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# *Policy and Technology as Factors in Industry Consolidation*

S.R. JOHNSON AND T.A. MELKONIAN

*Iowa State University  
Ames, IA*

## INTRODUCTION

Evidence of mergers, acquisitions, and strategic partnerships of firms specializing in biotechnology and the related product chain is widespread. Popular examples include the DuPont/Pioneer Hi-Bred International strategic partnership and acquisition; the purchase of Dekalb Genetics Corporation by Monsanto; the failed acquisition of Monsanto by American Home Products; the purchase of Holden Seeds by Monsanto; the consolidation of U.S. and European companies forming Norvatis; the consolidation of cooperatives and private firms specializing in grain and oil seed handling; and many others (Lerner and Merges 1997). The upshot of these mergers, acquisitions, and strategic partnerships is that there are currently many fewer major companies controlling most of the genetics and related developmental systems for supporting biotechnology advances in the production of major staple crops, and the processing and delivery systems for taking advantage of related traits.

What is causing the consolidation in the biotechnology industry? Many of the explanations are peculiar to the firms involved and their special circumstances. In this paper we focus on the economic aspects of these firms, and the conditions under which they operate. In addition, we emphasize the technology and policy factors responsible for consolidation. In the case of technology, there are many angles for investigation. For instance, aspects of technology that relate to the special and complex features of research and development for biotechnology products, the technology of organizations and our improved knowledge about contracts and incentive compatibility, the growth and evolution of information technology and its impacts on the development of integrated assembly, handling and processing systems for biotechnology/derived products, the scale and scope economies that emerge from various sources, and

technologies supporting marketing systems that can capture the values of special traits of products.

Policy factors that are important in determining patterns of consolidation and integration are equally important compared to technology. These include: Food safety and product integrity; anti-monopoly and related measures to control competition; the more open-trading environment and associated expansion of markets for firms specializing in biotechnology; innovations in equity markets that provide access to lower cost risk capital for supporting mergers and acquisitions; restrictions on information-sharing associated with expanded opportunities for licensing and patenting; the changing roles of the public and private sectors in carrying out societal responsibilities for research and development; and the pressures resulting in shorter product cycles for biotechnology products. These are among the factors that provide increased incentives for firm integration and expansion.

We will show that at the root of many of these policy and technological factors that have been identified as influencing industry consolidation are the pervasive concepts of asset specificity, incomplete contracts, and residual property rights. Our understanding of these and related concepts has rapidly expanded during the past two decades (Hart 1991; Grossman and Hart 1986; Aghion and Tirole 1994). These results have complemented the earlier work on transactions costs and industry structure (Williamson 1985; Klein, Crawford and Alchian 1978). Combined with game theoretic formulations for characterizing strategic behavior, these developments provide plausible and instructive explanations for how firms responding to the changing policy and technological factors like those described above are motivated to form strategic partnerships, make acquisitions, and merge. The actions lead to consolidation patterns consistent with those observed in the industry developing and bringing to the market products made possible by advances in biotechnology.

## SOURCES OF VALUE AND INDUSTRY CONSOLIDATION

A key factor in understanding industry consolidation is the idea of value-added. Specifically, firms considering strategic partnerships, mergers, and acquisitions are motivated to act by increased profits. In order for profits to increase, some kind of value must result from the consolidation. It is instructive to identify the sources of potential value as a basis for better understanding the incentives for and patterns of industry consolidation. For purposes of exposition, we classify these sources as organizational, strategic complementarities, strategic substitutes, and market power (Melkonian and Johnson 1999a; Vickers and Waterson 1991).

Organizational sources of value relate in general to the things that firms can do together more efficiently than they can do on their own. Examples of organizational sources of value include coordinated purchases of inputs, shared information on production and other technologies, cooperation in assembly

and handling functions, marketing, and what we will term “investment externalities.” In the latter case we refer to a situation in which firms acting together can benefit from “public good” type joint investments. For instance, biotechnology firms may find it convenient to cooperate in meeting food security and other regulations, jointly managing information on production patterns and product traits, or in risk management, e.g. self-insurance. These value sources are important because they are relatively easily defined and obtained, if the firms are prepared to cooperate “faithfully.”

