E C O N O M I C S B U L L E T I N

Notes on the Merger Strategy of High versus Low−tech Industries: Complementarities and Moral Hazard

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Abstract

In this essay I assess the role that is played by the two characteristics of high−tech firms in shaping their corporate strategies: short product cycles and the involvement of intangible assets in production. Short product cycles impose high−tech firms to seek complementary assets for entering new markets quickly and compete. The involvement of intangible capital in high−tech production, on the other hand, is related to the distinguishing characteristic of high−tech industries for which RDactivities are observed frequently and firms employ a large proportion of scientists, engineers and technicians. In this essay, I hypothesize and show that as a result of these two characteristics high−technology firms are likely to engage in vertical mergers more often than low−technology firms and vertical mergers are likely to involve firms that employ intangible assets in production.

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1.0 Introduction

Economic implications of mergers and acquisitions have long been an interest to economists. A merger by definition combines two firms leaving one surviving firm. An acquisition, on the other hand, describes the purchase of one firm by another. In this essay, I employ the term "merger" to identify both mergers and acquisitions.

Mergers are also often classified based on the type of merging firms' activities as vertical, horizontal and conglomerate. As explained subsequently, this distinction is a critical part of this study. A merger is classified as vertical if integrating firms belong to the neighboring stages of production such as a wine maker purchasing a bottle or cork factory. A horizontal merger on the other hand describes the case where firms who are involved in the same business line get together and form a separate firm. The third category of mergers are called conglomerate and they occur between firms with unrelated lines of business.

Motivations behind mergers have been studied under several headings in the literature. In this essay, my main interest is to distinguish between high and low technology industry behavior related to mergers, a topic which is left out in the literature. A systematic analysis on this subject is extremely useful for understanding the corporate strategy of high-technology firms, which is largely induced by their willingness to stay innovative.

High-technology firms show different behavioral characteristics in comparison to firms in other industries. For the purposes of this essay, two of these characteristics are particularly significant. First, firms in high-technology industries engage in R&D activities much more frequently than the firm in low-technology industries (Audretsch and Feldman, 1996). As an implication of this, firms in these industries employ a larger proportion of scientists, engineers and technicians in comparison to the firms in other manufacturing industries (Dung, 1990). Secondly, firms in high-tech industries face short product cycles. As a consequence of this, these firms find themselves engaging in various types of vertical agreements or contracts with others in order to access complementary assets and thus bring new products to the market. For example, frequently no one single firm does both the design and production of semi-conductor chips but rather firms enter into agreements to bring the new chip to the market.

One of the implications of the first set of characteristics is that high-tech firms are likely to employ intangible or tacit assets [1] more intensely in comparison to firms in other industries. In this essay, I consider only tacit-knowledge and describe it as the skills of engineers, mathematicians and technicians who are employed to achieve a particular task in the research or development phase of a product. Winter describes skills as a specified and defined set of capabilities applied to a particular task As reported in Winter (1987), Polanyi (1958), on the other hand, describes tacitness as a situation where the person who owns the skill can not provide as useful explanation of the rules to achieve a task.

The specific measure of tacit-knowledge that is employed in this study is justified in two ways. First of all the literature on tacit-knowledge describes activities that involve design, research, development, setting up, operating and maintaining laboratory instruments and equipment and alike as involving tacit knowledge. These skills are also described as the primary skills of engineers, scientists and technicians in the Occupational Outlook Handbook which is a product of the Bureau of Labor Statistics. The handbook provides detailed description of the existing occupations under each industry category in U.S. In the empirical part of this essay, I rank different stages of production in the Semiconductors Industry by the involvement of skilled labor. Features of this industry is deeply analyzed in the literature and this allows me access such information without having to collect data.

A critical aspect of tacit knowledge is the complexity that is involved in its exchange which originates from the difficulty of measuring and valuing this type of asset. As reported in Fortune Magazine, 1991, for example, Dennis Yablonsky, CEO of Carnegie Group explains this feature clearly: “Knowledge has been too hard to get to”, he explains “it’s in people’s heads its unstructured”.

Alchian and Woodward (1988) point the difficulty of exchanging such assets through contracts. Specifically, authors claim that some assets are more vulnerable to moral hazardous exploitation than others. In order to explain this, the authors compare a drug research laboratory with a steel manufacturer and conjecture that there are fewer options for discretionary firm behavior in steel manufacturing. Hence, the authors conclude, this increases the costs that are related to the detection of care or moral hazard

that is likely to induce the owner also to be the user of the asset. For example, Krickx (1995) finds that computer firms' tendency to integrate has increased as computer logic components have shifted from relatively simple ones such as receiving tubes to technologically complex integrated circuits. The difficulty with the exchange of tacit knowledge lies in its characteristics: it is difficult to specify the characteristics of such knowledge ex-ante, it is difficult to observe individual efforts and output is not verifiable by third parties ex-post.

