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Matti Suominen

Research Department
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Industry Equilibrium with Outside Financing and Moral Hazard:

Effects of Market Integration

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* INSEAD, Boulevard de Constance 77305 Fontainebleau, France. Tel. +33-1-6072 4484, fax +33-1-6072 4045. E-mail: matti.suominen@insead.fr. This research is partly based on the second chapter of my dissertation submitted to the University of Pennsylvania. I thank my dissertation advisors, George Mailath, Richard Kihlstrom and Steve Morris, as well as Jean Dermine, Rafael Rob, Jouko Vilmunen and especially Juha Tarkka for their comments on this paper. Part of this research was conducted while the author was visiting the Bank of Finland. I thank the Bank of Finland for its hospitality during my visit. I also thank the Yrjö Jahnsson Foundation for financial support. All remaining erros are mine.

Industry Equilibrium with Outside Financing and Moral Hazard: Effects of Market Integration

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Matti Suominen
Research Department

Abstract

In this paper we study industry equilibrium and the effects of integration under the assumptions that 1) firms must use outside financing and 2) they face a moral hazard problem due to the possibility of taking excessive risks. These are typical features of banking and insurance, for instance. We examine an industry equilibrium where firms choose not to take excessive risks and compare this with the equilibrium in industries that do not have a moral hazard problem. We show that, as markets integrate, competition intensifies and prices fall in both types of industry. In markets with moral hazard there are relatively more exits, a smaller fall in prices and, contrary to the other case, the market value of the industry increases.

Key words: industry equilibrium, outside financing, risk-taking behaviour, market integration.

Ulkoinen rahoitus, moral hazard ja toimialan tasapaino: integraation vaikutukset toimialan markkinarakenteeseen

Suomen Pankin keskustelualoitteita 23/99

Matti Suominen
Tutkimusosasto

Tiivistelmä

Tässä keskustelualoitteessa tarkastellaan toimialan tasapainoa ja integraation vaikutuksia silloin, kun yritysten on käytettävä ulkoista rahoitusta ja kun niillä on liiallisesta riskinotosta aiheutuva moral hazard -ongelma. Nämä piirteet ovat tyypillisiä esimerkiksi pankki- ja vakuutustoimialalle. Työssä tutkitaan tasapainoa, jossa ei ole liiallista riskinottoa. Tätä verrataan sellaisten toimialojen tasapainoon, joilla moral hazard -ongelmaa ei esiinny. Työssä osoitetaan, että markkinoiden yhdentyessä kilpailu lisääntyy ja hinnat laskevat kummankin tyyppisellä toimialalla. Moral hazardin vaivaamilla aloilla yrityksiä poistuu markkinoilta suhteellisesti enemmän ja – päinvastoin kuin tavanomaisessa tapauksessa, jossa moral hazardin vaikutusta ei ole – toimialan markkina-arvo kasvaa.

Asiasanat: toimialan tasapaino, ulkoinen rahoitus, riskinotto, markkinoiden yhdentyminen

Contents

1 Introduction

As markets integrate, due to globalization or the creation of regional common markets, conventional wisdom predicts that competition increases and there is a net transfer of wealth from shareholders to consumers due to lower output prices and smaller profits. We argue, however, that in industries where moral hazard problems in risk-taking are large, such as financial intermediation or insurance, for instance, competition can not become very intense, as, if it did, the firms would have an incentive to take excessive risks. Because of this, there must be relatively more exit from industries with a moral hazard problem, in case of market integration, than from industries where the moral hazard problems do not play a role. In fact, we argue that, to prevent firms from taking excessive risks, the exit from such industries must be so large that the remaining firms' profits increase. In the model below, this effect is so great that, *ex ante*, the shareholders of firms in such industries prefer integrated markets and higher competition.

