

# Standards Setting Consortia: A Transaction Cost Perspective

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## Abstract

*Consortiums are highly successful organizational systems for IT standard setting. However, it is not clear what advantages consortiums offer over the traditional approaches to standard-setting. We apply transaction cost economics to examine how and why consortiums are successful for standard-setting. We show that when standards are viewed as bundles of complementary patents, consortiums economize on transaction costs relative to the market. Further consortiums also economize on transaction costs relative to hierarchies, provided coordination costs are relatively lower than other types of transaction costs.*

## 1. Introduction

Standardization is one of the driving forces in information technology (IT), today. Individuals, firms, and governments demonstrate a preference for standardized IT [1-3]. Standardization allows designers to rapidly and reliably build technology at a lower cost and with greater appeal [4]. Because of standardization, millions of people can communicate with millions of other people in separate countries, on separate networks, through the use of mobile phones and the internet.

Because of the importance of standards in IT, standard-setting has received a great deal of attention [3]. The choice of a standard is as much, or more, an organizational issue as it is a technical issue. Incompatibility exists, not because of lack of technical expertise, but because of the self-seeking nature of businesses [5]. There is often an implacable standards' war before a dominant standard emerges [6]. Like many information system (IS) problems, solving the problem requires an understanding of the organizational system.

One organizational system that has been very successful in IT standard setting is the consortium. A consortium is a form of co-operation between a group of firms that may otherwise be competitors, to jointly set and administer IT standards [7]. For example, the DVD forum consists of more than 100 firms, including Sony, Toshiba, Phillips, IBM, and many others, which govern the standards' use to produce digital video disks. This consortium has been highly successful, allowing DVD to become the largest selling form of video media in just little over 4 years [8]. Other successful consortia include

RosettaNet for e-business standards, the Object Management Group for standardized object software, and Video Electronics Standards Association (VESA) for computing interface standards.

In this work, we apply transaction cost economics (TCE) [9-11] to examine when and why consortiums will be successful for standard setting. What we find is that when standards are viewed as bundles of complementary patents, the unique character of intellectual property gives rise to the unique form of organization - the consortium.

## 2. Theory and Model Development

To develop the theory, we first underline our conceptualization of a standard, define some terms and concepts and lay down our assumptions. Then we discuss TCE, and extensions to it that allow for consortia. Finally, we contrast standard setting in the traditional TCE forms of organization - markets and hierarchies - with standard setting in a consortium.

### 2.1. Conceptualization of a standard

We conceptualize an IT standard as a bundle of complementary patents.

In most research, a standard is viewed as a single item that is an input into a technology product [6, 12-14]. However, the truth is that most standards are made up of many unique patents. For example, there are over 500 essential patents owned by 9 different entities in 28 different countries that comprise the DVD standard ([www.dvd6cla.com](http://www.dvd6cla.com)).

Characterizing an IT standard as a single entity results in two difficulties. First, it ignores the fact that different pieces of the standard can be owned by different entities. This leads most research to inappropriately consider only binary ownership of a standard (i.e. either company X owns the standard or it does not). The other difficulty is that the standard is almost always the unit of analysis. Though the standard, as a whole, is important, so too are the components of the standard. At the operational level, organizations are worried about procuring the patents, rather than the standard.

By conceptualizing a standard to be a bundle of more elementary objects, this research allows for more complex ownership of standards. Moreover, it allows for the patent to be the unit of analysis. In this work, to develop

or adopt a standard then means developing or transacting for the patents.

The second piece of our definition of a standard recognizes that the component parts are complementary. This means that the patents need to be used together in order to gain value from this. This introduces specificity, in that the patents are specific to each other. This also introduces externalities, so that one firm's use of a patent impacts other firms. This means that it is inappropriate to analyze the patents individually, because the value of one patent depends on access to the other patents.

Patents are the final ingredient in the definition. We use the term patent very loosely to refer to protectable intellectual property, rather than to refer to a piece of paper on file with a government agency. Thus, we acknowledge that not all paper patents may be enforceable (e.g. Amazon's one-click shopping). At the same time, not all intellectual property is protected by patents. Some are protected as a trade secret (e.g. the formula for Coke) or by non-compete clauses (e.g. Walmart's inventory systems). However, the word patent is widely understood in the way that we intend it to be, most of the ideas we concern ourselves with in IT standards are patented, and patent rolls off of the tongue much more easily than protectable intellectual property.

