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Abstract

While referring to a present author's article that compared the J-model vs. A-model as stylized models of Japanese and American firms, O.E.Williamson (1995) suggested the possibility of the third model of organizational architecture referred to T-forms. As examples of the forms, he suggested temporary organizational forms such as joint ventures. In this paper, I formulate the third type of organizational architecture (information capsulated form) which may be naturally derived in contrast to the A-model (hierarchical decomposition) and the J-model (information assimilation form) from an information systemic point of view. Further, I formulate the model of clustering of entrepreneurial firms of Silicon Valley type nesting this third type and analyze its logical structure by which unique values can be created because of its temporariness -- option value and tournament value. Finally, using the game-theoretic framework, I explain reasons why the Silicon Valley model can have institutional coherency and suggest a way to extend the Williamsonian institution-analytic framework.

In commenting on my earlier work (1990) on the comparison of A-form vs. J-form of organization, Williamson (1995) suggested there is "a third form of organization, the *T*-form, where *T* denotes temporary, or transitional." He added, "*T* also denotes timeliness, which plays a huge role in the success or failure of firms that are operating in newly developing markets where technology and rivalry are undergoing rapid change. ……. Also, what may be thought of as disequilibrium forms of organization can be important in real-time responsiveness respects." Leaving aside for a while the question of whether the nature of T-forms may be captured as a disequilibrium phenomena or not, Williamson's call for a further inquiries into these alternative forms of organization has proved to be significant and timely in light of recent developments in industrial organization.

In the article referred to above, Williamson quoted joint ventures and alliances as cases of *T*-forms of organization. He characterized them as follows: "Each party being unable, by itself, to assemble and deploy the requisite resources in a timely way, the requisite resources are instead assembled by pooling. Thus constructed, both successful and unsuccessful joint ventures will commonly be terminated when contracts expire. Successful joint ventures will be terminated because the combined effort has permitted each to remain viable and learn enough and/or buy time to go it alone. Unsuccessful joint ventures will be terminated because the opportunity to participate will have passed them by." In contrast to these forms in which the requisite resources are temporarily pooled, there can be another class of T-forms in which the requisite resources are temporarily deployed by many quasi-independent entrepreneurial firms in the beginning, with the outcomes of their uses to be selectively combined to generate a large innovative product system ex post. The workings of the so-called Silicon Valley clustering may be looked at from this perspective. Mobilizing contractual (game-theoretic) and option-value theories, this essay tries to identify several technological and institutional conditions under which this type of T-form can perform better in terms of generating a large, complex innovation system vis-à-vis the traditional organizational architectures of A-form and J-form. This analysis also pinpoints some aspects of the nature of institutional coherency involved in the Silicon Valley clustering. In wrapping up discussion, the analytical frame and tools used for the analysis is related and compared to the Williamsonian framework for comparative institutional analysis.

Three-way Comparison

Imagine that an innovative technological product system can be generated by a new combination of modular component products (element technologies). For example, a laptop computer as a technological product system consists of component elements as a LC monitor, MPU, image-processing LSI, hard disk drive, OS, application software, audio and communication devices, etc. Suppose that the potential value of the system depends on the quality of design of each module as well as the compatibility and synergy effects among modules. Modules must be designed in such a way that they fit with each other to form a coherent, high-performing, market-competitive, technological system. An improvement in the design of each module, as well as that in the design of systemic characteristics, is costly in terms of effort in information processing and design decision as well as the use of financial resources. How much human and financial costs will be actually spent and how much value will finally be created will depend on organizational architecture for design activities. We will make a three-way comparison between A-form, J-form and T-form of organizational architecture, each simply composed of a system designer and two (classes of) module designers. The system designer S designs systemic characteristics of a potential innovation system (e.g., the division of a system into modules and specification of interface rules between the two), while module designers, M_1 and M_2, are engaged in the design of respective module, m_1 and m_2. There are three classes of environments for design tasks: the systemic environment relevant to the design of systemic characteristics, the engineering environment common to M_1 and M_2 and that idiosyncratic to each of them. There can be three forms of organizational architecture distinguished by the allocation of information processing tasks and associated decision rights among S and M_i's as below.