We analyze a model where all entrepreneurs of an industry must borrow a fixed amount from the financial markets to set up their production facilities. We assume that entrants which have successfully obtained credit have access to two possible production technologies: a safe and a risky technology. Because of the convexity in their payoffs due to their limited liability, the entrepreneurs may have an incentive to choose the risky technology even when it is, in expectation, dominated by the safe technology. As in Stiglitz and Weiss (1983), there is credit rationing in the equilibrium where the firms use the safe technology. In our model, this means that only a limited number of firms obtain credit, competition is imperfect and the entrepreneurs' profits are positive.

As one would expect, there are more firms in the larger markets, and the competition is therefore more intense. Nevertheless, in contrast to a similar model in the absence of a moral hazard problem, or the free entry model of Cournot competition by Novshek (1980), here the firms' profits are increasing in the market size, despite the increased number of entrepreneurs. The reason for this is that in larger markets the firms, in equilibrium, produce larger quantities and have greater potential gains from taking risks in relation to their costs of production. Therefore, to prevent these firms from taking risks, the equilibrium profits must also be increasing in the market size.

We then study the industry equilibrium when m markets of equal size are integrated into a single market. We show that there is always relatively more exit from markets with a moral hazard problem than from markets where the moral hazard problems play no role. In addition, the drop in the price cost margin is smaller, and, contrary to the latter case, the total market value of the industry increases. These results are important for understanding the trends in corporate merger activity, competition and equity valuation in Europe today.

2 The basic model

We assume a single period and two types of agents: lenders and potential entrepreneurs. Both types of agents are risk neutral and derive utility from their end of the period wealth. The entrepreneurs are endowed with a production technology, described shortly, but no initial wealth, and the lenders with F units of cash. To set up a firm, and produce, an entrepreneur must borrow F units of money from the lenders to buy a machine, or, alternatively, to cover his fixed costs. There is limited liability, so the payoff to an entrepreneur can not be negative. The loan markets operate competitively and all agents have access to a storage technology that offers zero returns.

We assume that firms' production, sales and profits are unobservable to the lenders. We assume, however, the existence of a costly monitoring technology that allows a lender to observe a firm's profits. The cost of using this monitoring technology is that it destroys a fraction $\beta > 0$ of the firm's revenues if used. We assume also that borrowers and lenders can *ex ante* commit to the use this costly monitoring technology in case the payment from the entrepreneur falls short of the agreed payment. Under these assumptions, the literature on optimal contracts, see, e.g., Townsend (1979) or Gale and Hellwig (1985), implies that the standard debt contract is optimal.

Once in possession of a machine, an entrepreneur has access to two different production technologies: a safe and a risky technology. With the safe technology, the cost of producing q units of output is:

$$C(q) = F + cq,$$

whereas with the risky technology it is:

$$C(q) = \begin{cases} F + \underline{c}q + B & \text{with } pr.\ \phi \\ F + \underline{c}q & \text{with } pr.\ (1-\phi) \end{cases},$$

where $0 \leq \underline{c} < c$, $0 < \phi < 1$ and $B > 0$.

The idea behind the cost structure is this: If the entrepreneur chooses to use low quality inputs, unskilled labor, for instance, the marginal costs are lower. By doing so, however, he increases the risk that something may go wrong, "the machine breaks down", and additional costs of size B must be incurred. For simplicity, we assume that B is independent of q.

A firm i can then sell its production in the output market, where the demand for its output, q_i, is given by:

$$q_i = G\left(\frac{\alpha}{n} - p_i + p_i^*\right). \tag{1}$$

Here p_i is firm i's price, n the total number of firms in the industry and p_i^* the average price of i's competitors, $\frac{1}{n-1}\sum_{j\neq i} p_j$. α is a positive constant and G a parameter that reflects the market size. It is easy to verify that, in this set up, the total demand for the industry output is always equal to $G\alpha$. Prices being equal, each firm has a demand equal to $\frac{G\alpha}{n}$. This demand schedule is similar to monopolistic competition: each firm's demand is decreasing in its own price and increasing in the price of its competitors. As in monopolistic competition, the price elasticity of demand is decreasing in the number of producers.

