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In between Markets and Hierarchies – Networking through the Life Cycle of New Biotechnology Firms

by

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ABSTRACT

Resource dependence and transaction cost theories focus on organizations as mitigating their dependence on the task environment through various strategies. However, these theories have contradicting predictions as to the conditions under which network alliances are formed. New Biotechnology Firms (NBFs) provide an example of knowledge-organizations, operating under uncertainty and competitive environmental constraints, yet highly dependent on external resources. The event history analysis (EVA) of NBFs (N=554) shows that although avoidance of formation of alliances is associated with death, the formation of at least one inter-organizational alliance for each age year of the firm has an inverse **U** shape. The life cycle dependence argument is further supported when an analysis conducted on only self-standing NBFs shows a higher and longer dependency on external alliances. These findings suggest an integration of the two theories into a firm life cycle network theory within the domain of population ecology survival theories.

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Markets and hierarchies are the two dominant forces under which transactions are governed (Williamson 1975,p. 1981). Firms (hierarchies) have three advantages over markets: "First, common ownership reduces the incentives to sub optimize. Second, and related, internal organization is able to invoke fiat to resolve differences, whereas costly adjudication is needed when an impasse develops between autonomous traders. Third, internal organization has easier and more complete access to the relevant information when dispute settling is needed." (198 1, p.559). Williamson lists the conditions under which organizations will tend to use intra-organizational transactions through hierarchies in preference to market transactions. Transactions will take place within hierarchies when their outcome is uncertain, when the transactions are frequent, and when the transactions involve specific assets. Transactions characterized by the opposite dimensions tend to exist in markets.

In contrast to this explanation for the organization of economic activity, resource dependency theory argues that organizations continuously seek resources from their environment, in order to survive (Pfeffer and Salancik, 1978, p.78). In order to acquire these resources, organizations interact with other organizational entities in their environment who control these resources. The resource dependency of the organization places the controlling organization in a position of power (Salancik and Pfeffer, 1974; Pfeffer and Salancik, 1978). Due to this dependency, organizations (a) attempt to manage their environments and plan responses to their contingencies (Aldrich, 1976) (b) strive for closeness (Thompson, 1967), and (c) avoid dependency on markets and technological opportunities (Kay, 1993, p.252).

Johanson & Mattsson (1987) extend resource dependency theory into a theory of network relations. They argue that "firm's activities in industrial markets are cumulative processes, in the sense that relationships are constantly being established, maintained, developed, and broken in order to give satisfactory, short term economic returns and to create positions in the network that will ensure the long-term survival and development of the firm. Through its activities in the network, the firm develops the relationships that secure its access to important resources and the sale of its products and services" (1987, p.35). Therefore, forming a network of inter organizational transactions gives the firm access to other firms' internal assets.

The major disagreement between the transaction cost model and the network model regards the issue of asset specificity. Williamson argues that a high degree of asset specificity will lead to vertical integration, while Johanson and Mattsson, instead, contend that firms engage in a process of mutual adaptation through network exchanges, and that asset specificity is one reason why firms depend on external resources. Since it is impossible to internalize all resources, firms devote through mutual adaptation important resources to investment in exchange relationship (pp. 262-263).

In this paper we argue that the choice between markets (i.e. inter organizational exchanges) and hierarchies depends neither on the characteristics of the transaction per se, nor on the aim to utilize markets, but on the stage within the life cycle of the organization. At early stages the firm may form market exchanges to mitigate its liability of newness (Stinchcomb, 1965; Aldrich and Auster, 1986; Singh, Tucker and House, 1986), by importing network resources form externa1 organizations. Once the firm has reached its "liability of adolescence" stage (Bruder and SchussIer, 1990) it will aim to reduce its external alliances and move towards transactions internal to the hierarchy.

Most studies based on the transaction cost theory focus on cross sectional analysis of dyadic exchanges, using the transaction as the unit of analysis (Auster 1990, Pisano, 1988). This paper provides an integrative view in which both longitudinal and cross sectional tests are offered, and uses the organization, rather than the transaction as the unit of analysis. Specifying the unit of analysis as the organization is of vast importance. Organizational transactions can not be explained as atoms, not accounting for the stage in the life cycle of the organization. Only if the unit of analysis is the organization, can the interdependence of organizational exchange activities, within its life cycle can be revealed.

The paper is organized as follows: the next section will offer an integration of the theories that deal with how organizations choose to form market or hierarchy transactions. Since the characteristics of the biotechnology industry introduce a specific case of a highly competitive environment, the following section will highlight these characteristics and show their relevance to the environmental conditions under which NBFs operate which lead to their networking choices. The hypotheses will examine the major argument of this paper, indicating both, the need to form network transactions for resources vitally needed for organizational survival, and the need to protect firm boundaries over time through the reduction of external alliances. Although these two forces seem to be contradicting, the findings show that different networking strategies are used at different stages within the organizational life cycle. The discussion will elaborate on the implications of these findings.

THEORETICAL INTEGRATION

The integration of transaction cost and the network theories, in this paper, leads to a life cycle network approach. Although the arguments are specified to the characteristics of the biotechnology industry, and New Biotechnology Firms (NBFs), they may be generalized to similar organizational fields. The basic assumptions borrow from both approaches, yet lead to an alternative model. If the transaction cost argument that asset specificity, frequency of use, and high level of uncertainty will lead to hierarchies, then under the specific characteristics of the biotechnology industry we should anticipate market failure. The fact that large markets of inter organizational networks emerged (Barley and Freeman, 1988; Barley, Freeman and Hybles, 1992) reflects a strong inter organizational resource dependence. On the other hand, if the network approach is suitable, than the formation of inter organizational alliances should steadily increase at every age-year of the firm. The third option, the life cycle network theory, is that organizations position their boundaries differently at different points of time within their life cycle in order to maximize utilization of network resources when needed, and minimize risks resulting alliances. The following section will underline the assumptions that lead to the above option of markets and hierarchies integration.