1. *A-form or functional hierarchies*: In this form, S designs systemic characteristics by processing the systemic environment, within which framework M_1 designs the module m_1 by processing information regarding the engineering environment common to m_1 and m_2, as well as that idiosyncratic to m_1. Then M_2 designs the module m_2, with design specifications made by S and M_1 as given. In other words, M_1 is subordinate to S in terms of information processing and design decision, and M_2 to M_1, in hierarchical order.

2. *J--form or horizontal hierarchies*: In this form, S designs systemic characteristics using information she obtains by herself (as well as a modicum of it fed by M_1 and M_2), regarding the systemic environment. Then she let the design result known to M_1 and M_2. M_1 and M_2 then process and pool information regarding the common engineering environment and utilize the shared knowledge, together with individual information regarding respective idiosyncratic engineering environment, in resolving the respective design problem.

3. *S-mediated T-form or information encapsulation*: Suppose that each module is competitively developed by multiple designers. Let us denote the number of designers of module m_1 as k_1 and that of m_2 as k_2 respectively. S designs systemic characteristics in a manner similar to her counterpart in the J-form. Within this framework of limited information sharing, each module designer individually processes information regarding the engineering environments, both common and idiosyncratic, completely independently of each other. In other words, information processing by individual module designers is hidden from each other except for the sharing of systemic characteristics and we refer to this characteristic as S-mediated *information encapsulation*. Only

after design decision has been made by each module designer, its performance characteristic is known to S and she selects the best combination of module designs that will maximize the value of the system. Albeit oversimplified, we may regard this form as capturing some essential aspects of the relationship between venture capitalists and entrepreneurial firms, as well as that among entrepreneurial firms, in Silicon Valley. According to this interpretation, S is the venture capitalist and module designers are entrepreneurial firms.

In the T-form, the design of each module is competitively performed by multiple agents. The additional cost of this form relative to others is the cost caused by the multiple experiments of designs involving the use of human and financial resources and its unique benefit is the one generated by ex post selection of the best combination from multiple design outcomes when uncertainty involved in system design is very high. Its net benefit depends on various conditions of institutional and market environments of its own. Before discussing those conditions, however, let us assume for moment that $k_1=k_2=1$ and examine basic conditions determining the relative advantages of three forms on equal footing, although this assumption ignores the essential characteristics of "temporariness" and "timeliness" of T-form. Suppose that the information processing capacity of each agent (measured in terms of the ratio of the variance of an observed environmental parameter to that of relevant observation error) is the same across all the agents and across the forms. When the net value of the final system created by one form is expected to be greater than those created by the other forms under this condition, we say the former form is informationally more efficient than the other forms. It is known that:

Proposition 1 (Cremer 190). T-form with $k_1=k_2=1$ is informationally more efficient than A-form and J-form, if and only if the design variables of the modules are not complementary.

The intuition behind the above proposition is as follows. In designing a module each designer needs to coordinate with each other to make their designs mutually compatible and synergetic in attributes, while he or she needs to be concerned with individual optimization on each design once interface rules are set up. Roughly speaking, we say that the design variables are attribute-complementary if the former requirement dominates the latter. In that case, module designs need to be coordinated so that the choice variables have to move in the same direction on the dimension of design attribute. Such a mechanism is internalized in the A-from and J-form since information regarding the common engineering environment used for design decisions is assimilated in those forms of organizational architecture. In contrast, in the S-mediated information encapsulation, the observations of the common engineering environments by module designers are mutually hidden, so that their decision choices are necessarily less correlated. This can reduce the aggregate costs of observation errors.