Hence, based on the above discussion, I claim that firms from high-tech industries are likely to engage in vertical mergers more often than the firms from other industries. Specifically, I argue that low-technology firms face different production characteristics in comparison to low-tech firms that induce them to use pricing strategies as opposed to performance. And hence, they are more likely to engage in horizontal mergers. Horizontal mergers are much less frequently discussed in connection to innovation which is the core strategy for high-tech firms to stay in the market and compete. Most discussion on horizontal mergers is on anti-trust issues and price collusion. Inefficiencies related to monopolistic structures which are created as a result of horizontal mergers have been the major target of most academic discussion. Of course, following the Schumpeterian conjectures (Winter and Nelson, 1982) one could argue that monopolies have a larger incentive to innovate and they also can benefit from internal returns to scale. It is not, however, clear at all that large firms and firms that face less competition have a higher propensity to innovate. As Geroski (1991) indicates: " The correlation between size and innovation is weak, and that between market concentration and innovation is tenuous at best".

Complementary to the above hypothesis, I also daim that because product cycles are short, vertical mergers in high-tech industries are likely to involve tacit assets more intensely in comparison to horizontal mergers. This is because vertical mergers are likely to occur between firms that strategize to access complementary assets involving the tacit knowledge of other firms and secondly these firms are likely to merge to further engage in R&D by combining their complementary assets. Forming horizontal mergers on the other hand is less likely to be considered as a strategy that is used for R&D.

Hence, the two core hypotheses in this study can be summarized as follows:

Hypothesis 1: High-tech firms engage in vertical mergers more frequently than the firms in low-tech industries.

Hypothesis 2: Firms in high-tech industries engage in vertical mergers more frequently as opposed to horizontal mergers when at least one firm in the merger owns tacit-skills (knowledge).

In order to test these two hypotheses I employ the Mergers and Acquisitions Database for the time period 1993-1998. I examine a total of 1025 mergers across two low-technology industries, Stone Clay, Glass and Concrete Product and Food and Kindred Products and one high-tech industry, Electronic and Electrical Equipment and Components Sector.

In the next section, I describe the specifics of the manufacturing process in Semiconductors industry, a sub-sector of Electronics Industry. In section 3, I summarize the data and the results and conclude with some remarks.

2.0 Semiconductors Industry

Semiconductors or as often called microelectronics sector (SIC 3674) is a sub-sector of Electronic Components industry which is the subsector of the Electronic and Electrical Equipment and Components Industry.

As reported in Stein et al. (1985), Semiconductors industry has three phases of product development and manufacture that require varying skill levels. The initial phase i.e. product development is synonymous with the research and development or design phase of production. And it includes the following activities:

1-Original conception. This activity includes ascertaining whether a market exists

2-Activities that involve extremely complex circuit design and engineering to meet the given product specifications.

3-Prototype production in order to refine and correct the design and to adjust the manufacturing process so that it will produce satisfactory yields.

As reported in Stein et al., at this initial stage, the success of production depends heavily on skilled-labor employment. Therefore, I claim that given the intensity of tacit knowledge, agreements between firms that are at the design stage of production are likely to involve partner cheating.

The second phase involves activities related to wafer fabrication. As reported in Stein et al., in this phase chemical and physical processes are used to embed a circuit design in silicon wafer from 2 to 10 centimers in diameter. Many individual circuits are tested by machine and then each circuit is mechanically cut out from the wafer. Circuits that pass the tests for quality control then progress to the third and final phase of production which is known as assembly (Stein et al.). Wafer production stage involves relatively less skilled labor employment. According to Stein et al. at this stage the skilled labor requirement in comparison to the first stage is 2 to 1. Hence, I hypothesize that when firms are involved at this stage of production the risk of partner cheating is much lower as compared to the first stage.

As reported in Stein at al., at the assembly stage, each circuit is encassed in a plastic or ceramic package, and tiny wires are welded to the circuit and to metal alloy leads or pins embedded in the package. These packages can then be plugged into circuit boards to perform their required function. As Stein et al. indicate "the assembly process is highly repetitive, requiring little technology, equipment or skill". Therefore, I claim that when firms are involved at the assembly stage, the risk of partner cheating is much lower as compared to the first two stages of production.