The first assumption is that young knowledge-organizations are confronting an existential dilemma which is associated with their age and size. On the one hand, young organizations suffer from limited resources (Freeman, 1982), need to carve out their strategic niche position (Hannan and Freeman, 1977; Freeman and Hannan, 1983), to gain legitimacy (Singh, Tucker and House, 1986) and are at high risk of early death (Aldrich & Auster, 1986, Carroll and Delacroix, 1982; Freeman, Carroll and Hannan, 1983; Romanelli, 1989; Singh, Tucker and House, 1986; and Stinchcomb, 1965). Being young and small is associated with the “liability of newness” (Stinchcomb, 1965) that steams from its inability to generate resources for a full production scale, and thus at need for help of external organizations to provide its vertical integration transactions. By utilizing the network potential, the young organization can “import” needed resources, such as funding, and legitimacy (Hannan and Freeman, 1984; Singh et al., 1986) into its boundaries, as well as establish ties to long-term potential collaborators (for vertical integration facilities such as testing, production, distribution, and marketing) - a resource dependence argument. On the other hand, from this network perspective, the young organization is at risk. It is at risk of losing its independence, being appropriated by its contenders, as well as being taken over by one of its allies that, through transactions, get an inside observation on the quality of work, ideas or products developed within its hierarchy - a transaction cost argument. As a result, the collaborating organization may borrow on the built interdependence and aim to capture internally (through mergers and acquisitions) or externally (through appropriations of knowledge, ideas or products) the core-resources of the organization - its ability to survive independently. The hazards potential hazards from allies increase as the firm continuous its internal growth and production ability - thus introducing an additional facet of the "liability of adolescence" (Bruderl and Schussler, 1990). Two major risks are associated with adolescence: the risk of running out of the initial stock resources, and the risks of being abandoned by financial suporters. I propose that appropriation of ideas and products, firm takeover, and loss of future return from products to be additional risks associated with this stage of liability.

Four conditions exacerbate the risks young organizations take when they elect to source key resources through inter organizational networks. These are: (1) operating within a highly competitive product environment; (2) operating within a product development process involving high intellectual capital; (3) developing costly products; (4) trading with similar allies. The following section will first describe the biotechnology industry in the US, and then elaborate on the degree to which the four conditions exist in the industry.

THE BIOTECHNOLOGY INDUSTRY

Biotechnology is not an industry, but rather a set of technologies. However, it is common to refer to organizations that conduct R&D and develop products based on biotechnologies as defining the boundaries of the biotechnology industry. The industry had its major breakthrough in 1973 when professors Cohen and Boyer from Stanford university discovered the recombinant DNA technique. Although fermentation techniques and alteration of genetic structures have been long existing, the new technology opened many new opportunities for commercializing biotechnology products. Although Cetus a Californian firm founded in 1971 has turned into biotechnology products, Genentech, founded in 1976 is considered the first biotechnology firm that aimed to exploit the commercial potential in biotechnology products, thus denoting the birth of the industry. The growth curve of formation of new biotechnology firms has been impressive, and by 1990 there were over 500 dedicated biotechnology firms in the US only. In addition to the formation of new firms, many pharmaceutical and chemical incumbent companies, such as Johnson and Johnson, and Eli Lilly, have formed biotechnology research units and established biotechnology joint ventures.

The major characteristic of the biotechnology industry is that it is based on commercialization of intellectual knowledge. This knowledge originates in scientists that transfer their knowledge and reputation into firm capital (Zucker, Brewer, Oliver and Liebeskind, 1993). Stringent regulations have also characterized the biotechnology industry. The principal regulating agency is the Food and Drug Administration (FDA), which has jurisdiction over products in the area of pharmaceutical, healthcare, food, animal drugs, and food additives. FDA regulations require costly and lengthy testing of therapeutics products. A new drug application for a single pharmaceutical product normally run to 100,000 pages, and FDA clearance requires from three to ten years with commensurably staggering expenses (Walton and Hammer, 1985, p. 15). The industry requires an enormous R&D expenditure in order to stay on the cutting edge biotechnology, and the intensive competition between companies over the development of new products generates a constant need for fiscal resources (Walton and Hammer, 1985, pp. 15-16).

Three major types of investors are active in financing the biotechnology industry: the public, the venture capital "sophisticated investors", and corporations. Out of these three groups, the major corporation have become biotech's most significant investor. Walton and Hammer (1985) describe the conditions that facilitate financial exchanges between small firms (NBFs) and incumbent firms:

> "...The small biotech companies, dedicated to pharmaceutical development, face a series of catch 22's in pursuing success, For a start, a small company generally does not have the funds (tens of millions of dollars) to generate the staying power (generally at least five years) to get a pharmaceutical through the FDA and onto the market. Given such resources, it generally does not have the marketing capability to effectively exploit the product. Finally, given the ability to market, there would almost certainly be competitors for the market...Agreement with major companies are clearly the choice most biotech companies have made. Such agreements involves joint ventures, licensing, or marketing or even an off-balance sheet R&D financing. Such agreements also take the form of R&D

contract work, another mean by which a biotech company can get immediate revenues on the books and retain a small percentage of sales revenues on the development product, should any exist. While these agreements involve immediate revenues, they are not the panacea they appear, since in each case the biotech company involved gives up something--usually a chunk from prospective revenues, thus diminishing the upside revenue potential for the company." (1985, p.23-24).

For many NBFs Vertical integration is a major strategic goal (Young, 1988, p.29). In addition, becoming vertically integrated protects the firm from any opportunistic behavior by allies. They do not expose their ideas or products to external allies, and thus manage to safeguard their boundaries. Young elaborates on the advantages of vertical integration:

"Vertically integrated companies command their own intellectual and material resources, they have no obligations to partners, and they directly manage their own marketing and interfaces. Their management structures are generally simpler, and their profits are their own. They are also perceived by their peers and crucially - by investors and the financial community as fully matured companies with a greater likelihood of long term growth and profitability" (1987, p.29).

The four conditions listed in the theoretical section as increasing the risks of opportunistic behavior of allies exist in the biotechnology industry. The need to reduce these risks may force NBFs into vertical integration.

Competitive Environment

NBFs operate within a highly unpredicted and competitive environment. The inability to predict results from two main factors: the advanced and changing technology coupled with the limited protection ability for property rights, and the serendipity of the market place. Both factors reflect an ambiguity, that generates conditions in which NBFs, searching for R&D ideas for future products, can be compared to searching a needle in a hey stack. In addition, the growing number of competing NBFs create a hypercompetitive market.

As environmental competition increases, the potential for inter organizational appropriation is higher. Organizations striving to be on the competitive frontier are aiming to absorb the maximum amount of knowledge and ideas existing either in their internal environment (hierarchy), or in the external environment (within other network organizations). Therefore firms in highly competitive organizational environments can expect to experience a high level of inter organizational opportunistic behavior. In the biotechnology industry, several disputes occurred between firms regarding their rights to patents and products occurred. Examples of such disputes are the Xoma vs. Centocor court settlement on a patent of the university of California in 1990; Upjohn vs. Syntro over rights to a genetically engineered veterinary product in 1990; Cetus vs. Du-Pont in 1991 over patent infringement charges; Amgen vs. Genetics Institute and Chugai Pharmaceutical ***over*** patent and marketing rights over EPO in 1989, and others (OTA 1991, p. 220).