In order to focus on the role of attribute-complementarities between the design tasks, Proposition 1 was stated for the case where the precision of observation is equal across all forms of organizational architecture. However, even with the same level of information capacity of module designers, the precision of processed information can be inherently different across forms of organizational architecture due to difference in communications modes. Recall that in the J-form, the module designers are collectively engaged in observations and communications of the common engineering environment, while in the S-mediated information encapsulation, they observe it separately and do not communicate with each other. Suppose therefore that the precision of processing information regarding the respective idiosyncratic environment is sacrificed relatively more in the J-form because of the diverted attention to communications, although the precision regarding the common engineering environment may be improved because of the pooling of data in this regard between the module designers. If such difference exists, then in some cases the S-mediated information encapsulation may become informationally more efficient than the J-form even in the presence of a modicum of attribute-complementarities. In order to identify such cases, we say that the engineering environments of module designs are correlated (or independent), when the variance of the common engineering environment is larger (respectively smaller) than those of the idiosyncratic engineering environment. Then we claim:

Proposition 2. If the engineering environments of the module design are correlated, then S-mediated information encapsulation is informationally more efficient *ceteris paribus* than the J-form even in the presence of a modicum of attribute-complementarities.

The above two propositions are genetically relevant for an understanding of the nature of an emergent industrial organization in the information industry. Baldwin and Clark (2000) documented the ways by which the complex IBM System/360 was first designed and noted that the following two important aspects of the process: (1) partitioning of the complex system into relatively independent modules; and (2) reduction in attribute-complementarities among the modules through the centralized specification of interfaces among them. We submit that the above two proposition have bearings on these characteristics.

First, consider the partition of a complex product system into modules. A module is a unit of a system within which elements are strongly interrelated to one another, but across modules they are relatively independent. In order to obtain this property of the system, the way in which partitioning is carried out cannot be arbitrary. Albeit in a different context, Cremer (1980) showed that the optimal way of partitioning an organization is one that minimizes the statistical correlations of technological environments facing subgroups of the units. In the present context, the whole design problem should be divided into two design tasks in such a way that technological correlation between the two is minimized. As Proposition 2 shows, S-mediated information encapsulation is viable and made relatively more efficient in information processing under such systemic design. In this sense, good modularization, namely good architecture of a product system, is complementary to the unique informational arrangement of the S-mediated information encapsulation.

Second, all the modules created through the process of partitioning as mentioned above have to be compatible with another type and work together in a smooth manner. In order to assure such compatibility, the interfaces among modules have to be explicitly determined and fixed. In other words, the interfaces have to be standardized. Under well-defined interfaces, design activities in respective modules can be conducted independently in parallel, while they have to be done sequentially in A-form and jointly in the J-form. Standardization of interfaces means a reduction in attribute-complementarities to be taken into consideration in the design of each module. Thus standardization of interfaces also complements S-mediated information encapsulation as a viable organizational arrangement (Proposition 1).

So far we have assumed that $k_1=k_2=1$ so that we have ignored the essential characteristics of "timeliness" and "temporariness" of the T-form. However, if attribute complementarities and technological correlation between module designs are reduced through standardization of interfaces, the potential value function for the system becomes nearly separable in the values of modules, meaning that the improvement of the whole system can result from that of each modular product, rather than from the coordinated improvements of multiple modular products. This sets technological basis for a product system to be formed evolutionarily by combining new modules in the best manner from many experimental designs. Therefore we now turn to an examination of the T-form with k_1, $k_2 \geq 2$, i.e., the situation where multiple agents experiment and compete in each module design while the standardized interfaces are made publicly open to them. As we will see shortly, this system of "modular cluster"(Baldwin and Clark 1990) may be considered as capturing essential characteristics of the Silicon Valley phenomena in which many entrepreneurial firms experiment and compete with each other in the innovation of element technologies of a larger system under a unique venture-capital governance mechanism.

The Tournament Effect and Option Value in the S-mediated T-form

Let us consider the following game played repeatedly in four dates.

