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Abstract

Standards and compatibility issues play a significant role in the software industry. Often, there are no uniform industry wide standards in a *standards immature* market. To overcome the lack of standards, firms in this market aim to establish alliances. In this work, we adopt a new research framework called network theory drawn from sociology research to represent the complexity of this market. This improves upon traditional microeconomic perspectives by addressing indirect relationships and their causal effects. We also introduce a concept called socio technical capital as substitute measure for a firm's clout or position among other firms. Using this approach we are able relate alliance formation by business application software firms and compatibility issues. The results of an ongoing study are presented to substantiate this approach.

Keywords: Standards, network analysis, ERP, alliances

1. Introduction

Standards and their adoption by various producers determine not only how compatible products and components are with each other, but also influence many other aspects, including consumer choices. When a uniform standard (for a certain product/component) is adopted throughout an industry, consumers benefit by potentially having a wide variety of manufacturers to choose from. For example, the adoption of VHS format by all VCR manufacturers gives consumers a greater variety of VCRs (Grindley, 1995). Standards potentially assume a still greater significance in the software industry, in view of a greater number of components that perform a multitude of tasks and the need for these products to seamlessly function with each other. Hence, software firms face an increasing need to adopt/adapt standards so as to ensure smooth inter-operability of various components.

Typically microeconomic models have attempted to explain the standards adoption behavior of firms. These models have primarily focused on only dyadic relationships. Concepts such as network externalities have been used to explain potential benefits that firms may derive by joining a network. We argue that relationships between firms in the software industry (hence the adoption of standards) are far more complex than a simple dyad. This complexity is only amplified in markets that have not adopted uniform industry wide standards. Therefore, the questions that we shall address henceforth are: what limitations do existing economic models face in this context? What framework or methodology is appropriate to address the limitation of economic models? How can one understand firm behavior using the proposed framework?

In Section 2., we classify the software industry along the dimension of the degree of maturity of standards. We are particularly interested in the behavior of firms in a standards "immature" market. The application software industry is portrayed as an example of such a standards "immature" industry and firm behavior in this marketplace is analyzed. The discussion in Section 3 on the complexity in this market helps to identify the limitations of microeconomic models in addressing firm behavior during standards adoption. The unique characteristics of modules that comprise the business application software environment are further discussed. In section 4.0, we propose a new approach drawn from the field of social networks to represent inter-firm relationships in this industry. A new construct called "socio-technical capital" represents the relative influence of a firm in the alliance network. We then study this measure in comparison to a firm's performance metrics. Based on the results we argue that firms strike alliances to improve their socio-technical capital and therefore their performance.

2. Maturity of standards in the software industry

Standards are simply a set of rules or protocols that act as guidelines. At a higher level of abstraction standards is infrastructure, i.e., they "inscribe" behavior in complex and non-transparent ways (Hanseth and Monteiro, 1997; Monteiro, 2000). Standards could involve rules at various levels, e.g., syntactic, semantic, business protocols, communication protocols, etc. In effect, a combination of these rules, determine how two components interact to effectively support a task (Altman, et al., July 1999). One can often observe that in some industry structures, these rules are well established. We classify such a market as *standards mature*, e.g., the dominant standards created or proposed by Microsoft in desktops operating systems (OS). Depending on the process through which they are established, standards can be termed either *de facto* or *de jure* (David, 1987; David and Greenstein, 1990).

We define a *standards immature* industry as one where there is a lack of uniform set of standards. This could be attributed to i. the lack of a dominant leader or a regulatory body or ii. in some cases the dynamic or evolving nature of the industry (Metcalfe and Miles, 1994). Note that while there may be *de facto* or *de jure* standards that might have emerged for specific parts of these components, an overall standard for all multi-component interactions may not be present (Altman, et al., July 1999). In the application software industry, efficient functioning of application software components require standards to be established, both at the technology and business protocol levels. While standard setting is more difficult at the business protocol level (e.g., common process flows, nomenclature, etc.), even at the technical protocol level (e.g., database schema, operating system), uniformity of standards across components is often found lacking. Even though some low-level standards (e.g., RPC, DCOM, CORBA, etc.) adoption can be observed in this industry, they do not necessarily translate to higher-level functional integration (Altman, et al., July 1999). All through this article we will refer to this overall integration standards as compatibility.