High Intellectual Capital Products

Knowledge organizations developing products that are intellect-intense (such as the biotechnology organizations), are susceptible to higher risk of appropriation by other organizations. This higher risk is attributed to the fact that it is hard to write protective contracts or "patents" for knowledge, as it is hard to avoid "knowledge leaking" when scientists share scientific information. Sharing scientific information among scientists is not only embedded in professional norms of scientists, but is also the common process in which science progresses. This notion has been elaborated elsewhere (Zucker et. al, 1993; Liebeskind, Oliver, Zucker and Brewer, 1994). Under these permeable firm boundaries, valuable information regarding applied scientific ideas can be transferred into future products, but can also be appropriated by other firms or individuals in the firm's environment. The protection of unpatented ideas form appropriation is very limited. Teece (1987, p. 188) argues that even patents, that are assigned at the later stage in the transformation of basic science into products, can rarely confer perfect appropriability, since many patents can be "invented" around at moderate cost. Patents are especially ineffective at protecting process innovation.

Costly Products

Developing products that have both high monetary value and a large potential market will increase the costs of appropriation of ideas and know-how by other firms. Key biotechnology products yield high revenues. For example, Epogen, a dialysis anemia product developed by Amgen had revenues of $395 million in eighteen month of sale, and Activase, a product developed by Genentech for acute myocardial infarction generated revenues of $375 million between 1989 and 1990 (OTA, 1991, p.77). It is therefore expected that firms operating within a "high value" product environment will closely monitor their boundaries, and aim to restrict alliances that may reduce their share in the future revenues of the product.

Similar Vertical Integration Partners

If a firm's trading partner is operating within the same industrial or product area, the potential for appropriation is higher than when the partner operates in another field. Similarity between two organizational entities allows comparability and gives each side a better understanding of the product development process of the other. It also means that the internal resources of each organization may be not only complementing but parallel. For example a small start-up NBF may form a marketing (vertical integration) alliance with an established NBF. The established NBF is in the position to offer appropriate marketing facilities since it operates in the same market, and has established an complementing marketing distribution system to the one the small NBF needs. However, for the exact same reason, the established NBF has the ability to understand and to gather information on the product developments of the small NBF. That is, through network- governed exchanges (Powell, 1990), the established NBF has the ability to "peek" into the R&D work carried in the small start-up, and appropriate some of these ideas. Thus, product or market similarity between two exchange allies increases the probability for appropriation. The frequency of exchanges with similar organizational allies is noted by Barley, Freeman and Hybles (1992). They found that NBFs form over 60 percent of their alliances with other NBFs or with diversified corporations. This finding is consistent across the four major biotechnoIogy specializations, and it indicates a heavy dependence on similar allies - exactly those having the potential for appropriating behavior.

HYPOTHESES

Forming external alliances with other organizational entities is the force that facilitates NBFs in progressing from their "emergent" to its "adolescence" stages. As mentioned above, product development in the biotechnology industry is very costly, and by nature, the small "research laboratory" type the of newly organized entity, NBFs need to utilize external alliances for the acquiring legitimacy, financial resources, and vertical facilities (Powell and Barntally, 1992). Therefore, it is expected that the lack of inter organizational alliances, will be associated with organizational mortality, to the degree that organizations which fail to form external alliances will show a higher odds for death.

> *Hypothesis I: Inability of an NBF to form inter organizational alliances is associated with organizational death.*

The central argument of this work is that NBFs make strategic choices between markets and hierarchies that depend on their growth dimension over time. Due to size and resources constraints young NBFs are forced into establishing alliances with external organizations. As NBFs experience internal growth, stability and recognition, they will aim to become vertically integrated, and decrease their exposure to external alliances.

> *Hypothesis 2: As NBFs experience internal growth (scientific and economic), they will tend to decrease their dependence on external allies by decreasing their inter organizational exchanges.*

According to resource dependence theory (Pfeffer and Salancik, 1978), organizations that can “afford” to avoid dependence for resources on external entities in their environment will opt to do so. In the context of NBFs, it is expected that “free standing” NBFs (NBFs that are not subsidiaries of larger firms) will depend on external contracting for a longer period of time, and their odds ratios for forming external alliances every year will be higher than for all NBFs. This is expected due to the fact that NBFs that are subsidiaries of larger firms, benefit from the supporting relations with their parent company, and thus reduce their dependence on external exchanges with other organizations for gaining access to critical resources.

> *Hypothesis 3: Free standing NBFs will have greater odds offorming external alliances than all NBFs, and will continue the use of these alliances for a longer period of time.*

METHOD

The Unit of Analysis

The strategy literature (Porter, 1985; Teece, 1987) provide detailed observations into the nature of agreement and alliances formed by firms, and the conditions under which firms should become integrated or contract for complimentary assets. The content, length, and volume of each agreement is a construct of an analytical decision making process that aims to estimate the “costs” and the “benefits” of each transaction. Teece (1987, p.204) argues that among other conditions, firms developing innovative technologies will prefer to integrate rather than contract when the appropriability regime is weak, when the specialized assets are critical, and when the cash position is good. The present study borrows the “costs” and “benefits” arguments to the context of the resource dependence approach. The assumption is that inter organizational alliances are needed for organizational growth at one stage (benefits), but are associated with a high cost at another stage. This view is aggregative, and does not take into consideration the details of the specific alliances. Thus, the organization is the unit of analysis rather than the transaction itself (as in transaction cost - Williamson, 1975). The analysis takes a time of an age-year as the “risk” period in which an NBF either forms at least one external alliance, or declines to do so. This view can be considered a very general strategic choice, or a non strategic choice imposed by environmental conditions or demands that generate constraints on the organization’s ability to form alliances (population ecology perspective, Carroll, 1984; Hannan and Freeman, 1977; Freeman and Hannan, 1983). The assumption is, that forming at least one external exchange with another company signifies a generated dependency for at least that year. Declining to do so, indicates that the NBF has chosen to refrain from contracting and retain its activities within its boundaries (hierarchy), for that year. The use of such an aggregative view, allows a cross sectional as well as a longitudinal presentation of a large set of transaction embedded in various varieties of organizational forms. However, at the cost of analyzing the specificity of inter organizational transactions.

Data

The data is based on two files produces by North Carolina Biotechnology Data Company (1991). This database monitors public literature citations of biotechnology agreements within the years 1981-1990. A market transaction is included in the database if either one of the firms involved has some biotechnology activities. The two data sets were the COMPANY and the ACTION. The file contains 554 NBFs, and 2043 actions. Firms “born” after 1975 and defined as “dead” within the period 1976-1990 in the FIRM data set (n=69) were included in the analysis as well.

The Variables in the Analysis

1. Internal growth: Internal growth of NBFs can be described within two dimensions: (a) Intellectual capital growth (e.g. patents assigned to the firm, a new product announcement, or a

scientific breakthrough), (b) Structural and financial growth (e.g. capital gain, stock offering, employment announcement or addition of a facility to the firm). The fact that the firm survives any additional year is, by nature, the most robust measure of internal growth as it reduces the liability of newness. However, in this analysis, since the intellectual and the structural growth measures correlated positively with firm age (Table 2), this variable substitutes for internal growth. In addition, since the analysis includes both, "live" NBFs as well as "dead" NBFs, growth is accounted for by firm's age as well as firm's survival status. Firm size is also an important factor contributing to internal growth, and therefore it is accounted for when testing the impact of age and survival status.