- The 1st date: The system designer S processes information regarding the systemic environment and determines the decomposition of a potential product system into two modules and specify interface rules that each module needs to satisfy. She decides the value of k_1 and k_2, i.e., how many module designers (entrepreneurs) are to be financed for each module design, on the basis of her ex ante knowledge about the stochastic characteristics of the systemic environment and provides a contract with each selected module designer regarding the shares of final value of design outcome at the final date. The amount of initial financing to each module designer is not sufficient for the completion of design of any module, however.
- The 2nd date: Each module designer process the state of the engineering environment, both common and idiosyncratic, independently of each other (information encapsulation) and utilizes the information to make a "temporary" (experimental) design of a module. The effort level of each designer is not observable by S, but the performance characteristics of the design can be transmitted to S.
- The 3rd date: The system designer selects only one temporary design for each module for additional financing needed for the completion of design in order to maximize the expected value of the total

system which she estimates with some imprecision (alternatively the valuation market for the final system is uncertain). Under the condition of absence of attribute complementarities and technological independence, the expected value of a total system can be represented as a linear function of potential values of component modules, each of which is strictly increasing in the level of effort spent for its design. The selected designer completes its own design within the date. At the end of the date all the environmental uncertainties are resolved.

- The 4th date: The system designer sells the total system composed of the selected modules to the market, of which uncertainty is resolved in the beginning of the date. The system designer and selected module designers share the sales value according to the initial contract. Unsuccessful designers receive nothing. The game ends.

In this game, the basic nature of T-forms pointed out by Williamson, i.e., temporariness and timeliness, is captured. The financing of module design is temporary only for one date except for the selected winners. The refinancing is made in the 3rd date in a timely manner only to those who have exhibited the highest potential values for their temporary designs. However, we assume that there are random elements in the selection of winners by S in the 3rd date because of her limited capacity in judging the potential values of each temporary design or the uncertainty of market conditions for the final system. There can be two types of unique values created under this T-form of organizational architecture: option values and externalities generated by a tournament-like competition among module designers (entrepreneurs). Let us examine first each of these separately.

For simplicity's sake, let us imagine for a while that in each module design the level of effort is constant and observable and that the engineering uncertainty can be resolved at the end of the 3rd date so that the best design can be identified then. This is the situation assumed in Baldwin and Clark (2000). Namely they regard the result of modular designs as “real options.” They suggest that the greater the number of parallel experiments (k_1 and k_2), the greater the value of real options, which they call the “value of substitution.” However, there is a cost in each experiment. Assuming constant cost of experiment and equating it with the marginal diminishing value of experiments, the optimal number of experiments can be determined. Applying the option value theory in a straightforward manner, it holds that the greater the uncertainty involved in modular design, the greater the optimal number of experiment (Baldwin and Clark 1990).

In reality, on one hand, the cost of experiment is not constant, as the level of design effort can be controlled by the module designer after the contract. On the other hand, the value of module design will depend on the precision of information processing activity, i.e., effort level of the module designer. However, as the level of design effort cannot be observed by the system designer, the level of effort will be undersupplied in case of $k_1=k_2=1$, because the utility-maximizing module designer will equate the marginal cost of own effort with its marginal value times his expected share in it which is less than one. Will the situation be altered when $k_1, k_2 \geq 2$, i.e., when tournament-like competition is managed by the system designer who evaluates the potential value of each module design with some imprecision? Yes, it will, albeit in a second best manner, because the marginal value of extra effort by the module designer is now composed of the expected marginal value of his effort when he wins the tournament *plus* the expected total value when he wins times the marginal increase in the expected probability of winning the tournament *plus* the marginal expected value associated with the market uncertainty/system designer’s observation error which he cannot control, with all the three values multiplied by his share in the final value (Aoki and Takizawa 2002). In other words, the tournament-like competition managed by the system designer can create kinds of externalities. Under the uncertainty involved in the market of the final system and the system designer’s error in identifying the best module designs, the last two terms (external effects) are strictly decreasing in the variance of system designer's judgment error and/or the market uncertainty, and strictly increasing in the uncertainty involved in module design. The first term is strictly decreasing in the number of module designers (k_1, $k_2 \geq 2$) as it reduces the probability of winning for each module designer. Thus, incentive consideration tends to reduce the desired number of module designers in each module, whereas the option value increases in the number of module designers. On balance, incentive consideration limits the effectiveness of the substitution operator.