In a standards immature industry, some firms may continue to adopt their own proprietary standards, while most others, including new entrants, are likely to partner with certain firms and adopt their standard. This adoption process appears to be complex in standards immature markets. While economic models may be able to predict aggregate equilibrium outcome, we believe that it is important to observe how the process actually unfolds. Economic models are found lacking in this sense (Hanseth, 1996). A new framework is necessary in order to capture cumulative effects of firm relationships.

We present a stylized view of the application software industry as being representative of the complexities mentioned above.

3. ERP – An example of a *standards immature* industry

The Enterprise Resource Planning (ERP) software industry can be broadly categorized into those firms that supply certain core components as well as additional ones and those that specialize in certain functional areas. The anatomy of an enterprise system (Davenport, 1998) consists of components serving distinct functionalities, such as, sales and delivery, reporting, financial, manufacturing, service, inventory and supply and human resource management areas. Further there are significant value-adding, and by no means trivial components that are often integrated with the core ones. Any single vendor may offer most of them (e.g., SAP, BAAN, etc.) or only a selected few functional areas (e.g., i2's Supply Chain Management (SCM) system, Siebel's Customer Relationship Management (CRM) software, etc.). In fact integration costs incurred during ERP implementations account for about 20-35% of the overall implementation costs[1]. As a result we can find numerous third-party consultants (integrators) and converter/adapter software in the ERP market.

The ERP industry has emerged in response to the business community's need to integrate its multiple workflows. The history of the ERP industry dates back to the days of Material Resource Planning (MRP) software, i.e., manufacturing oriented approach was initially adopted. However, with new heterogeneous requirements, the vendors often tightly integrated the newer components to work best with their existing setup. As there were no de facto business model templates, or standardized process architectures, these components simply took their own course of evolution. Today there are numerous ERP vendors and many more complementary software providers who did not necessarily adopt a uniform set of specifications for interfacing business and technical protocols. Since consumer firms had to anyway invest in consultants for their business protocol integration, technical integration was not seen as a separate issue but rather simply was absorbed into the overall implementation costs.

4. Economic models of standards and compatibility

The issue of compatibility ala standards has been discussed widely in economics literature (Economides, 1989; Farrell and Saloner, 1985; Farrell and Saloner, 1992; Katz and Shapiro, 1985; Matutes and Regibeau, 1988). The effects of compatibility on equilibrium market structures and social/private incentives for firms, to make their products compatible with other products, have been modeled in the context of established compatibility standards in technology industries (Farrell and Saloner, 1985; Katz and Shapiro, 1985). Their findings suggest that in the presence of positive network externalities, firms have an incentive to achieve complete compatibility, i.e., to adhere to a uniform standard. While these models had assumed the existence of standards in an industry, subsequent economic models (Economides, 1989; Farrell and Saloner, 1992; Matutes and Regibeau, 1988), have addressed the same issues in the absence of standards, as well. Some of these models have further analyzed the tradeoff between a firm's incentives to

[1]Components in the ERP World, K. Pond, R. Altman, GartnerGroup Intraweb, Research Note Technology, 04 May 1999

enable compatibility with rival products and the disincentives to create such a standard (Economides, 1989; Farrell and Saloner, 1985; Matutes and Regibeau, 1988). Some of this work (Economides, 1989; Matutes and Regibeau, 1988) has also explored the heterogeneity of products and their effect on incentives to achieve compatibility. Further, these have also addressed markets where there is an absence of any positive network externality. However Economides (Economides, 1989) (p. 1180) also points out that "analysis of compatibility under asymmetric strategy and technological conditions is still undeveloped" and further he opines that his results are not necessarily applicable when "one firm has a technological advantage in the production of one of the components or a strategic advantage in the game". In such a case, this work observes that although full compatibility between *components* of rival *systems* is the eventual outcome, firms may not have the incentive to decompose their products into a system of components.

In all the above models, compatibility has been characterized as being either fully compatible or totally incompatible. While this may be applicable in fully standardized industries (where a component is either integrable or not), a majority of software applications, in particular business software such as Enterprise Resource Planning (ERP) software environments, one can observe varying degrees of compatibility. As discussed in section 2., in this article we have characterized these industries as *standards immature*. Further, in the above models, firms have been characterized as being purely competitive and even though the firms may produce more than one component, these components are considered complementary to each other. In addition, it is also assumed that two components identical in functionality produced by two different firms are substitutable only functionally and not necessarily equally integrable with components by other firms.