2. The model variables: One dependent variable and six groups of independent variables are used in the event history analysis, and are described in Table 1. All variables are categorical (dichotomous with "1" as the variable value and "0" as the referent category). The dependent variable, formation of external alliances, is coded as " I" for an external exchange with another company, and "0" for no exchange.

The first set of variables compose the baseline model. It includes firm year-age (a dummy variable for each age group), survival status (value of " 1" if the firm is "dead" and value of "0" if not) and firm size (value of "1" if the firm has more than 50 employees, and "0" if less). This set serves as a baseline model (Model 1) to which the additional 3 **1** nested combination models, based on five sets of controI variables are added.

Five sets of variables are added to control for firm observed heterogeneity, and industry life cycle. The five sets are: (a) Industry life cycle stage measured by nine dummy variables for the years X982-1990 with 1981 acting as the referent category.

(b) Technological diversity measured by two dummy variables for medium diversity (2,3) technoIogies used by the firm, and high diversity (4,5 or 6) technologies used by the firm, with the referent category - low technological diversity (only one technology used by the Cm).

(c) Financial status of the firm, measured by a dummy variable for public firms (value of "l"), while private firms, joint ventures, subsidiaries, or divisions serving as the referent category ("0").

(d) Firm's major product focus measured by three dummy variables for agriculture, diagnostics and therapeutics as a major focus (value of "1" for each of the three variables), with 30 other foci (including biomass conversion, cell culture, vaccines, veterinary and fungi) as the referent category ("0").

(e) Product foci range, measured by two dummy variables: medium (3,4 product foci) and high (5,6 product foci) compared to few (1,2) foci as the referent category ("0").

The Event History Analysis

The event history analysis of external alliances of NBFs is based on the model of competing events (Yamaguchi, 1991, p. 169). This model assumes that competing events may occur within the same risk period. For the purposes of our analysis, entering into at least one external exchange in every given year of the firm's life signifies the fact that the firm has opened its boundaries to exchanges with external allies for that year. Yamaguchi refers to the second ideal situation of competing events as Type II in which "each of the multiple events has an independent set of parameters that determine its occurrence although, again, each event may involve the same covariates . . . if any event other than the event of interest occur, thereby removing the subject from the risk set of the event of interest, then the events are treated as censored observations" (p. 171). In the context of the proposed models, once a formal inter organizational exchange is listed in any dummy age group, the other exchanges (events) taking place in the same year are ignored.

The controlling variables have entered as contextual sets, and all possible combinations of those sets were run (N= 2 x 2 x 2 x 2 x 2 = 32 models). For theoretical purposes the baseline model including firm's age, survival status, and size was included in all models, while allowing all groups of the control variables to vary. As suggested by Yamaguchi (1991, p.33-34), all models were compared using likelihood ratio tests (L2). The Likelihood -ratio chi-square for goodness of fit tests, L2 is obtained when firm-period input data are used. This statistic is given as:

L2 = 2[(log-likelihood of the tested model) *(log likelihood of the constant rate model)]

where the constant rate model includes only the parameter for the intercept. The statistic L2 provides a significance test for the set of parameters used in the model, excluding the intercept. A larger value of L2 for a given degrees of freedom indicates a greater significance level. The statistical insignificance of L2 indicates that the tested model is not significantly better than the constant rate model (Yamaguchi, 1991, pp. 119-22). The models were run using PROC LOGIST in SAS (which is currently PROC LOGISTIC). The comparison between nested models is based on the differences in L2 and the degrees of freedom. Two models are nested if and only if one model is obtained by adding some parameter(s) to the other model. The test assumes that the model with more parameters is the correct one. However, only if the difference in L2 is significant given the differences in the degrees of freedom, this assumption is confirmed.

Insert Table 1 about here

RESULTS

The change in averages of internal action by NBF age signifies firm growth. Table 2 contains the averages for the general composite of internal growth (including scientific, structural & financial growth), and separately for the scientific growth measure.

Insert Table 2 about here

The results presented in Table 2 provide evidence for an increasing linear change in averages of the internal growth measures over firm's age. Since, on the average, all NBFs experience internal growth positively increasing with firm age, it is possible safe to assume that the year-age variables cover internal growth as well as survival.

Event History Models for External Actions

The event history analyses are discrete-time logit models. These models are useful when the measurement unit is relatively crude, such as year or individual age (Yamaguchi, 1991), and in this case, firm age. This model provides the logistic regression parameter estimates of the NBFs odds of entering an external alliance by firm age, size and survival status. The baseline model includes 14 dichotomous variables for firm age (age 1 to 14), with the first year (year 0) serving as the referent category; a survival status variable, with "live" firms acting as the baseline variable; and firm size variable (more than 50 employees), with less than 50 employees acting as the referent category. The results of the event history analyses are presented in Tables 3, while Table 4 provides the comparison of all of the L2 of the 32 models.

Insert Table 3, Table 4 and Figure 1 about here

Table 3 introduces the best fitted nested models for each hierarchical level. The best fitted nested models were selected through the comparison of the L2 statistic and the degrees of freedom. Out of the 32 possible models, the five significantly strongest nested models are presented (one for each combination of variables sets). The results show that the saturated model (the sets of 1,2,3,4,5,6), was not significantly better than its hierarchical nested Model 3 1 (1,2,4,5,6), and thus, model 3 1 is the best fitted model out of the 3 1 models. The findings strongly support to the first hypothesis. Live firms have a significant higher odds of forming at least one external alliance than do dead live firms. Firms that have ceased to exist, regardless of age at death, during the period studied have shown, consistently across all models, negative odds ratios of having external alliances. Finding these results systematically across all models, even while controlling for all firm and industry heterogeneity variables, adds significantly to their robustness. In general, these findings suggest that a lack of involvement in inter organizational alliances can serve as a precursor for death while generating alliances are essential and vital conditions needed for NBFs survival.

The results presented in Table 3 show that, overall, firm age has a significant effect on the formation of external alliances. The parameters presented in Model 1 show that the relations between firm age and the odds for forming at least one alliance each year are not linear, but rather form a pattern of an inverted U. This curvilinear pattern with a peak at age eight (in the baseline model and age 4 in model 3 l), a decline to a low at age 11, (1.11 in Model 1, .26 in model 3 l), and then a linear increase up to a second peak at age 14. This pattern is somewhat similar across all five models (figure 1).

Due to the smaller numbers of old NBFs, the addition of control variables to the baseline model reduces the significance levels of the later age-years (age 9 and up in model 3 1). However, at early ages, we can see a rapid increase in the odds for forming external alliances in each age period. In all five models, firms in their third year (age2 variable) have a significantly higher odds of being involved in at least one external alliance, compared to firms in their first year.