We have now fully described the the model. It should be clear that depending on the cost parameters B and ϕ there can exist two types of equilibria in this model. First we can have an equilibrium where all firms, that obtain credit, use the safe technology. Second, we can have equilibria where some or all firms in the industry use the risky technology. Throughout this paper, we confine our analysis to the equilibrium where all firms that obtain credit use the safe technology. This equilibrium is the unique equilibrium when B is large. We focus on this equilibrium for two reasons: First, we believe that in many industries moral hazard problems are severe enough to restrict entry, the way they do in the equilibrium with the safe technology that we analyze below. Second, the comparative statics of an equilibrium where firms use the risky technology, which prevails when B is small, are similar to those of an equilibrium in the absense of a moral hazard problem, i.e., when the risky technology is not available, which we will analyze later.

3 Equilibrium with moral hazard

We now characterize a market equilibrium in which the incumbent firms use the safe technology, and no additional firm can obtain sufficient capital to enter. In the equilibrium that we consider, the lenders lend F units of cash, with zero interest rate, to $n(G)$ randomly selected entrepreneurs. The interest rate is zero because the loan markets are competitive, firms use the safe technology and the return on the alternative storage technology is zero. In equilibrium, the lenders and borrowers commit to the use of the costly monitoring technology, that depletes the firm's revenues, whenever the payment by the entrepreneur is below the scheduled payment. The use of this costly monitoring technology guarantees that the lender is paid as scheduled and allows for the maximum number of firms in the market. As said, we assume that the cost parameters, ϕ and B, are large enough to deter entry by firms using the risky technology. This condition, which we later characterize, also implies that the number of firms is larger in the equilibrium where the firms use the safe technology than in the equilibrium where the firms use the risky technology.

3.1 Equilibrium conditions

In addition to the market clearing conditions in the product markets, the following three conditions must hold for an equilibrium in which the entrepreneurs produce with the safe technology: (1) the incumbent firms must make non-negative profits and (2) they must have an incentive to use the safe technology and (3) no additional lending to new entrants is profitable.

Denote by $\pi\left(n,G\right)$ the equilibrium profit, and by $q(n,G)$ the equilibrium output of a single firm, when the market size is G and all n firms in the industry produce with the safe technology. Each firm's maximization problem is:

$$\max_{p_i} \left[p_i - c\right]\left[\frac{G}{n}\left(\alpha - np_i + np_i^*\right)\right] - F.$$

The first order conditions imply a unique Nash equilibrium in which all firms set an equal price:

$$p = \frac{\alpha}{n} + c.$$

This implies that each firm produces q units of output and makes a profit equal to π, where:

$$q = \frac{G\alpha}{n}$$

and

$$\pi(n, G) = \frac{G\alpha^2}{n^2} - F.$$

To characterize the three equilibrium conditions, we must also calculate the profits of a firm which unilaterally and successfully deviates to the risky technology, $\pi^d(n, G, \underline{c}, F)$, i.e., when the machine does not break down. A deviating firm with marginal cost $\underline{c}$ maximizes his revenues:

$$\max_{p_i^d} \left[p_i^d - \underline{c}\right] \left[G\left(\frac{\alpha}{n} - p_i^d + p^*\right)\right].$$

The first order condition gives:

$$p_i^d = \frac{\alpha}{n} + \frac{(c + \underline{c})}{2}$$

and

$$\pi^d(n, G_t, \underline{c}, F) = G\left[\frac{\alpha}{n} + \frac{(c - \underline{c})}{2}\right]^2 - F. \tag{2}$$

In case the machine breaks down, and repair costs must be incurred, the profit is $\pi^d(n, G_t, \underline{c}, F + B) = \pi^d(n, G_t, \underline{c}, F) - B$.

