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ABSTRACT

Increasingly, firms are leveraging external knowledge sources for key technological components in creating innovations. However, use of external sources raises concerns about appropriability of technology for the firm i.e. is the firm able to get the required technical knowledge from the external sources. To address this concern firms choose appropriate governance mechanism for their technology collaboration with the objective to reduce the transaction cost associated with the technology collaboration. One reason for transaction cost to arise in technology collaborations is related to the nature of the innovation being developed. Using the framework of Thompson's classification of organizational technology, the paper conceptualises the types of innovation as either mediating, long linked or intensive. Based on the typology of innovation, the paper analyses the appropriability issues that would arise when collaboration with external sources are used for creating the innovation and thereby propose what governance mechanism would be appropriate to address the issues of appropriability.

INTRODUCTION

As markets for technology have grown over the years (Arora, Fosfuri and Gamberdella, 2001), the use of external sources of technology in innovation is becoming more prevalent. A study by Linder, Jarvenpaa & Davenport (2003) have found that an average of 45% of innovations came from external sources. The reason for this is that firms may not have the capability associated with the development and production of key technological components (Leiblein & Miller, 2003; Hoetker, 2005). Most managers now accept that "even the most capable R&D organization must leverage external knowledge sources as a core process in innovation". (Chesbrough, 2006:1).

However this new emphasis on using external sources goes against the conventional wisdom of emphasising internal sourcing of core technology due to concerns of horizontal and vertical appropriability (McEvily, Eisenhardt & Prescott, 2004). So how do firms resolve this dilemma of appropriabiltiy while agreeing to join hands with external sources in developing technology? According to transaction cost economics (TCE), technology collaboration transactions differ along three critical dimensions of asset specificity, behavioural uncertainty, and market uncertainty (Robertson & Gatignon, 1998), and these influence the choice of different collaborative arrangements depending on whether the technology development is at the pre-competitive stage or at the competitive stage (Chesnias, 1988). This raises an important issue for firms- to address their concerns of appropriability arising from technology collaboration with external sources; firms need to choose the appropriate governance mechanism.

The question arises whether firms able to choose the appropriate governance mechanism to address their concerns of appropriability while entering into technology collaboration with

external sources. Studies by McKinsey and Coopers & Lybrand suggest seven out of 10 R&D collaborations fail to meet the expectations and had to be dissolved (Achrol, Scheer & Stern, 1989) which points out that potential benefits of technology collaboration have not been received by the firms, and one of the reasons for this has been the issue of appropriability (Levin et al, 1987). Thus, a real and important concern for technology managers is what would be the appropriate governance mechanism to address the concerns of appropriability arising in the technology collaboration with external sources? The extant literature had identified that the knowledge characteristics (degree of social/ technical complexity, resource or context specificity, tacit or codified, etc.) of the new technology underlying an innovation impacts appropriability (Kogut & Zander, 1992; Reed & DeFillipi, 1990). Therefore, a moot question is what would be the appropriate collaboration arrangements for managing relationship with external sources being used for developing innovations. To answer this question, the paper uses the organizational technology framework of Thompson (1967) to conceptualise the nature of innovations being developed through leveraging of external sources and the appropriability issues that arise therein. Based on this conceptualization appropriate governance mechanism to manage the collaboration more effectively are proposed.

CONCEPTUALIZATION OF INNOVATION

James D. Thompson (1967) had developed a view of technology based on task interdependence i.e. the manner in which organizational tasks are related to one another. According to Thompson's classification there are three types of technology – mediating, long linked and intensive.

Mediating Technology

Mediating technology is based on pooled task interdependence. Organizations using mediating technology would have organizational tasks being carried out independently and each task's performance contributing separately to the performance of the whole organization. Thus, here the task interdependence is quite low as performance of a task does not require direct reliance on other tasks.