Strategic complementarities (first set out by Bulow, Geanakoplos, and Klemperer 1985) relate to efficiencies that can be achieved by coordinated investment and other activities. We take investment as the example. One firm may invest in specialized genetics while another may invest in chemical pesticides that result in reduced production costs, given success with the genetics. Processing firms may use agents that result in product traits that have special market values. If firms cooperate, again faithfully, value emerges from coordinated investment or product development strategies. In short, the firms cooperating in their decisions on investment can generate more value than if they proceed independently. Given the high research and development costs for biotechnology, the value generated by strategic complementarities can drive various forms of consolidation.

A strategic substitute (Melkonian and Johnson 1999a) is a concept referring to the converse of strategic complements. In this case, we can think of firms that are competitors in a limited market. Investments to expand output by one firm have the effect of driving down the price for both firms. Again, faithful cooperation among the firms can result in increased value and profit. These kinds of strategic substitutes are particularly important in the biotechnology industry. This is an industry with the capacity to produce products that have highly specialized markets, e.g. nutraceuticals, oils containing only particular types of fats, resistance to local pests, etc. In these segmented market situations, actions of one firm have important implications for the profitability of the competitors, and the industry.

Market power and its implications for profitability is well known from the traditional economic literature. Still, market power provides strong incentives for consolidation, whether to limit strategic substitutes, to manage product development cycles, to control pricing and inventory levels, or simply to drive out the competitors and prevent entry. In the biotechnology industry the complexities of product development, product registration and licensing, and the sharing of discoveries and patents provide opportunities for cooperation to improve market power. Firms have incentives to coordinate in meeting protocols for providing market access and for reducing the risks of sharing licenses and patents.

Of course, the regulatory environment in which the biotechnology and other industries operate may limit the opportunities for engaging in activities to

generate values from these sources. From a societal viewpoint, there are potential costs associated with industry consolidation designed to exploit these value sources. At the same time, allowing firms to coordinate to achieve these improvements in value puts at their disposal increased capital for investments in new technologies and products. National and international regulatory systems are implicitly balancing the benefits of consolidation with its cost. In the US, it would appear that the current environment tends to favor consolidations and transfers from consumers to producers that are rationalized on the basis of their implications for increased investment and more rapid rates of product development and technical change.

## INCOMPLETE CONTRACTS AND RESIDUAL PROPERTY RIGHTS

Given the value that can be generated by various forms of coordination simply by contracting, why is there a trend toward concentration? In an ideal world firms would recognize the value of coordination, develop the associated contracts to assure that it occurs, and gain the related value — without mergers, acquisitions, or strategic partnerships. Of course, there are legal constraints to these kinds of contracts due to the regulatory environment and national or international anti-monopoly policies. Still, it would appear that in the biotechnology industry the decision has been not to coordinate through specialized contracts, but to exchange ownership rights as a basis for cooperation.

One of the reasons for this tendency in the biotechnology industry is the difficulty in specifying and enforcing contracts. In reality when firms try to coordinate, the contracts that they write are incomplete. Simply put, they fail to anticipate all of the important contingencies and/or the specifics are not enforceable. In turn, the fact that firms understand these problems leads them to make non-optimal relationship-specific investments. Second-best solutions to coordination problems emerge as optimal strategies for firms that could benefit from fuller cooperation, if contracts are incomplete. Moreover, the residual property rights (those not anticipated in the terms of the contract) go to the owner. In the biotechnology industry where there are long lead times on investments and highly uncertain outcomes, contracts that cover all of the important contingencies are very difficult to specify.

Firms facing these contracting problems have a number of alternatives. First, they can proceed independently. This strategy results in foregoing the value that could be generated by coordination. Second, they can coordinate using incomplete contracts. This results in under investment and potential litigation and other costs associated with claims on residual property rights. Third, the firms can engage in partnerships that involve exchanges of assets, a mechanism that mitigates the problems of ill-specified contracts. These strategic partnerships are organizational mechanisms that provide compatible incentives for the cooperating firms. In this circumstance, less attention to the details of contracts

governing coordination initiatives and their enforcement is necessary. By virtue of the fact that the firms have shared ownership, they mutually benefit from successes of the cooperative ventures and quite importantly, have the incentives to make individual investments that are consistent with success. Shirking and free-riding problems are greatly reduced.

