{1}{r}\int_t^{t^*} s'(\tau)e^{-r(\tau-t)}\mathrm{d}\tau}_{\text{premium for selling early}}$$

where $t \in [0, z^*]$.

Notice that at $t = z^*$, $p(z^*) = \frac{z^*}{r}$, hence the marginal manager is indifferent between selling and not selling.
The discounted price function is composed by two elements: the first component is the continuation value for the target firm when it doesn't sell (the buyer must give at least this amount to the seller in order to make it accept the offer); the second component is a premium for selling early: assets are valuable and buyers would like to obtain them as soon as possible; there must be a premium for those sellers who accept to sell early on in time: this premium falls over time and becomes zero eventually, when the last seller is called to trade.
It is easy to check that this price function implies the following value for the generic seller $z \in [0, z^*]$

$$V(z, NR) = \underbrace{\frac{z}{r}}_{\text{continuation value}} + \underbrace{\frac{1}{r}\int_t^{t^*} s'(\tau)e^{-r(\tau-t)}\mathrm{d}\tau}_{\text{premium}}$$

Each seller receives its continuation value plus a premium for selling early.

4 Conclusions

In this paper I offer a theoretical explanation for unrelated acquisitions and provide a model which generates endogenously a merger wave.
Firms merge in order to appropriate part of the returns from R&D investments: research produces knowledge and knowledge can be transferred across activities; expanding the range of activities implies extending the returns from innovation. The riskiness of R&D generates a separation between buyers and sellers. Low quality managers disappear from the market by selling their companies to high quality managers: this prediction is consistent with the Q-theory of mergers. The model predicts also complete diffusion of the new technology.
During the wave, value creation falls over time because progressively lower ability managers enter the mergers. High ability managers are hungry for targets, and wish they could make the deal as soon as possible: as a consequence, targets are usually sold at a premium in order

to be motivated to sell early. The model predicts that the premium falls over time and eventually disappears.

The model proposes a source of value from mergers which can be captured with both related acquisitions and unrelated acquisitions. This is consistent with the historical evidence: business strategies shifted from related acquisitions towards unrelated acquisitions in the 1960s with no apparent discontinuity from the 1950s; as discussed in the introduction, this shift is due to a change in the institutional setting rather than to a change in economic behavior. It is therefore plausible to think that the economic motivations behind mergers in the two decades were not so different, that is, there exists a value from merger that doesn't necessarily have to be captured through related acquisitions.The decision to form a multi-industry firm is perfectly rational, firms decide to merge in order to maximize profits.

5 Appendix

5.1 First Order Conditions for the Buyer

Consider separately each term under the external integrals and derive with respect to t^b:

1.

$$\frac{\mathrm{d}}{\mathrm{d}t^b}\int_0^{t^b}\int_0^{\tau}(z-B)e^{-rt}\mathrm{d}t\lambda e^{-\lambda\tau}\mathrm{d}\tau = \int_0^{t^b}(z-B)e^{-rt}\mathrm{d}t\lambda e^{\lambda t^b} = \\ = \frac{\lambda(z-B)}{r}\left(e^{-\lambda t^b}-e^{-(r+\lambda)t^b}\right)$$

2.

$$\frac{\mathrm{d}}{\mathrm{d}t^b}\int_0^{t^b}\int_{\tau}^{t^b} Aze^{-rt}\mathrm{d}t\lambda e^{-\lambda\tau}\mathrm{d}\tau = Az\left[e^{-rt^b}-e^{-(r+\lambda)t^b}\right]$$

3.

$$\frac{\mathrm{d}}{\mathrm{d}t^b}\int_0^{t^b} -p(t^b)e^{-rt^b}\lambda e^{-\lambda\tau}\mathrm{d}\tau = \\ = -\left[(r+\lambda)p(t^b)-p'(t^b)\right]e^{-(r+\lambda)t^b}+\left(rp(t^b)-p'(t^b)\right)e^{-rt^b}$$

4.

$$\frac{\mathrm{d}}{\mathrm{d}t^b}\int_0^{t^b}\int_{t^b}^{+\infty}\phi(Az,2)e^{-rt}\mathrm{d}t\lambda e^{-\lambda\tau}\mathrm{d}\tau = \frac{r+\lambda}{r}\phi(Az,2)e^{-(r+\lambda)t^b}-\phi(Az,2)e^{-rt^b}$$

5.

$$\frac{\mathrm{d}}{\mathrm{d}t^b}\int_{t^b}^{+\infty}\int_0^{t^b}(z-B)e^{-rt}\mathrm{d}t\lambda e^{-\lambda\tau}\mathrm{d}\tau = \frac{r+\lambda}{r}(z-B)e^{-(r+\lambda)t^b}-\frac{\lambda}{r}(z-B)e^{-\lambda t^b}$$