As Stein et al. note as a whole the industry is largely dependent on highly skilled scientific and engineering workforce. However, the degree of this dependence increases as one moves from assembly to the design stage.

3.0 Data and Results

To test the hypotheses that are stated in Section 1, I employ the Merger's and Acquisitions database for the time period 1993-1997 and the first two months of 1998. The data is published in the Mergers and Acquisitions Magazine which belongs to a private enterprise, IDD, in New York City. I choose this particular time period, as the data includes more explicit information on the primary business of firms starting with the first quarter of 1993. In addition, this time period does not involve structural changes such as changes in the Anti-trust law as in 1984 or political administration.

The data is published quarterly for the period 1993-1994 and bi-monthly after that. I aggregate the bi-monthly data to obtain quarterly information. I choose one high-tech and two low-tech industries to carry this exercise. The low-tech industries are: Food

And Kindred Products and Stone, Clay and Glass Products Industries. The high-tech industry is Electric and Electronic Equipment And Components Industry. The low and high technology Industry classifications are made based on the previous work done in this subject area. The chosen industries are those for which there is no controversy as to what industry category they belong .

In order test the hypotheses, I classify each merger as vertical, horizontal and otherwise by the following criteria. This classification is similar to those in the literature such as Tirole (1988) and Stein et al. (1985). An example to such classification is illustrated in Table 1.

A merger is horizontal if the acquirer and acquired business are described by identical or close to identical phrases. All mergers where the majority of the business activities match and when two business activities are not complementary are also horizontal.

A merger is vertical when the acquired and acquirer activities are complementary. I classify the two business activities as complementary if they can be identified as adjacent parts of a production process. There are cases where merging firms' business activities are various and that each firm's activity can be both complementary and horizontal. In this case, I determine the major business activity of each firm and then decide which category the merger fits in.

All other mergers which do not fit to the above criteria are considered in the "Other" category

In order to test the first hypothesis, I count the mergers and acquisitions for all three industries based on this classification and find the percentage of horizontal versus vertical mergers in high and low-tech industries. Table 2 illustrates the results of this exercise. The results indicate that the high-tech sector has the highest number of mergers and is followed by the Food and Kindred Products and Stone, Clay and Glass Products sectors. Further, the high-tech sector has the highest percentage of vertical mergers. And it is followed by the Stone, Clay and Glass products and Food and Kindred products sectors. The observed percentages of vertical and horizontal mergers are quite stable over the years for all three industries.

In order to test the second hypothesis, I concentrate on the Semiconductors and related devices industry. I examine the business activities of each company for each merger in this industry. Based on my knowledge on the intensity of required skills for each stage of production in this industry, I classify transactions as involving tacit versus non-tacit activities. In order to simplify the analysis, I consider only the design stage activities as being tacit and adjust the classification accordingly. Further, I assume that the risk of partner cheating for agreements where one of the firms as opposed to both being engaged in tacit intense activities are identical.

The results of this exercise are in Tables 2 and 3 and they provide strong support for the second hypothesis. This simple exercise provides support for the separate ways of corporate re-structuring between the high and low technology firms. This is likely to have important implications in industrial organization theory and in practice on issues that involve anti-trust policy. A statistically more involved exercise is desirable to support and extend the results in this essay.

Appendix

Notes:

1- The literature on tacit knowledge has ample ways to describe this concept. In this essay, I employ the most generic definition i.e. knowledge embodied in human capital. Hence skills are a good measure following this definition. Below, is an example for the tacitness classification which is entirely based on the definition of production stages in Section 2.0

Ilustrative Examples to Tacitness Classification

SEMICONDUCTORS AND RELATED DEVICES (SIC 3674)
An example to a merger where the Target Business activities involve highly tacit assets
Acquirer: Helionetics Inc.
Irvine, CA
Acquired: Acculase Inc. (additional 67.5 %)
San Diego, CA
Terms: Helionetics acquired a majority in Acculase for an undisclosed amount of common shares. Heliotenics raised its holdings to more than 75% from its initial 7.5 % stake by acquiring securities
Completed: 4/18/94
Acquirer Business: Electronic converters and lasers
Programs
Target Business: Semiconductors and related products

SEMICONDUCTORS AND RELATED DEVICES (SIC 3674)
An example to a merger where the Acquirer Business activities involve moderately tacit assets