The situation with incomplete contracts becomes even more complicated when it is recognized that they may include components with different levels of enforceability. In this case, the parties to the contracts are likely to focus on the fulfillment of the components that are more enforceable and to under invest in the components where enforceability is more uncertain (Bernheim and Whinston 1998). At least two problems emerge from this characteristic of contracts. First, the components of the contracts are not independent in terms of the desired outcome. Thus, under investment in the components of the contract that is less enforceable can have significant impact on the success of the joint venture. Second, the parties to the contract may have beliefs about the success of the joint venture based on different perceptions of the fulfillment of the different components of the contract. Again, investment behavior that is influenced by enforceability will be the case. The role of the dominant party in obtaining the residual property rights when viewed in this context makes the outcome even less predictable.

The firms that are entering into the contracts also may have differences in the scope of their product lines. For example, one firm with a large portfolio of biotechnology products may contract with another firm that has a much more limited product line. If there are complementarities among the product lines, investment strategies will be affected. For example, strong complementarities for the firm with more product lines could induce it to invest more than would be rational given the incomplete contract considered in isolation. Thus, there is a "portfolio" effect that determines optimal investments for incomplete contracts. Independent consideration of the contracts, even with the benefit of the most advanced concepts, could result in inconsistencies between predicted and observed behavior. Alternatively, the firm with the narrow product line could be involved in a number of incomplete contracts with different firms. Here again the portfolio contracts, somewhat like a situation with larger scope multi-product firms, will influence investment patterns, and the way that the firm negotiates and executes particular contracts. All this means that the simple application of results from incomplete contracts and residual property right must be highly specialized to the partnering firms, if outcomes are to be predictable.

The problems of contracts with components that have different enforceability and the portfolio effects observed for multi-product firms or firms dealing with multiple partners, can be argued to suggest benefits of relatively simple contracts. The more complex the contract, the more components. The greater the scope for the portfolio of products, the more opportunity for complemen-

tarities that are not covered by product specific products. The more firms with which a representative firm has contracts, the greater the possibility for opportunistic strategies. Particularly in dynamic contexts, complexities of this type have been argued to imply benefits of leaving some contractible contingencies “ambiguous” (Bernheim and Whinston 1998).

## MERGER OR ACQUISITION VERSUS STRATEGIC PARTNERSHIPS

One of the important factors affecting decisions for mergers or acquisitions compared to the development of strategic partnerships (shared partial ownership) is the impact of management on the valuation of the firm. It is instructive to think of the valuation of the firm as consisting of two components. One component is management specific, identified with a very capable entrepreneur. The second component is transferable with acquisition, for example patents and licenses, physical assets, etc. Thus, firm decisions on joint ventures must be governed by the complexities of contracting and shared ownership and by strategies designed to capture the benefits of the management component of firm valuation. In the biotechnology industry where many start-up firms are identified with many gifted managers or scientists, this is an issue of particular relevance for consolidation and ownership patterns.

Suppose one firm acquires another. If the firm that is acquired has a high management component, then the acquisition package will have to include incentives for the manager. If the acquisition package does not include these incentives the manager will leave or behave in a way that reduces the performance of the acquired firm. For these reasons, it is not always clear that the solution to incomplete contracting problems associated with multi-firm ventures is acquisition or a merger. Instead, there may be reasons to use strategic partnership in combination with simpler contracts. This assures the retention of the benefits of the management components of the two firms and sufficient incentive compatibility that the unanticipated contract contingencies or relatively less enforceable features of the contracts will be honored in a way that contributes to the benefit of the firms (and managers).

An unanswered question for strategic partnerships is the optimal ownership share. Simply put, if two firms enter into a joint venture that is covered by an incomplete contract, what is the appropriate exchange of ownership to assure that both the firms and the managers have appropriate incentives to invest to fulfill the contract. In fact, there are two related questions. One is optimal investment for each of the firms. A second is the optimal level of ownership exchange to provide the incentives for the managers of the two firms to make the optimal investments (Melkonian and Johnson 1999a). Even from this simple characterization of the joint venture problem, it is apparent that the shares of ownership required to generate incentives for optimal investment will depend on the contributions of the management and transferable components of the value of the firm. The higher the share of the transferable component the

greater the incentive for merger or acquisition as a way of dealing with problems of incomplete contracts and the disposition of residual property rights.