For the moment, it is useful to abstract from any integer problems and treat the number of firms, n, as a continuous variable. In this case, in any equilibrium, it must be the case that $\pi^d(n, G_t, \underline{c}, F + B) < 0$. Otherwise, some firms producing with the risky technology can enter the markets. We can now state the first two of the equilibrium conditions, the non-negative profits and the incentive compatibility constraints, as:

$$\pi(n, G) \geq 0, \tag{3}$$

$$\pi(n, G) \geq (1 - \phi)\pi^d(n, G, \underline{c}, F). \tag{4}$$

The third equilibrium condition, of no additional entry, is a requirement that either one of these inequalities holds as an equality.

By looking at equation 4, we note that (because $\pi^d(n, G, \underline{c}, F) > \pi \geq 0$), equation 3 is never binding in the equilibrium and therefore, equation 4 determines the number of firms in the market. Let n^* denote the number of firms that satisfy the inequality 4 as an equality. We now want to characterize n^*.

Assuming that 4 holds as an equality, substituting for $\pi(n, G)$ and $\pi^d(n, G, \underline{c}, F)$ and rearranging, we obtain:

$$\frac{G}{n^2}\left[\frac{\alpha^2}{(1 - \phi)} - \left[\alpha + \frac{n(c - \underline{c})}{2}\right]^2\right] = \frac{\phi F}{1 - \phi}. \tag{5}$$

This gives us a second order equation for n^* which has the unique solution:

$$n^*(G) = \frac{2\alpha(c-\underline{c})}{\frac{4\phi F}{(1-\phi)G} + (c-\underline{c})^2}\left[\sqrt{\frac{1}{1-\phi} + \frac{4F\phi^2}{G\,(1-\phi)^2\,(c-\underline{c})^2}} - 1\right] \qquad (6)$$

Equation 5 shows that both $n^*(G)$ and $\frac{G}{n^*(G)^2}$ are increasing in G. In fact, it is easy to see from equation 5 or 6, that, for a very large G, $n^*(G)$ approaches a constant, $\overline{n}_\infty$. Thus,

$$n^*(G) \leq \overline{n}_\infty \equiv \frac{2\alpha}{(c-\underline{c})}\left[\sqrt{\frac{1}{1-\phi}} - 1\right]$$

and $n^*(G)$ approaches $\overline{n}_\infty$ as $G \to \infty$.

We can now determine the actual number of firms, in the equilibrium with the safe technology, by taking into account the fact that the number of firms must be an integer. As both inequalities 4 and 3 are relaxed when we decrease the number of firms in the market, the equilibrium number of firms, n, is simply the smallest integer below n^*, i.e., $n = int(n^*)$.

Now, there are two equilibrium conditions that we have omitted so far, and which we can now turn to. The first one is a condition on ϕ and B that guarantees that the equilibrium with safe technology is robust to the entry from firms producing with the risky technology. For this, it is sufficient that

$$E\pi^d(n(G), G, \underline{c}) = G\left[\frac{\alpha}{n} + \frac{(c-\underline{c})}{2}\right]^2 - F - \phi B \leq 0. \qquad (7)$$

When this condition holds, there is no room for any firm producing with the risky technology to enter, even if the lender could persuade the entrant to distribute its entire profits as interest to the lender. The second issue is a sufficient condition for the number of firms to be larger in the equilibrium with the safe technology than in an equilibrium where all firms use the risky technology. This condition is related to the robustness of the above market equilibrium. For this, it is sufficient that the expected profits be negative, when all firms use the risky technology and the number of firms is n. As the profits are independent of the marginal costs, when all firms have equal marginal costs, this condition can be stated as:

$$G\left[\frac{\alpha}{n}\right]^2 - F - \phi B \leq 0.$$

This condition is always satisfied when 7 holds. Let us assume, throughout this paper, that ϕ and B are such that 7 holds.