This definition of a patent conveys two things. First, the property is protectable, which introduces all manner of distortions into an analysis of ownership. Second, because it is intellectual property, rather than physical property, a whole range of other distortions, not usually considered in economic analysis, become important. We will discuss these in more detail in the analysis section.

To conclude, we conceptualize a standard as being composed of many smaller units of complementary protectable intellectual property. This is in contrast to the traditional analysis of a standard as a single entity.

## 2.2. Conceptualization of Patenting Process in Standard-Setting

de Vries (1999) gives a detailed explanation of the standard-setting process (de Vries 1999 pp 34-38).

Standards inherently are complex creations. To create a standard, the knowledge and needs of multiple entities have to be pooled together. It is often not possible for a single entity to develop and promote a complete standard. To deal with the complexity, standards are developed in modules. Each module is a responsibility of a different team. For example, more than seven teams worked on different aspects, like delta-filtering, deflate compression, and 24-bit support, of the PNG web graphics compression standard [15]. The modules so created are intellectual property of the creator and potentially protectable as independent patents. Thus, patents are a byproduct of a larger intellectual effort.

Sometimes firms also develop and patent technologies not targeted towards specific goals. The development can be a part of the proactive research project undertaken by a firm to keep ahead of competitors or efforts of some tech-savvy individuals. The technologies so developed can be patented as a part of the company policy and may find use elsewhere. The firm holding the patent can license it to other firms for inclusion in their standards. For example LZW technology for lossless data compression was originally published as a research paper by two Israeli researchers, Jacob Ziv and Abraham Lempel in 1977. The algorithm was modified and patented by Terry Welch of Sperry Corporation which later became Unisys Corporation. The LZW algorithm found widespread application in variety of web based standards like Acrobat Reader and GIF images [15].

To summarize, patents can be intentionally acquired with an aim to license it in the future or they can be the byproduct of a larger technological goal. Nevertheless, patents are reusable technologies and can find applicability in myriad of situations. These patents have widespread implications for standard-setting process if due diligence is not followed from the start.

## 2.3. Standard-Setting Modes

There are various organizational systems for IT standard-setting. A firm in need of IT standards can follow a hierarchical system and develop proprietary standards, get together and form a consortium to jointly develop standards, use services offered by a standard-developing organization [7] or follow a market system by individually transacting with the patent owners

**2.3.1. Hierarchy.** In a hierarchical system, all resources needed to create and implement a standard are produced in-house. By resources we mean codes, procedures and policies. The resources so developed become the intellectual property of the firm and can be protected by way of patents.

In a hierarchy, the developing firm bears all the cost of research and standards development. Since internal organizational communication is centralized the decision making, and information dissemination, is fast and inexpensive. The standards so developed are customized and match closely to the organizational needs [7].

**2.3.2. Markets.** For IT standardization, a market form of organization occurs, when a firm procures the necessary intellectual property externally. This requires that the firm individually contracts with every other relevant patent holder. To illustrate we consider a hypothetical example. If DVD forum had not explicitly agreed upon the DVD standards, then any firm wanting to manufacture optical discs would first come up with workable

technology and then individually transact with 9 different entities in 28 different countries to acquire 500 patent licenses. The process would be repeated for each manufacturer wanting to manufacture optical discs. A more daunting task would be to search for these 500 patents that a firm might infringe upon while implementing a technology standard.

**2.3.3. Standard-Development Organization and Consortium.** Even though both standard-development organizations and consortiums play conceptually similar roles in the society i.e. developing and promoting standards for a technology, they differ based on their access [7], objectives and operations [16]. The terms are often used interchangeably. The standard-development organizations are broader in their objectives and provide services to wider disciplines in the society [16]. They are more concerned with standards of national and international interests and encourage participation of all interested groups e.g. ANSI [16].

Consortium, on the other hand, is formed by way of cooperation amongst some competitors to jointly address a standardization issue [7]. Membership in a consortium is usually restricted and commercial in nature. A consortium's scope of operation is limited to providing industry specific standards and is targeted towards a specific need.