Firm size has a consistent and significant positive effect on the odds of entering an external exchange: the larger the NBF, the higher its odds of at least one external alliance. Industry cohort has a significant effect as a whole for the ten years studied, and a yearly effect starting in 1983. The odds for forming external alliances increases with industry development when compared with the baseline year, 198 1. The year 1988 is a peak year in which NBFs have the highest odds of entering at least one external exchange.

The medium and high technological diversity measures did not enter any of the nested "best" hierarchical models of external exchanges. However, the parameter estimate of these variables in a Model that included Model 1and the technological diversity variables, show that the high technological diversity dummy had a significant effect on the dependent variable (.38, p<O.Ol), while a medium technological diversity had no significant effect. This finding shows that larger technological diversity leads to a higher odds of entering external alliances compared to NBFs with low technological diversity.

As to the legal status of the firm, public companies show a significantly higher odds of entering at least one external alliance than do private companies, a result which is consistent across all four models in which this variable appears. This finding, although net of age effect, may be accounted to the fact that public companies are required by law to publicly inform all formal alliances, while private firms do not have this constraint.

NBFs, focusing in therapeutic products, have significantly more external exchanges, compared with NBFs with other product foci (.96, p<O.01; .91, p<O.01; and .97, p<O.Olin models 3,4 and 5 respectively). Although NBFs that focus on agricultural products share this tendency, their odds are lower (.32, p<.05; .28, p> .05; and .43, p<.01 respectively). NBFs that focus on diagnostics products are between agriculture and therapeutic NBFs (.72, p<O.01; .74, p<O.01; and

.77, p<O.01 respectively).

The final result represented by variables in set VI, is that firms with medium and high diversity of product focus have higher odds of forming external alliances, compared with firms with low focus diversity, even when controlling for all the other variables in Model 3 1.

Free-standing NBFs are expected to exhibit a higher and a longer use of external alliances than all NBFs by the third hypothesis. It is expected that for free-standing NBFs (e.g. excluding all subsidiaries or joint ventures NBFs) the event history analysis of the odds ratios for forming at least one external alliance every year will be higher than for all NBFs, and will last longer.

Tables 5 and 6 and Figure 2 show the same analyses as in Tables 3 and 4 and Figure 1, but on a sample limited to free-standing NBFs only (n = 433). By comparing the results to Table 3 and to Figure 1, the difference between patterns of forming alliances of free-standing NBFs and all NBFs is demonstrated. The general expectation expressed in H3 is that free-standing NBFs will show more dependency on external alliances than will all NBFs. The lack of "parenting" sponsorship and financial support increases the dependency on external organizational entities. Therefore, the free-standing NBFs are expected to enter more external exchanges than the general NBFs population, and peak at a higher age before declining.

The results in Table 5 (based on the comparison of the nested models in Table 6) support the above hypothesis. By comparing the best fitted models for both samples we see indeed that the odds of entering external exchanges for free-standing NBFs are consistently higher. They are higher both for the statistically significant ages (2-8 for all NBFs, and 2-9 for the free-standing NBFs) as well as for the older age groups. Alternatively, the same concept can be observed through the opposite direction -- free-standing "dead" firms had a higher negative (and significant) odds of entering an external exchange (-.59* for free-standing NBFs, -.37 for all NBFs).

Both directions, as demonstrated by the results, support the hypothesis. Free-standing

NBFs form more external alliances at any age, and are at higher risk of death when they decline to form alliances. As to the impact of the industry cohort, the odds of forming external alliances are significant for the years 83-90 for both models, but the years 88-89 have the highest odds. Public free- standing NBFs have higher odds of forming external alliances than the general population of NBFs.

Firm focus range has again a significant and stronger effect compared to all NBFs. Free-standing NBFs with medium and high focus diversity have greater odds of entering external exchanges than do all NBFs (.73** compared to .65 ** for medium focuses, and .75** compared to .60** for high focus diversity). This finding can be interpreted so that in order to maintain a larger focus diversity, free standing NBFs depend more on external resources than do all NBFs.

Insert Table 5, Table 6 and Figure 2 about here

CONCLUSIONS

This paper aims to integrate institutional economic theory (Williamson, 1975, 1981) with the network theory (Johanson and Mattsson, 1987) based on the resource dependency perspective (Pfeffer and Salancik, 1978), all within the boundaries of the population ecology paradigm. The integration represents a configuration approach (Meyer, Tsui and Hinings, 1993) which calls for a holistic synthesis of organizational observations rather than reductionist contingent arguments, focusing on changes in the networking patterns of NBFs within their life cycle. The intention to provide a holistic view of organizations, coupled with ability to control for cross sectional differentiation and industry cohort impact, lead to the choice of the organizational life cycle as the unit of analysis rather than the single transaction level.

Inter organizational transactions constitute choices and constraints embedded in the life cycle and growth curve of newly founded organizations (Aldrich and Auster, 1986; Romanelli, 1989; Singh, Tucker and House, 1986; and Stinchcomb, 1965). At the same time, firm's boundaries specification are determined by the markets/hierarchies altering choices (Williamson 1975, 1981). The biotechnology industry introduces an environment where: competition is high, product development are very costly but have yelled a potential for high return, and intellectual capital is the major vehicle moving the industry forward (Kenney, 1986; OTA, 1984, 1993). It has been argued that such hypercompetitive environment, newly founded organizations (NBFs) will aim to specify and protect their boundaries by acting contingently on needs. The leading assumption is that firm age is a factor that can facilitate in explaining these alternating choices. Specifically, as organizations grow, they depend predominantly on external resources, thus increasing the tendency to form market alliances. This tendency increases up to the turning point where internal strength allows for reduction in the odds of alliances formation. The external dependency was expected to be higher and longer for free-standing firms. The event history analyses showed that these two process do exist. A general overview of the results introduces a process of convergence into firm boundaries (e.g. hierarchies) as age progresses. NBFs tend to define their boundaries by making efforts to limit their exposure to external dependencies as allowed by the constraints posed by their struggle for external resources.

Exogenous variables, specified by population ecology models, but not in the study model, could attribute to both organizational death and lack of alliances. These would include firm level and population level competition and density (Carroll and Hannan, 1989a), legitimacy level of the firm, or of the niche product area of the firm (Carroll and Hannan, 1989b), structural inertia (Hannan and Freeman, 1977), and niche width (Freeman and Hannan, 1983). However, since the focus of the study was on internal processes of organizational populations, rather than on Organizational death, the findings highlight new interesting directions. The notion of the "liability of newness" (Freeman et al. 1983; Stinchcomb, 1965; Singh et al, 1986) provided the grounds for assuming increasing need for alliance formation at early age, while the "liability of adolescence" (Bruderl and Schussler, 1990) adds to the expectation that alliances will decrease at the adolescence stage. Although the data does not inquire death propensity as the dependent variable, the patterns of alliance formation over the life cycle of the organization, coupled with the fact that relatively few NBFs have died within the period studied (69 out of 554), provides support for both arguments. Growing firms such as NBFs suffer from several liabilities over their life cycle that are associated with market transactions. At early stage, lack of market alliances is associated with organizational failure (Shan, 1990; Kougut, Shan and Walker, 1992). At adolescence stage, the liability becomes associated with the risks generated by the dependency over market alliances.