4.1 Limited applicability of economic models for a *standards immature* industry

Most of the economic models discussed above use profitability as the primary criterion by which firms decide on compatibility issues. However, other researchers (Hagedoorn and Duysters, August 1999) have also pointed out that this decision may not solely rest with short-term profitability, but there may other factors in dynamic and immature industries. In such industries a firm maybe more interested in capturing a larger user base to generate a positive network externality for its current and any future products. Most of these models predict that firms would make their products compatible with everybody (Economides, 1989; Matutes and Regibeau, 1988). Even assuming that there are no disincentives (in terms of strategic alignments), the cost of achieving this compatibility in the absence of standards would be extremely high. Therefore, the prediction of a firm establishing compatibility with all other firms may not apply to this industry. In fact the business application software industry does not exhibit many of the characteristics assumed in the microeconomics models.

The complexity of this industry is not only due to great component varieties but also because of the large number of firms involved in their production. While most of these firms do not produce the entire systems (i.e., all components), many of them do not even produce competing components. In other words it is possible to find niche firms who may not have full substitutes in the market. Furthermore presence of partial substitutes may also introduce certain asymmetries that may affect the even the niche player's compatibility with everyone in the industry. This is in spite of the fact that the niche player by itself does not offer any substantial value to a consumer, in the absence of certain basic components.

Another dimension of alliance formation is the social dimension and the extended relationships that the firms have to maintain. As Metcalfe (1994) points out earlier, certain learning mechanisms and social relationships are constantly created to harness innovations. This dimension is not addressed by any of the above economic models and even some empirical work on firm alliance behavior (Axelrod, et al., 1995; Hagedoorn and Duysters, August 1999) does not refer to this dimension. In summation, relationships in this industry are significantly affected by the dynamism.

5. Social network approach

In order to truly represent this standards immature market we adopt an approach derived from the sociology literature called social network analysis. A social network may be simply represented as a set of agents and links between them. Sociology research has commonly utilized such representation to study sets of individuals with links between them representing specific social ties such as interaction ties, friendship ties, marital ties etc. Using network analysis it has been possible to examine the effect of not only, the direct relationships of an individual with other individuals but also the effect of their indirect relationships with individuals throughout the social network. For example, this theory has been used to explain the formation of the Renaissance state in Florence in relationship to the rise of certain network of family clans (Padgett and Ansell, 1993).

Research in organizational behavior has also adapted this approach to study individual networks within organizations. For example network theory has been used to show that a central contact (regular employee) in a hierarchy gets the same information available to a manager and therefore cannot be avoided in a manager's negotiation with other contacts (Burt, 1992). A similar approach can also be observed in current literature to study industry/market level behavior where the network represents organizations and relationships between them. Networks have been shown to act as a resource for the organizations (Uzzi, 1996; Uzzi, 1997; Walker, et al., 1997). While each organization strives to maintain a viable network of relationships (Kogut, 1991), these networks can also capture complexity such as addition of new entrants reshaping of existing relationships, etc. (Galaskiewicz and Wasserman, 1981; Kogut, 1991; Marsden, 1983). Market level networks can be viewed using different dimensions of linkages, e.g. patent-citation networks in semi-conductor industry (Podolny, et al., 1996).

Researchers have used network analysis to represent competitive positions of firms. It has been demonstrated that the structural position of an organization within a relevant network of relationships can be significantly correlated to its economic performance (Podolny, et al., 1996). In this network, the structural position of an organization can be described by a measure called social capital. Social capital refers to an aggregate set of resources possessed by actors in a network by virtue of their relationships with other actors. It is a valuable resource for conduct of social affairs, providing their members with "the collectively-owned capital…" (Nahapiet and Ghoshal, 1998).

5.1 Socio-technical capital

While the issue of standards and technology has partially been taken into account in some of the early microeconomic models, there is a social dimension that influences an organization's product compatibilities and hence standards adoption (Actor-network theory (Monteiro, 1998; Monteiro, 2000). To capture explicit and implicit dimensions of this compatibility, we introduce a concept called *socio-technical capital*. Standards literature on technology has exhaustively discussed the effect of creating fully compatible components. In this section, we will attempt to illustrate some of the embedded social linkages that constrain economic choices of firms. These embedded linkages represent commitment to resources (human and otherwise), presence of converters/adapters, evolution of the industry itself, etc.