Integrating the option value approach (Baldwin and Clark 1990) with the tournament game approach (Aoki 2001), the following holds:

Proposition 3. (Aoki and Takizawa 2002) If the total value of a final system is expected to be very high, and if the system designer's judgment in the selection of tournament winners is believed to be precise by the module designers, then there exists k_1, $k_2 \geq 2$ for which the total value of a final system net of multiple effort and financial costs is expected to be higher than in the case of k_1=k_2=1. Conversely, if module designers' confidence in the system designer's competence is low, the system designer cannot elicit the module designers' efforts that can compensate the costs of multiple financing.

Proposition 4 (Aoki and Takizawa 2002). The optimal number of module designers in the T-form of organizational architecture (k_1, $k_2 \geq 2$) is strictly increasing in the uncertainties involved in module designs and valuation of final product system.

Complementary Institutional Environments of SV-clustering

The T-form in the previous section is formulated at a very abstract level. However, it may be considered that the model captures some essential aspects of the so-called Silicon Valley phenomena at a generic level (e.g., see Aoki (2001), ch.14 for a justification). In this interpretation, the module designers may be identified with entrepreneurs competing in a niche market that may constitute a element technologies of an innovative technological system. The system designer may be considered as the generic venture capitalist that makes initial financing to multiple entrepreneurs and successively makes selections from among them for refinancing (I will present another, more subtle interpretation shortly). The realization of value of a final product by a successful module designer may then be interpreted as the sale of a successful entrepreneurial firm in the IPO market or its acquisition by an established firm. Let us refer to the formulated T-form in these interpretations as the *SV-clustering,* implying a model of the clustering of entrepreneurial firms of Silicon Valley type. Applying a Williamsonian framework (a layer schema in Williamson (2000)) dealing with interactions between the institution of governance and institutional environments to this T-form, we may derive a few interesting points. Later I submit a complementary conceptual and analytical framework for endogenizing some of institutional environments.

First, let us take the proposition that the confidence of competing entrepreneurs in the competence of venture capitalists is complementary to the SV-clustering. It is analogous to the situation that, unless the referee is believed to be fair and able, the players of sports game may not be motivated to play earnestly. However, the availability of such referee cannot be taken for granted. She needs to be well versed in the rules of the game and have been trained in judgmental skills. Also she herself needs to be motivated to be unbiased and neutral. Professional reputation may be one possible source for such motivation in a sports game. One of the major reasons why the clustering of Silicon Valley type has not emerged so easily in Continental Europe and Japan until recently in spite of promotional public policy may be sought in the shortage of supply of credible venture capitalists. In these regions venture capital firms were first set up more often by financial institutions. On one hand, their managers were not necessarily equipped with technological expertise necessary for either drawing future prospects of technological development ("the design of systemic characteristics") or making proper judgment on staged-financing. On the other hand, the evolution of the Silicon Valley clustering was greatly aided by the ample supply of knowledgeable, skillful, and imaginative venture capitalists. A great majority of them were actually those who had quit large established organizations, such as IBM, Bell Lab., Xerox, with the background of management of technological development. In this sense, the modularization in the initial design of IBM/system 360 and the emergence of the Silicon Valley clustering is inter-linked in path-dependent manner. On the other hand, potential venture capital talents are still largely harbored by established firms in Continental Europe and Japan. However, even in these regions there have recently been emerging clear signs of change. This suggests that the clustering of entrepreneurial firms of the Silicon Valley type needs to co-evolve with the "creative decomposition" of old forms of organizational architecture (the A-form and J-form) in the industry fitting T-forms.