Although the model seems to call for a contingency approach to network patterns, it is developed on a much broader holistic observation of organizational and environmental features, as proposed by Meyer et al. (1993). In addition to the life cycle findings, the analysis shows that, even when controlling for firm age, larger firms have stronger odds for forming alliances. This finding, in conjuncture with the finding that higher focus diversity is associated with higher dependency on alliances, provide support to the network dependency theory (Johanson and Mattsson, 1987). In addition, the fact that therapeutic and diagnostic companies have higher odds for forming market alliances, reflect again the fact that since product development in these areas is very costly, the dependency on external alliances is higher.

In all models, the year 1988 seems to have generated the highest odd for formation of alliances. Several reasons may account for this finding: 1. the monotonic increase in the number of NBFs established since 1976 is changing direction at 1988, probably suggesting a saturation of venture capital resources, and thus, a higher dependency on market resources. 2. It could also indicate that the legitimacy of the new form has risen to the highest level which encourages many inter organizational alliances. 3. In October, 1987 the Dow Jones Industrial Average plunged to a lowest record, and initial public offering in biotechnology-based companies virtually ceased for two years (OTA, 1991, p. 4). In addition to the previous point, this led to a very dry period in the financial market, that directed NBFs to search for other avenues for financial support - market alliances.

The study calls for new avenues for additional research. To begin with, a complimentary study on organizations operating within a less competitive environment will add the needed perspective to this study. Measures providing information on the level of competitiveness of the environment of each organization will add value and robustness to the arguments. A differential analysis of various levels of competitiveness within similar environments can provide a crucial test to the hypotheses proposed here. This measure can be useful, however, if companies were to specialize in one niche only. However, for generalist companies (as some of the older NBFs tend to become), such a measure will become too vague. Another direction refers to the life cycle effects at later stages. The findings of the analysis suggest a tendency toward a second waive of increasing externa1 alliances (yet not significant mainly due to the small number of older NBFs). Future research will be able to illustrate whether this is a clear pattern, and if it is, which organizational and/or environmental variables contribute to it.

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FOOTNOTES

1.This technology is used for cutting and pasting DNA and reproducing the newly created DNA in bacteria.

2.Patents are one of the most important assets of a biotechnology start-up, and a failure to procure patent protection can effect the company's ability to secure the financing needed to develop processes and products. However, achieving patent protection is problematic from the standpoint of the inventor for the following reasons: It creates a delay in getting the patent can slow down the efforts for commercialization (the average approval time for biotechnology patents is about 37 months), in addition, fifing for protection in foreign countries, patent filing costs are high, the third problem relates to the fact that in the U.S. pending patent applications are secret. This can lead to cases where new patent files are rejected due to earlier "hidden" inventions (OTA, 1991, pp. 210-212).

3.The COMPANY file contains information on 1075 firms involved in the biotechnology industry. The variables included in this data base were: name, company's main address, year of founding, personnel, total revenues, R&D budget, financing status (i.e. private, public, joint venture, subsidiary), U.S and foreign investors, technologies used by the company, type of company (i.e. biotech, chemical, agricultural, pharmaceutical, etc.), biotech focus, and information regarding the products. The firm level information is given for the year 1990. The ACTION tile contains 4561 entries representing two levels of information: 1. internal actions to the firm, and 2. actions of exchanges with other organizational entities. The internal actions include information such as stock offering, employment announcements, changes in facilities, product and patent announcements, and scientific breakthroughs. The external actions' categories include acquisitions, equity, joint ventures, marketing licensing and research contracts. The ACTION data base includes additional information on the two companies involved in the action (name, type and country), as well as information on the date of agreement, the biotech area of R&D, the technology and the product associated with the action. The two files were merged so that for all firms in the COMPANY file that were involved in any action, the ACTION entry was attached to the firm's background information. This procedure excluded all actions for which none of the two firms listed in the exchange were listed in the COMPANY file (1541 actions excluded). The total number of actions listed in the merged file is 3028 (out of which 902 are internal and 2139 were external, the two numbers exceeds the 3028 since a few actions contained information on both internal and external actions). In the following step, the NBFS file was generated. This file is based on all actions in which at least one of the exchange partner was an NBF. The operational definition for NBFs were firms "born" after 1975, and are defined as a biotechnology company by the "firm type" variable. This file contains only NBFs, including these that have ceased to exist ("dead"), and isolates (e.g. these not involved in any external action). Since the file aims to provide the data for testing firm level questions, some additional modification was made. Actions for which the two organizational entities involved were NBFs, were entered twice (once for each

NBF). The file contains exchange information for 554 NBFs, out of which only 217 were involved in at least one internal or external action, and 2043 actions.

4. Since the action data set contains information only for the years 1981-1990, these were the only years for which the industry life cycle could be controlled for.

5. Seven different biotechnologies exist in the data, however only six possible combinations were allowed for. The technologies are: cell culture, fermentation, hybridoma, liposomes, protein engineering, rDNA and tissue culture.

6. Examples for such foci are: animal agriculture, plant agriculture, cell culture, human diagnostics, food production, aqua culture, fungi, drug delivery systems etc.

7. Obviously, a more suitable analysis would compare the models for free-standing and non-free-standing. However, the small size of the second group did not allow to competed these comparative models, and therefore the comparison is to the total NBFs population.

Table 1: DUMMY VARIABLES INCLUDED IN THE EVENT HISTORY ANALYSIS

Variable	Content	Mean	S.D.
Dependent:			
ALLEXTR	All external actions	.96	.19
Independent:			
AGE0	Firm's first year-referent category	.12	.32
AGE1	Firm's second year	.13	-33
AGE2	Firm's third year	.13	.33
AGE3	Firm's fourth year	.12	.33
AGE4	Firm's fifth year	.11	.31
AGE5	Firm's sixth year	.lO	.29
AGE6	Firm's seventh year	.08	.28
AGE7	Firm's eighth year	.07	.25
AGE8	Firm's ninth year	.05	.22
AGE9	Firm's tenth year	.04	.20
AGE10	Firm's eleventh year	.02	.15
AGE11	Firm's twelfth year	.Ol	.12
AGE12	Firm's thirteenth year	.Ol	.lO
AGE13	Firm's fourteenth year	.005	.07
AGE14	Firm's fifteenth year	.OOl	.04
DEAD	Firm that ceased to exist	.ll	.32
SIZE	Firm with more than 50 employees	.31	.46
YEAR81	Industry in 1981-referent category	.04	.02
YEAR82	Industry in 1982	.05	.22
YEAR83	Industry in 1983	.07	.25
YESR84	Industry in 1984	.08	.28
YESR85	Industry in 1985	.lO	.29
YESR86	Industry in 1986	.ll	.31
YESR87	Industry in 1987	.13	.33
YEAR88	Industry in 1988	.14	.34
YEAR89	Industry in 1989	.14	.35
YEAR90	Industry in 1990	.14	.35
MEDNUMT	Firm with med. tech. diversity	.18	.39
HIGHNUMT	Firm with high tech. diversity	.39	.49
OWNPUBLI	Public firm	-22	.41
AGRIFOC	Major foc. in agri. biotech	.ll	.31
DIAGFOC	Major foc. in diag. biotech	.20	.40
THERFOC	Major foc. in therap. biotech	.20	.39
MNUMFOC	Firm has med. diversity of foci	.31	.46
HNUMFOC	Firm has high diversity of foci	.21	.41