6.

$$\frac{\mathrm{d}}{\mathrm{d}t^b}\int_{t^b}^{+\infty} -p(t^b)e^{-rt^b}\lambda e^{-\lambda\tau}\mathrm{d}\tau = \lambda p(t^b)e^{-(r+\lambda)t^b}-\left[p'(t^b)-rp(t^b)\right]e^{-(r+\lambda)t^b}$$

7.

$$\frac{\mathrm{d}}{\mathrm{d}t^b}\int_{t^b}^{+\infty}\int_{t^b}^{\tau}\left(\phi(z,2)-B\right)e^{-rt}\mathrm{d}t\lambda e^{-\lambda\tau}\mathrm{d}\tau = -\left(\phi(z,2)-B\right)e^{-(r+\lambda)t^b}$$

8.

$$\frac{\mathrm{d}}{\mathrm{d}t^b}\int_{t^b}^{+\infty}\int_{\tau}^{+\infty}\phi(Az,2)e^{-rt}\mathrm{d}t\lambda e^{-\lambda\tau}\mathrm{d}\tau = -\frac{\lambda}{r}\phi(Az,2)e^{-(r+\lambda)t^b}$$

The FOC is:

$$Aze^{-rt^b}-Aze^{-(r+\lambda)t^b}+\left[rp(t^b)-p'(t^b)\right]e^{-rt^b}+\phi(Az,2)e^{-(r+\lambda)t^b}- \\ -\phi(Az,2)e^{-rt^b}+ze^{-(r+\lambda)t^b}-\phi(z,2)e^{-(r+\lambda)t^b}=0$$

5.2 Proof of Proposition 1

This requires an application of the Implicit Function Theorem.
We will also need to rely on one of the assumption made at the beginning of the paper on the shape of the profit function: $\phi_{xy} > 0$.

Define

$$\Phi(t^b, z) = rp(t^b) - p'(t^b) - (\phi(Az, 2) - Az)\left(1 - e^{-\lambda t^b}\right) - (\phi(z, 2) - z)\, e^{-\lambda t^b} = 0$$

This function is continuous and differentiable. By the Implicit Function Theorem:

$$\frac{\mathrm{d}t^b}{\mathrm{d}z} = -\frac{\frac{\partial\Phi(t,z)}{\partial z}}{\frac{\partial\Phi(t,z)}{\partial t}} < 0$$

In fact

$$\frac{\partial\Phi(t,z)}{\partial z} = -A\left[\phi_x(Az,2) - 1\right](1 - e^{-\lambda t}) - \left[\phi_x(z,2) - 1\right] e^{-\lambda t} =$$
$$= -A[\underbrace{\phi_x(Az,2) - \phi_x(z,1)}_{\text{positive from } \phi_{xy} > 0}](1 - e^{-\lambda t}) - [\underbrace{\phi_x(z,2) - \phi_x(z,1)}_{\text{positive from } \phi_{xy} > 0}]e^{-\lambda t} < 0$$

and

$$\frac{\partial\Phi(t,z)}{\partial t} = rp'(t) - p''(t) - [\phi(Az,2) - Az]\lambda e^{-\lambda t} + [\phi(z,2) - z]\lambda e^{-\lambda t} =$$
$$= rp'(t) - p''(t) - \lambda[\underbrace{(\underbrace{\phi(Az,2) - \phi(Az,1)}_{>0 \text{ from } \phi_y > 0}) - (\underbrace{\phi(z,2) - \phi(z,1)}_{>0 \text{ from } \phi_y > 0})}_{>0 \text{ from } \phi_{xy} > 0}]e^{-\lambda t} < 0$$

5.3 Proof of Proposition 2

As above: define

$$\Phi(t^s, z) = z - rp(t^s) + p'(t^s) = 0$$

This function is continuous and differentiable. By the Implicit Function Theorem:

$$\frac{\mathrm{d}t^s}{\mathrm{d}z} = -\frac{\frac{\partial\Phi(z,t)}{\partial z}}{\frac{\Phi(z,t)}{\partial t}} > 0$$

in fact:

$$\frac{\partial\Phi(z,t)}{\partial t} = 1 > 0$$

and

$$\frac{\partial\Phi(z,t)}{\partial t} = -rp'(t) + p''(t) < 0$$

5.4 Proof of Proposition 3

Let z^* be the ability at which $V(z^*, R) = V(z^*, NR)$. Existence is proved by showing that $V(0, NR) > V(0, R)$ and $V(z^b, NR) < V(z^b, R)$ (this holds for values of B sufficiently low. The restriction I made is sufficient for existence) and applying the mean value theorem to ensure that a value in the interval $[0, z^b]$ is a zero for the function $V(z, R) - V(z, NR)$.
First notice that by Envelope Condition

$$\frac{\mathrm{d}V(z^*, \cdot)}{\mathrm{d}z} = \underbrace{\frac{\partial V(z^*, \cdot)}{\partial t^b}}_{=0 \text{ by Envelope Thm}} \frac{\mathrm{d}t^b}{\mathrm{d}z} + \frac{\partial V(z^*, \cdot)}{\partial z}$$

It is easy to verify that

$$\frac{\partial V(z^*, R)}{\partial z} > 0$$

and

$$\frac{\partial V(z^*, NR)}{\partial z} = \frac{1}{r}(1 - e^{-rt^s(z)}) > 0$$

Both derivatives are continuous and differentiable.