A similar argument may be easily seen to follow from the proposition that a reduction in the uncertainty involved in the valuation of a final product system will enhance the viability of the T-form. The well-developed, reliable markets for corporate assets and/or IPO markets have formed institutional environments for providing enormous incentives for entrepreneurs to compete, even in excessive degree in recent past. Conversely, many of recently emerged leading companies in the communications and information industry, as exemplified by Cisco Systems, Microsoft and so on, have attained their dominant positions in respective niche markets largely by the acquisition of carefully selected new technologies developed by small entrepreneurial companies. Thus, the corporate asset markers and new organizational architecture emerging from A&D (acquisition and development), on one hand, and the SV clustering of entrepreneurial start-up firms, on the other, may be considered as institutionally complementary.

Finally, let us reinterpret the role of the system designer in terms of a mechanism rather than a concrete human entity. Above, I suggested a simple interpretation to identify her with the generic venture capitalist. However, in the actual working of the Silicon Valley clustering, the system designer's role, especially that of drawing a possible road map for the future evolution of a new technological system, is dispersedly and informally performed by many actors. They may include not only venture capitalists, but also angels, leading firms in niche markets, standard-setting industrial associations, consulting firms, law firms, university professors, and so on. Further, at the early stage of development of a potential technological system, communications are often informal, because knowledge exchanged is still at a formative stage, often remains tacit and communicable only on the face-to-face basis. Standard-setting is often evolutive. Knowledge exchanged in this situation is therefore not proprietary. Yet there are intensive interactions and communications among those agents and entrepreneurs in Silicon Valley, making clustering one of distinguish features of the region (Saxenian 1994). Indeed, the sharing of generic knowledge relevant to potential directions of total technology on one hand and the encapsulation of processing of potentially proprietary information on the other appear to be inseparable dualistic characteristics of the SV-clustering. However, if the generic knowledge is potentially capable of generating proprietary knowledge, why do the agents no hesitate to exchange it without explicit pecuniary compensation? If they benefit from an access to such knowledge, why do they not try to free ride on the supply of knowledge by others while holding his or her knowledge in secrecy? Further, there may be differentials among agents in their ability to generate and disseminate potentially useful knowledge. Why are able agents willing to part his or her knowledge to others without necessarily being reciprocated in communications as such? Apparently what is operating here is something reminiscent of "social embeddedness" (Granovetter 1985) of communications in the professional community.

Namely they are able to gain higher status and esteem within the community by making best efforts in disseminating their superior knowledge. The opportunity costs of cooperative contributions incurred by them are compensated for by a greater amount of intangible social capital allotment to them such as social esteem, professional reputation (Aoki (2001), chapters 2.2, 8.1). Further, such reputation-building may be eventually useful for gaining venture capital financing and other pecuniary opportunities in the future (Lerner and Tirole 2002).

Some Generic Remarks on Institutional Analysis

What has been discussed in this short essay may be summarized as that the clustering of small entrepreneurial firms as observed in Silicon Valley – the phenomena dubbed here as the SV-clustering -- may be understood as the emergence of a new organizational architecture and an institutional arrangement complementary to it. They are characterized by such factors as: modular industrial architecture of a T-form and its governance by the tournament-like mechanism of venture capital financing; complementary institutions of markets for corporate assets (IPO markets and A&D) and venture capital governance skills which have evolved partially out of traditional market institutions but also as a result of "creative decomposition" of old organizational architecture of A-form; "embeddedness" of competition of innovation within the "community" of professionals and engineers. There can be certainly other characteristics not mentioned above (such as complementary roles of public policy as discussed by Saxenian 1994), but above factors may be suffice for now to understand the SV clustering as a *coherent* institutional arrangement.