3.2 Comparative statics

From the equilibrium conditions, we have the following results for market conduct. First, note that $n^*(G)$ is uniformly increasing in the market size, G. Second, note that the output price is declining in the number of producers, n. These two results show that as the market size increases, typically more firms enter the markets, competition increases and prices decline. Given that G/n^{*2} is strictly increasing in G, by 5, we also have the result that typically firms' profits, $\pi(n, G)$, are increasing in G, despite the new entry into the markets. In the equilibrium above, the incentive to switch to the risky technology is greater in larger markets (because of larger production). Similarly then, the value of behaving prudently, or, in other words, the equilibrium profits must also be increasing in the market size. In large markets, as $n \to \overline{n}_\infty$, the profits become approximately proportional to the market size, G. The result that 3 never binds, i.e., that profits are always positive, is similar to the result in Stiglitz and Weiss (1983). What we have shown also, however, is that in an industry equilibrium where firms' gains from taking risks are proportional to their production, the profits are larger in larger markets.

Using 5, and the result that $n \leq n^*(G)$, we can provide a lower bound on the total industry profits, $n\pi(n, G)$. First note that 5 can be written as:

$$\frac{G(1-\phi)}{\phi n^*(G)}\left[\frac{\alpha^2}{(1-\phi)} - \left[\alpha + \frac{n^*(G)(c-\underline{c})}{2}\right]^2\right] = n^*(G)F.$$

Using this we get:

$$n(G)\pi(n,G) > n^*(G)\pi(n^*,G) = n^*(G)\left[\frac{G\alpha^2}{n^*(G)^2} - F\right] = \frac{G\alpha^2}{n^*(G)} - n^*(G)F$$

$$= \frac{G(1-\phi)}{\phi}\left[\alpha(c-\underline{c}) + n^*(G)(c-\underline{c})^2\right], \qquad (8)$$

which approaches infinity as $G \to \infty$.

4 Equilibrium without moral hazard

For comparison, let us characterize the market equilibrium in the absence of a moral hazard problem, i.e., in case the risky technology is not available to entrepreneurs. In this case, it is the zero profit condition, 3, that determines the number of firms in the industry. Setting the profits equal to zero would imply that the number of firms is:

$$n^c = \sqrt{\frac{G\alpha^2}{F}}.$$

This need not be an integer. However, the actual number of firms in the absence of a moral hazard problem must be between n^c and $n^c - 1$. Given this, the firms profits may be positive, but are always less than

$$\pi \leq \overline{\pi} = \frac{G\alpha^2}{(n^c-1)^2} - F.$$

As we shall see shortly, $\overline{\pi} \to 0$ as $G \to \infty$ implying that, in contrast to the previous analysis, firms' profits, π, approach zero as the market size increases. A related result, which proves the former result, given that $n^c \to \infty$ as $G \to \infty$, is that the total industry profit, $n\pi$, is bounded by a function that approaches $2F$, from above, as G increases. Using the result that $n > n^c - 1$, we have:

$$n\pi < \frac{G\alpha^2}{n^c - 1} - (n^c - 1)F = F + \frac{F}{1 - \sqrt{\frac{F}{G\alpha^2}}}.$$

So, although a firm's profits can be positive, in small markets, as the market size increases, each single firm's profits approach zero and the bound on the total industry profits approaches $2F$. These results are similar in spirit to those in Novshek (1980), who studies Cournot competition under free entry, and should be contrasted with the results of the previous section.

5 Market integration

Let us now consider what happens to the number of firms, the price cost margins and the total industry profits if we, totally unexpectedly, merge m markets of equal size G (as in the case of the common market in Europe). For the moment, let us abstract from the integer problems and assume that $n = n^*$ under moral hazard and that $n = n^c$ in the absence of moral hazard. Our previous results show that the number of firms in the integrated markets is then either $n^*(mG)$ or $n^c(mG)$, depending on whether there is a moral hazard problem or not. As in both cases, $n(mG)$ is greater than $n(G)$, the competition is more intense and prices are lower in integrated markets. Nevertheless, in both cases, some firms must exit as markets integrate.