When a vendor makes it products compatible, it also commits to certain resources to also maintain future compatibility. These resources maybe result in investment in training personnel, sharing knowledge, marketing tie-ups etc. Networks are also very dynamic and certain decisions may be effected by knowledge of potential future entrants into the market. Further, compatibility may also occur as a result of third party firms (such as consultants) who provide adapters and converters that could effectively bridge any gap. In this market, these converters, known as middleware, may become such an acceptable component that effectively the two components it bridges may be considered compatible. Thus, players other than the two firms involved have committed some intangible resources. As Podolny (1996) states, "receiving deference eases the problem of mobilizing resources to build, to sustain and to expand organizations."

Thus, by representing a network of these business application software providers through their alliance formation linkages, it is possible to capture all the above embedded social and obvious technical compatibility decisions. The measure *socio-technical capital* can therefore be used represent those organizations that enjoy a significant clout or position in the market, i.e., a measure of its structural position. Researchers (Hagedoorn and Duysters, August 1999; Podolny, et al., 1996), to compute the structural position of actors in a network have used a measure known as the (Bonacich, 1972). This can be used to capture the degree to which a firm has alliances with other powerful firms in terms of their network position. Bonacich Power identifies the centrality of each firm as a function of the centrality of the firms to which it is connected. A high score for a firm is an indicator that the firm is associated with a large number of powerful players in terms of their centrality in the network. We have used this measure to represent *socio technical capital* resulting from alliance linkages.

6. Results and Conclusions of a Stage I Study

In order to understand the relationship between "socio-technical capital", a firm's profitability, the nature of alliance formation, etc. we devised a two-stage study. The first stage was to identify the formal alliances that each ERP and specialist firms entered into with each other. It is interesting to note that many large vendors often charged a certain fee for a partner to enter into an official and formal alliance. A formal alliance indicates many levels of relationships. First, it allows a firm to advertise its status as a partner; second, this allows transfer of technology (prior disclosure of APIs, protocols, etc.). Third, it also allows firms to get access to consultants, integrators, trade fairs, etc. which allows for the firm to establish indirect social relationships with other players in this marketplace. In other words, a formal alliance suggests compatibility resulting from a higher intensity of knowledge sharing.

For this first stage, we collected this alliance information from a sample of 42 business application software firms. At the outset we identified the 10 most popular ERP vendors from a third party, non-profit information source. This also ensured that these were the most dominant players in the ERP industry and therefore can expect them to occupy a central position in the network we would be constructing. Then we picked a random sample of 32 firms from a list of vendors obtained from each of the above ERP firm's list of alliance partners.

It was now feasible to construct a social network of actors (the firms) where the linkages represented the alliances between them. Figure 1 represents this network. As expected the five dominant ERP vendors (in terms of revenue and product reach) had the highest socio-technical capital (Table I). In other words, the market operates more like a natural oligopoly (Katz and Shapiro, 1985) where certain vendors influence compatibility decisions (standards) as though the smaller ones did not participate in the market. This simply implies that these firms with the higher socio technical capital predominantly control market compatibility issues. Furthermore, from our network we were also able to observe that all firms did not have an alliance with all the ERP vendors (the natural oligopolists) or all the other specialized firms. Thus, this gives a clear indication that in this standards immature market where the cost of adopting multiple standards are quite high, a firm does not approach the market with increasing its profitability through the generation of a higher positive externality effect.

The preliminary analysis serves to demonstrate the validity of the network approach to represent standards immature industry. However, the alliance information obtained from the firms is an imperfect (binary) proxy for the degree of compatibility. In the next stage of this study, we will use some direct measure of the degree of compatibility through various levels of technological integrability. The data collection for this study is currently in progress in form of interviews and questionnaires addressed to actual implementers or integrators. These consultant opinions can be taken to serve as true indicators of compatibility.