Several reasons have been cited for the popularity of consortiums. Prominent amongst them is the notion that SDOs are slow to respond in the fast changing high technology environment [16]. This is plausible given the fact that the operations of an SDO are influenced by a diversified group of members as compared to a consortium, where the decision making is restricted to a focused group.

## 2.4. Assumptions

Though there are functional and definitional differences between an SDO and a consortium, the differences are mainly related to the technical approach to standard-development. Our analysis is focused towards the commercial transaction cost of access to a standard. Thus, we assume no differences in the role of a consortium and an SSO. The analysis that we present is as applicable to SDOs as they are to consortia. This is not an implausible assumption given the fact that both SDOs and consortia share a similar goal of achieving standardization by improving communication between members, reducing the scope of opportunism, facilitating search for patents, and cost sharing, thus lowering the transaction cost.

We assume that the standard-setting consortium takes due diligence in identifying the patents before releasing the final details of the standard. If a consortium agrees on

a standard and later realizes that the necessary patents are not available on reasonable and non-discriminatory (RAND) terms, the adoption of the standard will be severely hampered.

There are two modes of acquiring patents once the standard has been announced by a consortium. First, the consortium may specify a standard and leave the acquisition, of patents involved, to the individual adopters. In this case, the adopter will have to individually transact with each patent holder. Alternately, the consortium members can get together and form a patent-pool to facilitate one-stop shopping for adopters. We assume that the standardization efforts of a consortium will eventually result in formation of a patent-pool. This is more general than it sounds because even if a consortium does not form a patent pool, they usually make an arrangement for purchasing of the patents that is fair to members. Moreover, antitrust law and unfair competition law facilitate this equitable treatment of patent licensees. Thus, the consortium effectively establishes a patent pool even if it does not officially establish one.

Finally, we also assume that there is a profit motive for a firm to patent its intellectual property and to participate in the standard-consortia. In case of open source, the contributors to a standard do not profit from the development of the standard but from the application of the standard to a problem. Our analysis concerns with firms that seek to profit from the standardization process.

## 2.5. Transaction Cost Economics

Transaction cost economics (TCE), is a branch of economics that concerns itself with the frictions involved in executing transactions [9-11]. TCE posits that economic agents economize on the sum of production and transaction costs, rather than on production costs alone. This viewpoint recognizes that producing a product is only part of the economic activity of an economic agent. The agent must also procure its inputs and, in turn, sell those inputs to other economic agents.

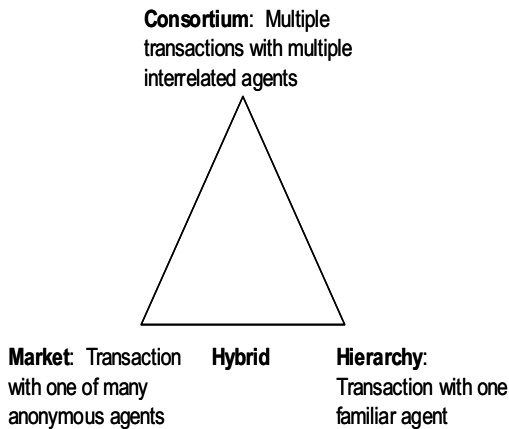
The central question of TCE is economic organization of transactions. Thus, the unit of analysis is a transaction, and the question is how economic agents should organize the transaction in order to economize on production and transaction costs. Traditionally, TCE allows for industries to organize as markets, hierarchies or hybrids [10, 11, 17]. TCE concerns itself with how different forms of governance mitigate transaction costs. The IS literature, on the other hand, has primarily focused on how the introduction of IT moves the organizational structure on market-hierarchy continuum [18-20].

However, there are forms of organization other than markets, hierarchies and combinations of the two [17, 21].

In particular, economic agents may organize in consortia, also known as networks [21] or cooperation [22].

In a market, a transaction is arranged with an anonymous economic agent, usually based on price. The transaction is independent of the parties involved and does not build on other transactions. In a hierarchy, a transaction is arranged with a specific, familiar economic agent. Usually, this is a different division of the same firm. The transaction partner is predetermined and is specific to the parties involved. Hybrid governance falls somewhere between these two extremes. The identity of the parties matter and other transactions between the parties are important, but transactions can be shifted to other agents with ease.