Consider first the case where the marginal manager falls at the right of the median (there is an excess of targets over buyers). In this case $t^s(z^*) = \infty$ in equilibrium, while $t^b(z^*) < \infty$. It is possible to check that $\frac{\partial V(z^*,R)}{\partial z} > \frac{\partial V(z^*,NR)}{\partial z}$ (for $t^s(z^*) = \infty$, the second element is constant over time; the first element decreases over time and is greater than the second at infinity).

If, however, the marginal manager falls before the median the optimal rule for the agent is: $t^s(z^*) < \infty$, and $t^b(z^*) = \infty$. In this case it is easy to see that $\frac{\partial V(z^*,R)}{\partial z} > \frac{V(z^*,NR)}{\partial z}$.

It is also easy to check that $V(z, NR)$ is convex in z:

$$\frac{\partial^2 V(z^*, NR)}{\partial z^2} = \begin{cases} \frac{1}{r} e^{-rt^s(z)} \frac{\mathrm{d}t^s}{\mathrm{d}z} > 0 & \text{if } t^s(z) < \infty \\ 0 & \text{otherwise} \end{cases}$$

Unfortunately it is not easy to check convexity for $V(z, R)$. However, since in each crossing point the function $V(z, R)$ must intersect $V(z, NR)$ from below (because the derivative of the first is strictly greater than the derivative of the second), it must be that the crossing point is unique (if there were more than one solutions, then $V(z, R)$ should cross $V(z, NR)$ from above, or at least be tangent; the condition on the derivatives rule out these cases).

5.5 Proof of proposition 4

Equating the FOC for the buyer and the seller at time t it is possible to obtain $T(b,s)$:

$$T(b,s) = -\frac{1}{\lambda}\log\left[\frac{(\phi(Ab,2)-Ab)-s}{(\phi(Ab,2)-Ab)-(\phi(b,2)-b)}\right]$$

defining $x = b/s$

$$T(x,1) = -\frac{1}{\lambda}\log\left[\frac{(\phi(Ax,2)-Ax)-1}{(\phi(Ax,2)-Ax)-(\phi(x,2)-x)}\right]$$

and

$$\frac{\mathrm{d}T(x,1)}{\mathrm{d}x} < 0$$

5.6 Proof of proposition 5

Substituting the pricing function into the problem of the marginal seller z^* (that is, the manager who is indifferent between selling or investing in R&D) we can see that its value is constant:

$$V(z^*,NR) = \int_0^{t^s(z^*)} z^* e^{-rt}\mathrm{d}t + p(t^s(z^*))e^{-rt^s(z^*)} =$$

$$\frac{z^*}{r} + \underbrace{e^{-rt^s(z^*)}\left[p(t^s(z^*)) - \frac{z^*}{r}\right]}_{=0}$$

In fact, given that $s(\tau) = z^*$ in the relevant region (that is, for $t > t^*$), we have

$$p(t^*) - \frac{z^*}{r} = \int_{t^*}^{\infty}(s(\tau)-z^*)e^{-r(\tau-t^*)}\mathrm{d}\tau = 0$$

We can see that for each $z < z^*$ the term in brackets is always positive. Compare the two values:

$$p(t^s(z)) - \frac{z}{r} = \int_{t^s(z)}^{\infty}(s(\tau)-z)e^{-r(\tau-t^s(z))}\mathrm{d}\tau > 0$$

since $s(t^s(z)) = z$ and $s(\tau) > z$ for $\tau > t^s(z)$.

Now we must prove that $t^b(z^*) = \infty$. Since at time t^* there is still a mass $F(\underline{z}_b) - F(z^*)$ of potential buyers, target firm z^* will sell at the highest possible price: that is, it will sell at the manager who assigns the highest possible value to the new assets. This manager is exactly $\underline{z}_b$

Remember that by definition $V(z^*,NR) = V(z^*,R)$; so it must be:

$$V(z^*,R) = \frac{(z^*-B)}{r+\lambda} + \frac{\lambda A z^*}{r(r+\lambda)} = \frac{z^*}{R}$$

From this we obtain $z^* = \frac{rB}{\lambda(A-1)}$

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