Acquirer: MEMC Electronic Materials Inc.
St. Peters, MO
Acquired: Albemarle Corp. (Electronic Materials Business)
Baton Rouge, LA
Terms: MEMC Electronic Materials, controlled by VEBA AG Germany, acquired the electronic materials business of Albemarle for $ 47 million cash.
Completed: 7/31/95
Acquirer Business: Silicon wafers
Target Business: Polysilicon material

Illustrative Examples to Merger Classification:

Table 1

An example to a Horizontal Merger

SIC 3625 RELAYS AND INDUSTRIAL CONTROLS
Acquirer: Ansoft Corp.
Pittsburgh, PA
Target: MacNeal- Schwendler Corp. (Electromagnetics analysis business)
Terms: Ansoft acquired the electromagnetics analysis business of MacNeal Schwendler for $ 5.6 million
Completed: 7/25/96
Acquirer Business: Electromagnetic Engineering Software
Target Business: Electromagnetic software

An example to a Merger in the "Other" Category

SIC3675 PRINTED CIRCUIT BOARDS
Acquirer: Pacific Animated Imaging Inc.
Annapolis, MD
Target: U.S. Technologies Inc.
Austin, Texas
Terms: Pacific Animated Imaging acquired U.S. Technologies for an undisclosed amount of common shares
Completed: 7/25/96
Acquirer Business: Imaging Systems
Target Business: Printed Circuit Boards

An Example to a Vertical Merger

SIC3674 SEMICONDUCTORS AND RELATED DEVICES
Acquirer: Orbit Semiconductor Inc.
Sunnyvale, CA
Target: Paradigm Technology Inc.(San Jose wafer plant)
San Jose, CA
Terms: Orbit Semiconductor acquired a wafer fabrication plant in San Jose from Paradigm Technology for $20 million . Terms were $6.6 million in $5.8 million note. And the assumption of $ 7.6 million in liabilities.
Completed:11/18/96
Acquirer Business: Semiconductors that allow designers to manage specific integrated circuit development, production, scheduling and control.
Target Business: Semiconductor wafers

Notes: The first example illustrates a horizontal merger where the business of the acquired and acquirer firms are described by "close to identical phrases" as mentioned in the text. The activities of both firms match and they are not complementary. Ansoft Corp., in this example, produces a slightly differentiated product of what MacNeal- Schwendler Corp. produces.

The second example illustrates a merger which can be classified as "other". The businesses of the acquirer and acquired firms are not related in a vertical or horizontal way.

The third example illustrates a vertical merger where the two businesses complement each other. Semiconductors and wafer production are complementary phases of microelectronics business

Summary Statistics for the vertical versus horizontal classification in high and low-tech industries: Table 2

Low-Tech Industry No:1
Food and Kindred Products [SIC 20]:

Year	Total number of mergers	Percentage of vertical mergers	Percentage of horizontal mergers
1993	**68**	**6 %**	**34 %**
1994	**56**	**3 %**	**32 %**
1995	**69**	**3%**	**39 %**
1996	**64**	**3%**	**47 %**
1997	**55**	**3%**	**38 %**
1998 [a]	**16**	**0 %**	**37%**
Total	328	3 %	37%

Low-tech Industry No:2
Stone, Clay and Glass products [SIC 32]:

Year	Total number of mergers	Percentage of vertical mergers	Percentage of horizontal mergers
1993	**16**	**12 %**	**37 %**
1994	**24**	**24 %**	**21 %**
1995	**12**	**2 %**	**5 %**
1996	**27**	**11%**	**44%**
1997	**27**	**11%**	**44%**
1998 [a]	**3**	**33%**	**66%**
Total:	109	16%	50 %

High-tech Industry
Electric and Electronic Equipment And Components Industry [SIC 36]:

Year	Total number of mergers	Percentage of vertical mergers	Percentage of horizontal mergers
1993	**85**	**29 %**	**28 %**
1994	**96**	**11 %**	**37 %**
1995	**89**	**29 %**	**28 %**
1996	**150**	**31 %**	**37%**
1997	**150**	**31 %**	**37 %**
1998 [a]	**18**	**22%**	**44%**
Total	588	31 %	28%

[a] *Notes:* For the year 1998, data is available only for the first quarter

Summary Statistics for The Semiconductors and Related Devices Industry

Table 3

Vertical Mergers	Horizontal Mergers
Percentage of vertical mergers: 41 %	Percentage of horizontal mergers: 28 %
Percentage of vertical mergers which involve design stage (tacit) activities: 99 %	Percentage of horizontal mergers which involve design stage (tacit) activities:60%

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