TABLE 2: GENERAL INTERNAL ACTIONS, AND SCIENTIFIC GROWTH OF NBFS BY FIRM AGE

AGE	# OF NBFS	INTERNAL ACTIONS	AVERAGE
A. General Internal Growth			
0	184	8	0.04
1	197	17	0.09
2	198	26	0.13
3	192	23	0.12
4	175	56	0.32
5	155	50	0.32
6	143	62	0.43
7	118	93	0.79
8	93	76	0.82
9	78	70	0.90
10	33	33	1 .00
11	20	18	0.90
12	15	21	1.40
13	7	8	1.43
14	4	6	1.50
B. Scientific Internal Growth			
0	184	2	0.01
1	197	12	0.06
2	198	24	0.12
3	192	18	0.09
4	175	42	0.24
5	155	42	0.27
6	143	43.	0.30
7	118	72	0.61
8	93	56	0.60
9	78	52	0.67
10	33	26	0.79
11	20	14	0.70
12	15	14	0.93
13	7	5	0.71
14	4	6	1.50

TABLE 3: EVENT HISTORY MODELS FOR THE ODDS OF ENTERING AN EXTERNAL ACTION BY NBF AGE

Covariates	Model 1	Model 4	Model 14	**Model 23**	**Model 31**
I. Time-Varying Age (versus age 0)					
Age0	—	—	—	—	—
Age1	**0.46**	**0.47**	**0.47**	0.34	0.33
Age2	0.99**	**1.02****	**1.04****	0.76**	0.75**
Age3	1.08**	**1.10****	**1.12****	0.77**	0.75**
Age4	**1.32****	**1.34****	**1.39****	0.98**	0.94**
Age5	**1.43****	**1.44****	**1.50****	0.96**	0.92**
Age6	**1.48****	**1.46****	**1.52****	0.91**	0.87**
Age7	**1.63****	**1.57****	**1.63****	0.87**	0.83**
Age8	**1.70****	**1.61****	**1.68****	0.84**	0.80**
Age9	**1.45****	**1.31****	**1.37****	0.64*	0.59
Age10	1.44**	1.39**	1.48**	0.64	0.59
Age1 1	1.11**	1.06**	1.17*	0.25	0.26
Age12	1.11**	1.09*	1.20*	0.29	0.32
Age13	1.49**	1.34*	1.53*	0.64	0.69
Age14	1.96*'	1.57	1.56	0.85	0.97
Dead	-0.87**	-0.73**	-0.65**	-0.58*	-0.37
Size	1.57**	1.35**	1.36**	1.59**	1.58**
II. Industry Cohort Effect (versus 1981)					
Year82	--			0.31	0.31
Year83				0.86*	0.88*
Year84		--		1.13**	1.15**
Year85				0.92*	0.95*
Yera86				1.33**	1.37**
Year87				1.53**	1.59**
Year88				2.19**	2.26**
Year89				2.07**	2.14**
Year90	--			1.54**	1.60**
III. The Number of Technologies Used by the NBF (versus low)					
Highnllrn					
Mednum					
IV. The Financial Status of the NBF (versus private)					
Public		1.49**	1.30**	1.52"'	1.45**
V. The focus of the NBF (versus other)					
Agrifoc			0.32*	0.28	0.43**
Diagfoc			0.72**	0.74**	0.77**
Therafoc			0.96**	0.91**	0.97**
VI. The number of foci of the NBF (versus low)					
Medfoc					0.65**
Highfoc					0.60**
V. intercept	-3.53**	-3.93**	-4.34**	-5.55**	-5.96**

TABLE 4: COMPARISON OF MODELS BASED ON LIKELIHOOD RATIO TESTS

	L2	d f	significance
External Actions			
Model 1: 1	535.47	16	
Model 2: 1,2	602.55	25	
Model 3: 1.3	556.45	18	
Model 4: I,4	784.98	17	
Model 5: 1,5	682.86	19	
Mode16: 1,6	590.58	18	
Model 7: 1,2,3	620.55	27	
Model 8: 1,2,4	896.67	26	
Model 9: 1,2,5	747.25	28	
Model 10: 1,2,6	661.73	27	
Model 11: 1,3,4	800.46	19	
Model 12: 1,3,5	694.94	21	
Model 13: 1,3,6	601.51	20	
Model 14: 1,4,5	856.56	20	
Model 15: 1,4,6	814.28	19	
Model 16: 1,5,6	745.09	21	
Model 17: 1,2,3,4	908.87	28	
Model 18: 1,2,3,5	756.71	30	
Model 19: 1,2,3,6	670.60	29	
Model 20: 1,3,4,5	867.57	22	
Model 21: 1,3,4,6	824.19	21	
Model 22: 1,4,5,6	891.94	22	
Model 23: 1,2,4,5	962.75	29	
Model 24: 1,2,4,6	931.42	28	
Model 25: 1,3,5,6	749.67	23	
Model 26: 1,2,5,6	813.28	30	
Model 27: 1,2,3,4,5	970.39	31	
Model 28: 1,2,3,4,6	938.53	30	
Model 29: 1,3,4,5,6	897.70	24	
Model 30: 1,2,3,5,6	816.22	32	
Model31:12456	1002.30	31	
Model 32: 1,2,3,4,5,6	1005.60	33	
Comparison of the models			
Model 4 vs. Model 1	249.51	1	.ooo
Model 14 vs. Model 4	71.50	3	.ooo
Model 23 vs. Model 14	106.19	9	.ooo
Model 3 1 vs. Model 23	39.55	2	.000
Model 32 vs. Model 3 1	3.3	2	>.05

Note: models numbering key (1) firm age and survival status, (2) industry life cycle, (3) firm's technological diversification, (4) financial status, (5) major biotechnology focus (6) focus diversification. Each Model represents the sets of variables entered.