A consortium is distinct from this continuum, as noted in Figure 1. In a consortium, multiple specific firms engage in interrelated transactions with one another [21]. It is the interdependencies among multiple firms that is not captured by the market-hierarchy continuum. A consortium is concerned with the organization of a group of transactions, and it is inappropriate to consider the transactions independently. Nor is it appropriate to consider the relation between two transactors, separate from the myriad relations among all transactors.



**Figure 1:** Differences between markets, hierarchies, and consortiums

To summarize, TCE concerns itself with the governance of transactions. It allows transactions to be governed either through markets, hierarchies, hybrids, or consortiums. Consortia differ from the traditional markets-hierarchies continuum in that they involve multiple interrelated economic agents, make multiple interrelated transactions. This interrelatedness disallows decomposition into one-to-one transactions.

## 2.6. Transaction Cost Analysis of IT Standards

We examine several types of costs and how each of the organizational structures deals with them. The types of

costs are: production costs, opportunism costs, search costs and coordination costs.

**2.6.1. Production costs.** Before considering pure transaction costs, we consider production costs in each of the various organizational forms. TCE posits, and in this context we agree, that production costs will be lower in a market than in a hierarchy, due to economies of scale. If we assume that there are  $n$  patents needed per standard and each costs  $c$ , then a market can provide all of the patents for all users of the standard at a cost of  $nc$ . This is the case because there are no marginal costs associated with duplicating patents [23]. Once the intellectual property is created, it can be transferred virtually costlessly. In fact, patents are publicly available knowledge, so once the right to use it is granted, there need be no transfer.

This is an important distinction of intellectual property that is not the case with tangible property. Usually, producing more of an item requires more cost, as it requires additional consumption of inputs. However, duplicating intellectual property requires no inputs. A cost may certainly be incurred in building the item that the intellectual property describes, or developing more intellectual property to serve as an additional input into the production of items. Nevertheless, it requires nothing to produce one more unit of a patent. Thus, when organizing the transaction for the patent, the marginal cost is zero.

In a hierarchy, the situation is slightly different. If a single firm desires to provide for all  $n$  patents internally, then the cost to that firm is  $nc$ . However, if there are  $m$  firms making this decision, the total production cost for the industry becomes  $mnc$ . On the other hand, if the same  $m$  firms use the market to transact for patents, the total industry cost is  $nc$ . Looking at it in another way, each firm's share of the cost in a market is  $nc/m$ , while, if each firm provides for the patents internally, each firm's cost is  $nc$ . Thus, the cost to a market is less than the cost to a hierarchy.

A consortium, if made up of all firms associated with the patents, can also provide the standard to the industry for a total cost of  $nc$  or  $nc/m$  per firm. If the consortium is made up of less than all the relevant firms, then the price will depend on how the consortium members provide for non-consortium owned patents. We will not consider these hybrid forms, but we believe it is important to note that they can exist.

To summarize, the production cost is highest if each firm organizes as a hierarchy and patent development effort is duplicated fully by each firm in the industry. The full consortium and a pure market minimize the costs of producing the patents by only producing each patent a single time.

**2.6.2. Opportunism costs.** Opportunism costs arise when a party to a transaction charges more than the marginal cost for the item being transacted. This is a slightly incomplete definition vis-à-vis TCE, which technically requires that the additional charges are the result of willful misrepresentation. However, the distinction is not important here. What is important is that the price paid for a patent may be very different than the marginal cost of production of the patent.

TCE suggests that the opportunism cost will be higher in a market than a hierarchy. In a hierarchy, transfer pricing only serves an administrative purpose. The central authority pays the same price regardless of how much the transfer prices are set to. Anything that one division over charges another division still goes to the central authority. Thus, even if the central authority fails to set prices to marginal cost, the net cost to the central authority is the same,  $nc$ , which is marginal cost.

In a market, each economic agent will charge as much as possible. The charges may occur after the parties have entered into a relationship. Thus, if one economic agent commits to buy from the market, each seller sees an opportunity. Specifically, each market transaction can command more than  $c$  per patent.

Assume that the value of the standard to an agent is  $v > nc$ . Thus, the standard is worth more than it costs to make. Further, consider that the agent is committed to a market supply. Given that an agent is committed to transacting in the market, the suppliers will jointly extract  $v$  from the agent. This may be done because each supplier individually asks for  $v/n$ , or it may occur because the last supplier asks for  $v$  minus the total cost already paid. This occurs because the standard is a complementary bundle. Without any one patent, the entire standard is useless. Thus, in any bargaining situation, the economic agent procuring the patents has no credible bargaining situation, other than his threat to exit the market.