In concluding this short essay dedicated to O.E.Williamson who has made substantial contributions to the development of comparative institutional analysis, I would like to make a few generic remarks concerning analytical methodology for understanding the nature of the coherency of institutional arrangement. This understanding may be potentially helpful for that of institutional change (the process of the demise of coherence of one arrangement and the reconstruction of another viable arrangement): a most acute and difficult subject matter which social scientists face today.

A distinctive feature of Williamson's analytical frame is to focus on the transaction as the unit of analysis and examine how different *institutions of governance* (market, hierarchy, hybrid, t-form, and bureaus) can/cannot economize costs of transaction with various attributes. The *institutional environment* (political and legal institutions, laws) is treated as the locus of shift parameters that induces changes in the comparative costs of governance. Further, the institutions of governance and political and legal institutions are embedded in social norms and customs which are more stable and inertial (Williamson 2000). It is in this hierarchical layering of institutional arrangement e that insights of disciplines other than economics are incorporated into the Williamsonian frame, while the comparative analysis of the institutions of governance is conducted basically in the spirit of efficiency criteria of economics. This is certainly a tractable and operational approach, under which many important testable propositions have been generated. .

A complementary approach for integrating trans-disciplinary insights into institutions may be to deal with the logical linkages between social embeddedness, legal and political institutions, and the mechanism of governance; and try to understand the coherency of institutional arrangements across these elements. I proposed one possible such approach elsewhere (Aoki 2001). The essence of this approach is to understand institutions in each domain (social, political and economic exchanges) as an equilibrium of the game being played thereon and then go on to understand their linkages by the use of game theoretic tools such as linked games and strategic complementarity analysis. The parable narrated in this essay is based on such methodology. Let me elaborate on it a little bit more.

Let us take the game as the unit of analysis. The game is defined on a domain composed of the set of strategic players and the composite sets of (technologically and cognitively) feasible action choices as well as the pay-off functions that maps each feasible profile of action choices across the players into a profile of pay-offs for the players. As Field (1981) reminded us some time ago, it is not possible for us to define a completely institution-free, history-independent game. For example, the specification of initial endowments of resources among the players may already implicitly assume the presence of a property rights institution. Other factors can be law that affects the shape of pay-off functions and organizational entities with certain characteristics that constitute the set of players. In the Williamsonian frame, institutional environment is incorporated as the (exogenous) rules of the game, while the mechanisms of institutions are captured as the endogenous outcome of the game. We relate view institutions in general to equilibria of games. Specifically, we identify an institution as a summary representation (sufficient statistics) of Nash equilibrium outcome (strategic profiles) as reflected in *self-sustaining shared beliefs (common expectations) of the players about ways how the game is repeatedly being played* (Aoki (2001) chs. 1 and 7). Institutions are endogenously created but regarded as exogenous constraints by individual players (because it is Nash). These dual characteristics of institutions, a focus of the new institutional sociology (Powell and DiMaggio 1991), can be analytically grasped nicely by identifying them as equilibria of the game.

As suggested, one of the great advantages of the equilibrium approach proposed is, among others, that it provides an analytically tractable and operational conceptualization of the interdependencies of institutions across domains, as well as institutional linkages of different domains, and thus an understanding of the coherency and robustness of over-all institutional arrangement. For this purpose, we try to enlarge the classes of domains to be endogenously considered. Specifically, we may identify five basis types of domains: commons, economic, organizational, social, and political exchanges. Corresponding to each domain, a variety of institutions such as property rights and community norms, contract enforcement mechanisms, organizational conventions and governance, social norms, and states may evolve as equilibria. By the nature of game-theoretic setting, there can be multiple equilibria in each domain, which implies the possibility of a diversity of institutions. But how are institutions are interrelated across domains? Why do a certain combination of institutions evolve and is sustained in one economy vis-a-vis other combinations?