TABLE 5: EVENT HISTORY MODELS FOR THE ODDS FOR ENTERING AN EXTERNAL ACTION BY NBF AGE

Covariates	Model 1	Model 4	Model 14	Model 22	Model 31
I. Time-Varying Age (versus age 0)					
AGe0	—		—	—	—
Age1	0.44	0.43	0.43	0.43	0.33
Age2	1.18**	1.21**	1.22**	1.23**	0.89**
Age3	1.20**	1.24**	1.25**	1.26**	0.82**
Age4	1.67**	1.71**	1.75**	1.76**	1.28**
Age5	1.70**	1.72**	1.77**	1.78**	1.13**
Age6	1.56**	1.54**	1.58**	1.58**	0.83**
Age7	1.93**	1.86**	1.93**	1.93**	1.01**
Age8	1.87**	1.79**	1.86**	1.85**	0.86**
Age9	1.76**	1.64**	1.71**	1.70**	0.83*
Age10	1.67**	1.64**	1.71**	1.73**	0.70
Age1 1	1.35**	1.35**	1.43**	1.50**	0.41
Age12	1.30**	1.40**	1.52**	1.57**	0.49
Age13	1.54*	1.47*	1.58*	1.67*	0.52
Age14	2.01**	1.88*	1.86*	2.05*	1.20
Dead	-1.04**	-0.93**	-0.86**	-0.65*	-0.59*
Size	1.82**	1.65**	1.31*	1.26**	1.50**
II. Industry Cohort Effect (versus 198 1)					
Year82					0.19
Year83					1.04*
Year84					1.22**
Year85					0.92*
Yera86					1.58**
Year87		—			1.83**
Year88					2.38**
Year89					2.30**
Year90	—				1.76**
III. The Number of Technologies Used by the NBF (versus low)					
Highnurn					
Mednum					
IV. The Financial Status of the NBF (versus private)					
Public		1.65**	1.47**	1.41**	1.66**
V. The focus of the NBF (versus other)					
Agrifoc		-_	0.22	0.38*	0.36
Diagfoc			0.61**	0.66**	0.70**
Therafoc			0.84**	0.93**	0.85**
VI. The number of foci of the NBF (versus low)					
Medfoc				0.67**	0.73**
Highfoc				0.63**	0.75**
V. intercept	-3.77**	-4.30**	-4.63**	-5.06**	-6.42**

TABLE 6: MODEL COMPARISONS FOR EXTERNAL ACTIONS - FREE STANDING NBFS ONLY	L	df.	significance
Model 1: 1	521.04	16	
Mode12: 1,2	573.53	25	
Model 3: 1,3	533.60	18	
Model 4: 1,4	737.24	17	
Model 5: 1,5	619.11	19	
Model 6: 1,6	559.87	18	
Model 7: 1,2,3	584.49	27	
Model 8: 1,2,4	824.65	26	
Model 9: 1,2,5	666.27	28	
Model 10: 1,2,6	616.92	27	
Model 11: 1,3,4	749.31	19	
Model 12: 1,3,5	624.04	21	
Model 13: 1,3,6	564.06	20	
Model 14: 1,4,5	775.97	20	
Model 15: 1,4,6	762.36	19	
Model 16: 1,5,6	667.32	21	
Model 17: 1,2,3,4	834.99	28	
Model 18: 1,2,3,5	670.33	30	
Model 19: 1,2,3,6	619.77	29	
Model 20: 1,3,4,5	784.03	22	
Model 21: 1,3,4,6	768.47	21	
Model 22: 1,4,5,6	806.41	22	
Model 23: 1,2,4,5	858.44	29	
Model 24: 1,2,4,6	856.87	28	
Model 25: 1,3,5,6	667.85	23	
Model 26: 1,2,5,6	718.94	30	
Model 27: 1,2,3,4,5	856.0 1	31	
Model 28: 1,2,3,4,6	860.75	30	
Model 29: 1,3,4,5,6	809.52	24	
Model 30: 1,2,3,5,6	719.05	32	
Model31: 1,2,4,5,6	895.45	31	
Mode132: 1,2,3,4,5,6	896.92	33	
Comparison of the models			
Model 4 vs. Model 1	216.20	1	.00
Model 14 vs. Model 4	38.73	3	.00
Model 22 vs. Model 14	30.44	2	.oo
Model 31 vs. Model 23	89.04	9	.oo
Model 32 vs. Model 31	1.47	2	> .05

Note: models numbering key (1) firm age and survival status, (2) industry life cycle, (3) firm's technological diversification, (4) financial status, (5) major biotechnology focus (6) focus diversification. Each Model represents the sets of variables entered.

Figure 1: Event History Models of the Odds Ratio for Forming External Action by NBF Age

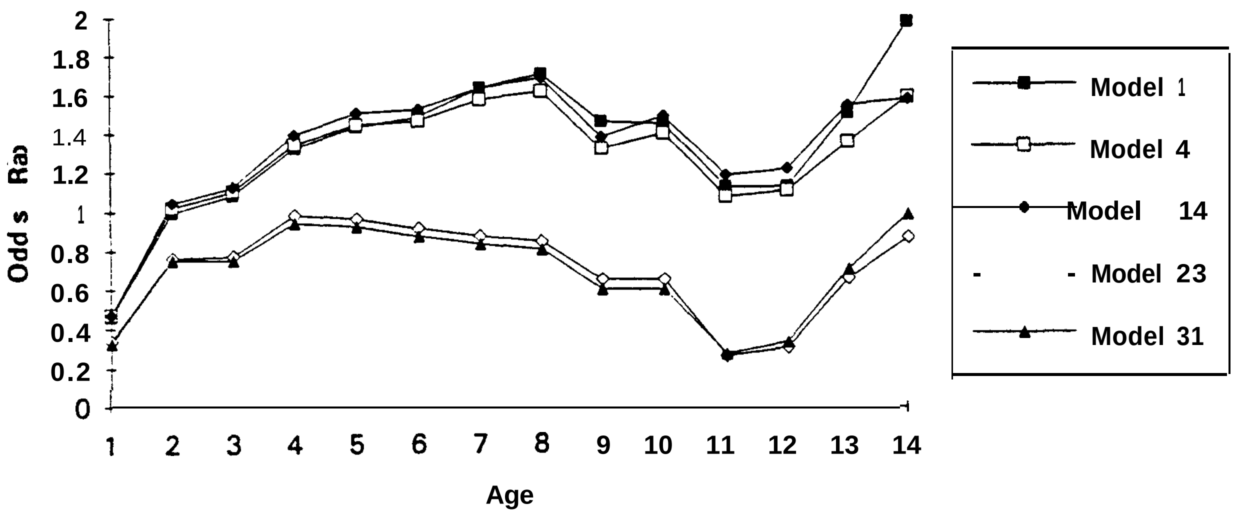

Figure 2: Event History Models of the Odds Ratio for Forming External Action by NBF age (Only Free Standing NBF's)