Let us look at the relative exit ratios from markets in these two scenarios. We have shown that the number of firms in the absence of moral hazard is:

$$n^c(G) = \sqrt{\frac{G\alpha^2}{F}}.$$

In the absence of moral hazard, the exit ratio, due to the integration of m markets, is then:

$$Exit\% \equiv 1 - \frac{n^c(mG)}{mn^c(G)} = 1 - \frac{\sqrt{\frac{mG\alpha^2}{F}}}{m\sqrt{\frac{G\alpha^2}{F}}} = 1 - \frac{1}{\sqrt{m}}.$$

By contrast, in markets with moral hazard, given our previous result that $G/n^*(G)^2$ is increasing in G, we have:

$$Exit\% \equiv 1 - \frac{n^c(mG)}{mn^c(G)} > 1 - \frac{1}{\sqrt{m}}.$$

Also, given that $n \to \overline{n}_\infty$, the $Exit\%$ in markets with moral hazard approaches $1 - \frac{1}{m}$ as G increases. So there is much more exit from industries with a moral hazard problem, than from industries without, when markets integrate.

Given that the price cost margin is proportional to n, $p - c = \frac{\alpha}{n}$, these results also imply a smaller proportional drop in the price cost margin in markets with a moral hazard problem, as compared to markets without. Indeed, in markets without a moral hazard problem, the relative drop in the price cost margin is:

$$-\Delta(p-c)\% = -\frac{\Delta(p-c)}{p-c} = 1 - \frac{n^c(G)}{n^c(mG)} = 1 - \frac{1}{\sqrt{m}}.$$

By contrast, in case of a moral hazard problem, also using the result that $G/n^*(G)^2$ is increasing in G, we have:

$$-\Delta(p-c)\% = 1 - \frac{n^*(G)}{n^*(mG)} < 1 - \frac{1}{\sqrt{m}},$$

and, given that $n^* \to \overline{n}_\infty$, the drop in the price cost margin goes to zero as G goes to infinity. So, as we merge large economies, in case of a moral hazard problem, the market integration will have no effect on the price cost margins, and the number of firms in the new integrated market is equal to the number of firms in each of the single markets.

Last, but not least, let us look at the effect of market integration on total industry profits.

Proposition 1: *In case the firms have a moral hazard problem in taking excessive risks, when m markets of equal size merge, the change in total industry profit is positive. That is,*

$$\Delta\Pi = n^*(mG)\pi(mG) - mn^*(G)\pi(G) > 0.$$

The proof is given in the Appendix.

This result is much stronger than our previous result that, under moral hazard, both individual firms' profits and total industry profits are greater in larger markets. The above result says that, in case of moral hazard problems, the industry profits in integrated markets are more than m times the profits in the smaller, unintegrated markets.

Compare this result to the case of competitive markets with no moral hazard, where the individual firms' profits, and the industry profits, are always equal to zero. This result is also different from the conventional wisdom in Industrial Organization, which would predict that the individual firms' profits and the total industry profits decline, due to increased competition, when m markets of equal size are integrated into a common market. The conventional wisdom, which follows from the analysis in Novshek (1980), can be understood by considering our model in the absence of a moral hazard problem, if we require that the number of firms must be an integer. In this case, we showed that as G increases the bound on total industry profits approaches $2F$ from above. If we now merge several markets, where the industry profits are, say, F in each market, the total industry profit decreases from mF to something less than or equal to $2F$. So the above result, that the industry profit increases in industries with a moral hazard problem, at least when abstracting from the integer problems, when m markets integrate, is intrinsically different from the traditional story in Industrial Organization, and from industries without a moral hazard problem.

6 Conclusion

We have studied the industry structure and the effects of market integration in industries that rely on outside financing and have a moral hazard problem in taking excessive risks. Our results suggest that, for such industries, the common markets will result in a large shakeout, only slightly declining prices and an increase in the total value of the industry due to cost savings. Examples of industries with severe moral hazard problem in risk-taking are, for instance, Banking, Insurance, Airlines industries and possibly high tech industry, where it is difficult for the investors to be informed of the size of R&D risks that are being taken. It may not be a coincidence that many of these industries currently undergo major consolidation in Europe either through mergers and acquisitions or the creation of strategic alliances (see Figure 1).