In fact, it is possible for suppliers to extract as much as  $vn$  for a set of patents that is only worth  $v$ . Imagine the agent who wants the standard approaches the first patent holder. The patent holder then demands  $v$  for the patent arguing that without the patent, the agent cannot implement the standard. The agent is indifferent between opting out of the market and getting zero or paying  $v$  for a standard that is worth  $v$  and getting zero. Assume the economic agent chooses to purchase the patent. The agent then approaches the second patent holder, who demands  $v$ , again based on the fact that the standard is worthless without the patent. The agent is then faced with the choice of paying  $v$  and having a net gain of  $-v$ , or dropping out of the market and having a net gain of  $-v$ . Again, he is indifferent. This can be repeated with all  $n$  patent holders for a net loss of  $nv$ .

In reality, it is not likely that any agent would be so naive. However, the operative word is so. Agents are

likely to face this problem to some degree and to overpay for the standard because of the complementarities of the patents. If each were independent, then the most a supply could charge would be the value of the single patent. However, with perfectly complementary patents, a supplier can charge the price of the bundle. With less than perfectly complementary patents, a supplier can charge some amount between the value of his own patent and the total value of the bundle. This is still more than the charge for a non-complementary bundle.

A consortium mediates this problem via joint ownership<sup>1</sup>, which is buttressed by anti trust law. Anti trust law is very concerned with cooperation between competitors. If competitors cooperate in a manner that is deemed illegal, then courts award treble damages. That is, the firms must compensate those whom they overcharged, three times the amount of the overcharge. This generates significant incentive for overcharged customers to sue, and significant incentives for the cooperating firms not to engage in illegal trade.

However, the government recognizes that cooperation, particularly in technology standard setting, is beneficial. Thus, technology standard-setting consortiums pre-approve and register with the governmental agencies like the US DOJ by way of Business Review Procedure. This requires that the consortium follow certain guidelines, like making the standard available on a non-discriminatory basis (i.e. charging a fair, usually equal, price to anyone who wants to use the standard). Registering the consortium and making the standard available at a fair price greatly reduces the chance that the court will find the consortium's activities illegal. Thus, plaintiffs can only sue the consortium for damages (rather than treble damages) and plaintiffs are much less likely to win. Therefore, technology consortiums are by and large governed by these legal guidelines.

By design and by law, consortiums are constructed in such a way as to guarantee the members a fair price. Because anti trust requires a fair price, there is incentive not to overcharge. Even if they do overcharge, the members are the owners, so any over charge flows back to them just like it would in a hierarchy. This means that the standard will be supplied at a price close to marginal cost for the standard,  $nc$ . Each patent holder will gain more than marginal cost in order to cover fixed costs, but the net result is a price identical to that charged by a hierarchy, where the marginal cost of the bundle is actually  $nc$ .

To conclude, opportunism costs are highest in the market, and they are higher than normal in TCE because of the complementary nature of the patents.

<sup>1</sup> By ownership we mean effective control, not necessarily legal ownership. This means that a consortium as a whole controls the use and dissemination of the standards, even if individual entities have legal ownership of specific patents.

Opportunistic suppliers can extract, not just more than marginal cost, but more than the value of an individual patent, because the loss of one individual patent reduces the value of the bundle by more than it increases the value of the bundle. Hierarchies and consortiums both mitigate opportunism through joint ownership. A consortium is encouraged, by law, to price the patents in a fair manner.

**2.6.3. Search costs.** Search costs refer to the costs associated with finding potential suppliers [24]. Clearly, this cost is high in a market because an economic agent must search a potentially large market in order to locate all the patents that it needs for the standard. A market has no mechanism for transferring this information. The amount of communication and repetition involved is very high. This view of market search costs is consistent with standard TCE.

However, our view of search costs in a hierarchy is different than TCE's usual treatment. As is the case above, this difference arises because of legal issues concerning intellectual property. TCE usually holds that search costs inside a hierarchy are very small [19, 25, 26]. Obviously, the hierarchy mechanism is set up for the sharing of information across divisions. Hence, the central authority knows what is being produced in the hierarchy.