In a dynamic setting there is the possibility that a strategic partnership can provide an opportunity for learning. In this case, a firm that is well managed may form a partnership with another firm and during the dynamic process acquire the specialized management knowledge of the second firm. Thus, strategic partnerships can be used as a pre-acquisition tactic. Of course, if this is a tactic for acquisition then the investment strategy and the ownership for the strategic partnership are affected. The firm intending to use the strategic partnership, as a tactic for acquisition, may be willing to enter into an exchange of ownership which viewed in the short run as non-optimal. The capacity of one firm to learn from another may also be related to the ability of the management to handle diverse enterprises. For example, other things equal, multi-product firms may find it less costly to acquire the management skills of their strategic partners.

These decisions on strategic partnerships, mergers, and acquisitions are clearly dependent on nature of technology and a policy environment. Different strategies can be anticipated if, for example, the joint venture involves the development of a product for which the technology is highly uncertain, compared to the situation where the technology is standard. Policy is also important in governing these strategies. For example, threats of intervention by government to reduce monopoly power may limit plans for acquisition. Expansions of patent and licensing opportunities may reduce the contribution of the management component, increasing the transferable component and providing incentives for more rapid merger or acquisition. These outcomes illustrate the factors contributing to consolidation in the biotechnology industry.

## SPECIAL FEATURES FOR BIOTECHNOLOGY

The observed rapid concentration in the biotechnology and related sectors can be viewed in part a result of problems related to incomplete contracts. Many biotechnology products are produced in highly integrated systems. These highly integrated systems may be required to assure expression of the trait that is adding value, meaning that firms along the product chain have incentives to cooperate. Experiences with the complexities of contracting appear to have led to partnerships that generate compatible incentives, and ultimately to consolidation.

Critical factors have already been identified. They include the complexity of the contracts, the uncertainties associated with technologies being used to execute the contracts, and the incentives for non-optimal behavior. These are fairly standard results from the available literature on incomplete contracts. What we have added are critical factors that appear special to the biotechnology

industry. Examples include the importance of understanding the management and transferable components of firm value, strategic partnerships as acquisition tactics, the implications of differential enforceability for provisions of contracts, and what we have termed “portfolio effects related to multiple contracts of a single firm or single contracts for multi-product firms.”

There is significant public participation in the biotechnology industry. In terms of agricultural research and development, public universities and research enterprises invest almost as much as the private-sector. This feature of the societal investment strategy appears to generate a continuing number of small and specialized firms. These firms are often participants in strategic partnerships with the larger firms, and ultimately are acquired. The public sector is in some sense providing innovation to a consolidated industry. The result may be a reduction in the implications of the observed concentration for innovation and product development. Public sector investments are in fact providing the source of this innovation and change. One could argue that in such circumstances the consolidation and concentration effects are being at least partially mitigated by the large role of the public sector in research and development investments.

The implication is then for increased consolidation, less limited by policy interventions and less damaging in terms of effects of concentration. Reductions in the share of public sector in research and development could significantly alter this situation, however. With high public investments there are always threats of entry and sources of new innovation. Perhaps this is one of the unanticipated benefits of the public role in research and development in sectors where contracting and other problems provide strong incentives for consolidation.

## CONCLUDING OBSERVATIONS

In fact, there is an “industry policy” for the biotechnology sector. A major instrument for this industry policy is the large public investment in research and development. A second instrument that is of importance is the expanded scope for patents and licensing. Anti-monopoly policy is also exercised. However, it is not clear that this industry policy is reflective of the special circumstances in the biotechnology sector. Our conclusion is that there will continue to be strong incentives for consolidation. Moreover, these forces are largely driven by advantages of integration and associated contracting problems. At least one of the implications is for better understanding of public research and development as a key component in the strategy for “managing” the sector.

We have not yet raised the question of the implications of consolidation for developed versus developing nations. In fact, implicitly, the discussion and observations have been within the context of the industry, as we understand it in the U.S., or more generally the developed nations. If public research and



development expenditures are important in counterbalancing the consolidation in the biotechnology sector, there are implications for the developing nations. These nations have relatively low public investments. Impacts of consolidation in the industry could be more pervasive and/or require the use of other instruments for managing the effects of consolidation and concentration.

The opportunities for better understanding the incentives for mergers and acquisitions and, more generally, for industry consolidation, are being greatly enhanced by our increased understanding of asset specificity's, incomplete contracts, and residual property rights. We have tried to add to this understanding by investigating more carefully the features of the contracts, the role of management, and the complexities introduced when it is recognized that firms tend to have multiple contracts and multiple products.

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