One limitation of our model is that, for expositional reasons, we have assumed a demand structure where the total industry demand is always constant. In reality, for most industries, one would expect the total industry demand to be a decreasing function of the average price of the industry. The likely implication of relaxing this simplification would be a prediction that the total industry output increases as markets integrate, due to higher competition and lower prices, and does so especially within those industries, where the moral hazard problems do not play a role. Indeed, it is easy to construct more complicated models, along the lines of our analysis, where these predictions always hold.

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Appendix A. Proof of Proposition 1

First note that:

$$\Delta\Pi = n^*(mG)\pi(mG) - mn^*(G)\pi(G) = mG\left[\frac{n^*(mG)\pi(mG)}{mG} - \frac{n^*(G)\pi(G)}{G}\right].$$

To show that this is increasing in m it is sufficient to show that $\frac{n^*(G)\pi(G)}{G}$ is increasing in G. Using 8 we have:

$$\frac{n^*(G)\pi(G)}{G} = \frac{1-\phi}{\phi}\left[(c-\underline{c}) + n^*(G)(c-\underline{c})^2\right],$$

which is increasing in $n^*(G)$ and therefore in G.

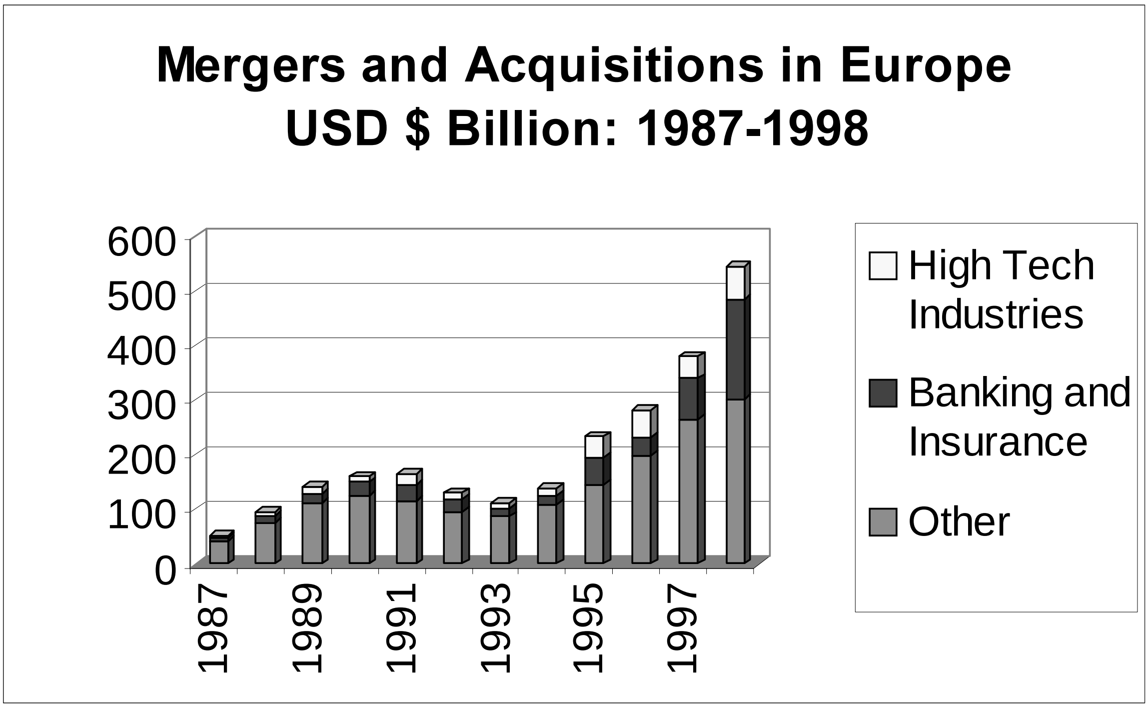
Mergers and Acquisitions in Europe
USD $ Billion: 1987-1998
600
500
400
300
200
100
0
1987
1989
1991
1993
1995
1997
High Tech Industries
Banking and Insurance
Other

Figure 1.