Firms invest in research and development to find solutions to the problems. To safe guard their interests and possibly generate some returns on their investment, firms patent their ideas and solutions. Often times, these problems are not unique to a firm. It is possible that most of the firms in the industry face the same problem because of their need to communicate with each other or because they serve the same customers and thus they need the same standard.

The difference arises because traditional production is not protected. If one factory produces a widget, it does not necessarily preclude other factories from doing the same. However, patent law is designed to do exactly that - to preclude others from developing the same patents. Thus, when the product is intellectual property, a hierarchy must still search other potential suppliers to make sure that the intellectual property they have developed does not infringe upon some other firm's patents.

This may seem trivial at first, but the amounts involved are tremendous. For example, Microsoft was recently ordered to pay Eolas Technologies \$521 million for patent infringement [27]. Similarly, IBM is being sued for more than \$1 billion over the use of patented software in Linux [28]. Given these potential losses, it makes sense for a hierarchy to be very careful in searching the market for patents before incorporating ideas into products.

A consortium partially mitigates this problem. When joining a standard setting consortium, firms must disclose relevant patents. This is not a legal requirement, but a

rule in virtually all standard-setting consortia. Even where it is not a rule, membership in a consortium severely limits a member's ability to recover damages for patent infringement. Legal doctrine holds that property that is not actively protected when the owner is aware of another's use is no longer private. It is difficult for a consortium member to argue that though, they were a member of the consortium, participated in the standard setting process, and were privy to consortium's documents, they were unaware that their intellectual property was being infringed upon by the consortium.

A consortium only partially mitigates this problem because there may be relevant patents held by non-members. For example, British Telecom claims to hold the patent for hyper-linking, even though they are not usually thought of as an internet company. Thus, the consortium will still incur some search costs. However, it is likely that the majority of relevant patent holders will also be those agents who participate in the consortium. Thus, the consortium has to search fewer agents and those agents are less likely to actually hold a patent of interest. The latter is important because damages from patent infringement can be much more than the search costs incurred.

To summarize, both markets and hierarchies incur significant costs of search for potential patent holders. Consortia incur less, though not the minimum search costs, because they do not have to search their own members.

**2.6.4. Coordination costs.** Coordination costs refer to the costs involved in communicating with and gaining agreement from suppliers. These costs are particularly problematic when bargaining for a bundle of goods, where each is owned by a different individual. In a market setting an economic agent has to coordinate with all of the patent holders, maintain a separate account of the usage, and reimburse them separately - a process that adds substantially to the overhead costs of using the patents from the market. Moreover, because the bundle is made up of complementary patents, one patent holder may base its interactions on the actions of some other patent holder, exponentially increasing the cost of coordination. Thus, IT standard setting, by way of markets, incur substantial coordination costs.

In a hierarchy, coordination costs are reduced significantly because a central authority coordinates activity via fiat. The hierarchy has, by its nature, standard operating procedures, communication channels, and meetings, which facilitate the coordination of activities.

A consortium incurs a medium amount of coordination costs. Again, by its nature, particular operating procedures are in place in order to coordinate activity. However, fiat is absent, so more negotiating accompanies consortium decisions than hierarchy decisions. A consortium allows for a single point of contact for any

agent desiring to purchase the entire bundle, thereby eliminating a substantial portion of the coordination costs of markets. However, a consortium also requires an initial investment in coordination that will match that of a market. The difference is that it only has to be paid once, whereas, in a market, these costs have to be paid for each of the  $m$  agents desiring the standard. Thus, consortiums offer lower coordination costs than markets, but greater coordination costs than hierarchies.

Consequently, overall a market results in tremendous coordination costs. A hierarchy results in minor coordination costs. A consortium results in a level of costs between the two.

### 3. Discussion

Our results are summarized in Table 1. The results suggest that consortiums are frequently the most cost effective way of organizing a standard setting body. Hierarchies are cost effective if coordination costs make up the bulk of the costs. Markets are strictly dominated by consortiums.