Applying a super-modular analysis developed by Topkis (1978) and Milgrom and Roberts (1990), we can analyze how an equilibrium constellation of strategic choices of players in one domain can become strategically complementary to, or conditional on, the equilibrium choices of other (and/or the same) players in other domain(s). In this way, we may understand the conditional robustness of an overall institutional arrangement (constellation of institutions across domains) of the economy as well as the multiplicity of such arrangements. We have already hinted that there may be such institutional interdependencies between the SV-clustering on one hand and competitive markets for corporate assets and particular governance skills (venture capitalist skills) on the other.

In the approach of D. North (1990) who identifies institutions as rules of the game, organizations are not regarded as institutions because they are players of the game but not rules. However, as the discussion in this essay implies, we may treat conventions of organizational forms as institutions (equilibrium in the organizational exchange domain). If we focus on the nano-structure of transactions with institutional environment of law, customs and the like as given as in the Willimasonian framework, markets and hierarchies can be substitutes, the selection from which may be determined by their relative transaction cost economizing functions. However, if we treat organizational conventions as institutions and various types of market governance mechanism (trust and reputations, merchants' norms, third-party contract enforcement, "digital enforcement" and so on) as institutions arising in the commodity exchange domains, there may be complementary relationships between a certain pair of them.

Another possible type of institutional linkage is that the players may coordinate their own strategies across domains rather than taking an equilibrium profile of choices (an institution) in another domain as given – the situation called the linked games. By being able to do so, players' viable choices may be effectively enriched and the possibility of a new institution that is not feasible without such linkage may emerge. One particular class of this category is the aforementioned "social embeddedness" (Granovetter 1985) in which the social-exchange domain "embeds" another type of domain and enables some strategy profile to be sustained in the latter which would not be otherwise viable. The social exchange domain may be conceptualized as the one in which non-economic goods/bads (social symbols, languages) which would directly affect the pay-offs of recipient players, such as esteem, approval/disapproval, sympathy, accusation, and so on, are unilaterally delivered and/or traded with "unspecified obligations to reciprocate"(Blau, 1964/1988), sometimes accompanied by gift-giving.

Then, even if the cooperative standard of behavior, say in the traditional commons, may not appear self-enforceable in isolation because of the technological difficulty of excluding free-riders (the tragedy of commons), it may become sustainable, if the same players are repeatedly engaged in a social exchange game as well. If such exchange can produce a sufficiently large amount of social/reputation capital for players them, members of the community may be induced to penalize the deviant in the commons game by ostracizing him in the social exchange game even at their own costs. Social/reputation capital refers to the present value sum of future benefits from non-economic goods/bads that individual players expect to derive from cooperative association with the community of the social exchange. Although not explicitly formulated in game form, the "strategic" nature of social embeddedness was already referred to by the originator of the concept, Granovetter, who argued that values and norms may be perceived as exogenously given by individuals but actually they are endogenously shaped by them, "in part for their own strategic reasons" (1985: p.57).

The linkage in the above example was between a commons domain and a social exchange domain. But the same idea can be extended to a linkage between another type of domain, such as economic, organizational, and even political, exchanges, on one hand, and a social exchange domain, on the other. Further there are also other types of linked games useful for understanding various forms of intermediaries, organizational architecture, contracts, and so on (Aoki (2001), chs. 8.2, 10.2). For example, the tournament game played on the S-mediated T-form may be considered as one investor linking multiple games of bilateral transactions ($k_1,k_2 \geq 2$) with one entrepreneur. By such linkage, externalities are created and in spite of duplication of investment costs, it may become profitable for the investor (i.e., venture capitalist) to finance risky development projects that may not be otherwise.

I hope that the simple analysis in this essay suggests the potential of a broader approach to institutional analysis transcending various domains of games in the society traditionally dealt with by different social scientific disciplines. We owe a great deal to Williamson's long-standing intellectual leadership in institutional analysis for having led us to such window of opportunity.

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