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Figure 1

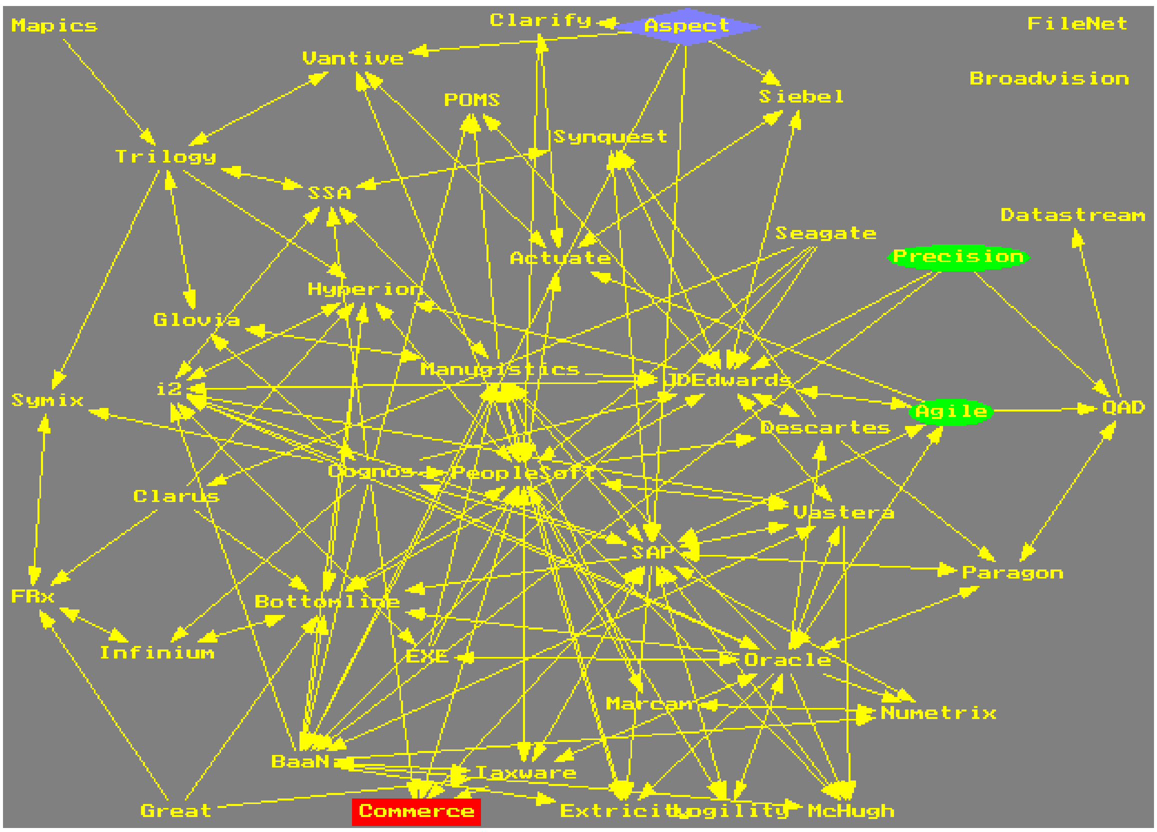

Table I

Rank	Vendor	Socio-technical capital	Rank	Vendor	Socio-technical capital	Rank	Vendor	Socio-technical capital
1	PeopleSoft	78.54	15	EXE	31.20	29	Trilogy	18.17
2	SAP	74.59	16	Descartes	31.01	30	Vantive	18.12
3	Oracle	72.06	17	Commerce	29.89	31	Glovia	17.69
4	BaaN	68.16	18	Agile	29.13	32	Clarus	17.29
5	Cognos	66.12	19	SSA	27.94	33	Precision	17.23
6	JDEdwards	63.00	20	Numetrix	27.47	34	Infinium	15.96
7	Manugistics	62.58	21	Seagate	26.70	35	Clarify	15.30
8	i2	58.83	22	Logility	25.52	36	Siebel	13.75
9	Bottomline	53.57	23	Aspect	23.99	37	Great	13.31
10	Vastera	52.48	24	Synquest	23.65	38	Symix	12.42
11	Hyperion	42.76	25	Paragon	22.88	39	QAD	11.14
12	Extricity	40.59	26	POMS	22.17	40	FRx	9.90
13	Taxware	39.66	27	Actuate	20.48	41	Mapics	2.82
14	McHugh	39.58	28	Marcam	19.86	42	Datastream	2.11