**Table 1:** Relative costs of different forms of organizing an IT standard setting body

	Market	Hierarchy	Consortium
<b>Production Costs</b>	Low	High	Low
<b>Opportunism Costs</b>	High	Low	Low
<b>Search Costs</b>	High	High	Low
<b>Coordination Costs</b>	High	Low	Medium

These results are predicted on the assumptions that we made. First, a standard is a bundle of complementary patents. Given this assumption, these results seem to be borne out in reality. Most standards that fall into this category are governed as either consortiums or hierarchies. There are other things that are called standards that are arranged as markets, but these are generally simple unique items, rather than bundles. Some examples might include the amount of mass in a kilogram or the size of railroad track. In both of these cases, the standard is a single piece of intellectual property rather than a bundle.

Our analysis holds to the degree that a standard satisfies the definition. As a standard drifts away from this definition, the analysis becomes less robust. For example, this analysis applies less to a standard made up of two patents, than a standard made up of three. Similarly, it applies less to a standard made up of relatively independent patents, than to one made up of highly complementary patents.

However, information technology standards are overwhelmingly complex structures that are not easily described as single units of intellectual property, but rather, are bundles. Further, they are bundles of complementary items. In many cases, they are perfect complements so that the whole is useless without just one of the component parts. Lastly, these multiple components are protectable under intellectual property law, which distorts natural economic forces.

Further, we assumed that the standard-setting consortia exercises due diligence in identifying patents before releasing the standards. If a consortium fails to identify all the patents that the standard may infringe, the viability of the standard becomes questionable. Even though there are obvious benefits of the standardization process in terms of providing unified guidelines to perform a task, the members of a consortium and the potential adopters will shy away from implementing the standard for the fear of patent infringement lawsuits.

We also assumed that the standardization process will eventually lead to the formation of a patent pool (or an operational equivalent). In the absence of such a pool, the results of our analysis become contingent on the coordination cost. Since, the adopters now have to acquire patents individually; the coordination cost for each adopter will increase substantially. If the coordination costs outweigh the cost savings, it will discourage the potential adopter to commit to a standard. Consortium, however, will still maintain rest of the advantages like reduced opportunism, by including only those patents that are available on RAND terms, and reduced search cost, by listing all necessary patents required to implement the standard. Thus, our analysis will hold for situations where the search cost and opportunism form the major portion of the total transaction cost.

Finally, we also assumed that there are profit incentives for patent holder's participation in the standardization process. If there are no profit motives or if firms do not patent their intellectual property; the transaction cost does not come into consideration. Since IPR is a knowledge product, it can be replicated without incurring any cost and at will. Without the fear of patent infringement, there will be no transaction cost involved making the analysis redundant.

### 4. Contribution and directions for future research

This work lays the foundation for applying TCE to the study of IT standards. While standards, in general, are well studied, the unique characteristics of IT standards are less well studied. Yet, the management of standards is increasingly important to IT practitioners and researchers. Thus, it behooves us to understand how the unique

character of IT standards, as a bundle of complementary patents, generates unique consequences to the management of standards.

However, we only lay the foundation. There is a great deal that remains to be studied. We have deliberately ignored the impacts of uncertainty on the governance of IT standards. Undoubtedly, the different forms of governance handle different forms of uncertainty differently.

Likewise, we have ignored the hybrid forms of governance, in favor of the pure forms. One hybrid form of particular interest would be the combination of hierarchy and consortium, where there were multiple consortia competing, or a consortium competing against a single hierarchy. Given the prevalence of consortia formed in response to Microsoft (e.g. The Object Management Group, Symbian, Project Hudson), it seems that this is a likely hybrid to observe in practice.

We also ignore equilibrium analysis. It is easy to conceive of equilibrium where all firms make a sub-optimal decision. All firms could organize as hierarchies when a consortium would be superior, in hopes of winning a standards war and capturing the entire market.

Related to the last two points is what we would term The Microsoft Effect. Imagine a scenario where all firms in an industry were roughly equal and competed instead of cooperating. Then a rich, powerful, aggressive firm from some other industry decided to expand into the competitive industry. The firms that had formerly been competing would have real incentive to stop and form a more economical governance system (i.e. a consortium).

## 5. Conclusion

We have shown how transaction cost economics can be applied in order to understand the rise of a form of governance called a consortium in the IT standard setting arena. We posit that, since IT standards are bundles of complementary patents, rather than single items, therefore they should be governed by groups of complementary economic agents in order to economize on transaction costs. By doing this, we lay the foundation for a new sub-field of IT research aimed at the fundamental task of understanding how to manage IT standards.

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