Lets consider a situation where an innovation being created in similar to the characteristics of mediating technology. This would mean that different technological components, each independently developed, are coordinated together to create the innovation. An example of this type of innovation is the creation of the personal computer. For creating the personal computer different technological components like drive, display, memory, motherboard, etc. are pooled together. Each of these technological components has their separate technological trajectories with little interaction with the development of the other technological components being used. For example, the technological development of display devices from CRT to LCD is independent of the technological development taking place in drives or memory. Thus LCD display based personal computers can exist side by side with CRT display based personal computers with each exhibiting differing levels of performance (in resolution and display) for the user.

What are the implications of creating such innovations when the firm wants to collaborate with external sources for different technical components to be required in the innovation? As the technological development of different components would be independent and not linked to the need of the specific innovation in which the component is to be used, the developer of

the technical component would not have make investments in technology development that are specific to the requirements of the collaboration. Thus in such circumstances, the transactions between the collaborators would be characterised by low "asset specificity" (Williamson, 1991), as investments can be redeployed to alternative uses, and external sources participating in the collaboration are less liable to be held to ransom by the firm creating the innovation. Also, as the nature of interdependence with other technical components involved in the innovation being low, developer of technical components would not have to share core technology information with other collaborators thereby reducing the uncertainty involved with opportunistic behaviour of collaborating partners to appropriate technical knowledge. Overall, the transactions between the firm and the external sources would be characterised by low uncertainty with each knowing what is expected from the other. As the performance of the innovation is dependent on the performance of the component, the relationship with the external source would be driven primarily by technical requirements with relatively less ambiguity.

Proposition1: When innovation, characterised by mediating technology type is sought to be developed through collaboration with external sources, the most effective governance mechanism would be the one that is based on arms-length interaction between the collaborating partners.

Long linked technology

Long–linked technology involves sequential interdependence between tasks whereby the output of the preceding task becomes the input for the succeeding task. Thus the performance of the succeeding task depends on the performance of the preceding task and cannot be

performed before the preceding task is completed. Therefore there is need to manage coordination between the sequential tasks for effective development of the final output in long-linked technology.

Thus when the creation of an innovation is based on the characteristics of long-linked technology, technical knowledge developed in the preceding stage of the innovation would be used for developing technical knowledge in the succeeding stage and the outcome of innovation is dependent on the effectiveness of technology development at each stage. Innovation in pharmaceutical or chemical field could be classified as similar to long-linked technology type. For example, creating a new drug starts by seeking new chemical compounds which have the potential solve health problems. If the discovery phase yields promising compounds, attempt is made to develop a safe and effective product by screening from the promising compounds. Then the screened product is tested on infected laboratory animals. If the product is found to have no harmful effects then it is subjected to clinical trial on humans. If the trials are successful, the drug is then tested on patients before approval is granted. (Pisano, 1994). Thus technology development here involves multiple stages where preceding stage's output becomes the input for the next stage and effectiveness of the final output (drug) is dependent on performance of the various stages.

As long as these stages of the vertical chain are located within the same firm, the issue of coordination does not present a major problem as, according to TCE theory (Williamson, 1985), the uncertainty that encompass the transaction between the stages have been resolved by the choice of the governance mode of vertical integration whereby the decisions regarding the stages are brought with the decision scope of one firm.

However, the question arises how the coordination is achieved when the stages are located within different firms. Under such circumstances the issue of uncertainty in the transaction between the stages cannot be wished away. Lets take the example where the upstream stage (U), being managed by firm A, produces technical knowledge to be used by downstream stage (D), being managed by firm B. For effective development of the final technology, both the stages need to be developed effectively. For this it is essential for stage D to have full information about technology from stage U and thus firm A needs to share adequate technical information with firm B. However, sharing full technical information could be risky for A if B decides to act opportunistically and walk out of the transaction after getting full information. Also as the stages are sequentially interlinked, effective development of stage D might require firm B to develop capability to integrate technical knowledge being produced from stage U. This would require firm B to make investments that could be specific to receive the technical knowledge of stage U. However, this poses risk to firm B as opportunistic behaviour by firm A in not transferring output of stage U would make the redeployment of investments made by firm B difficult, leading to increased "asset specificity" (Williamson, 1991). These uncertainties surrounding the transaction would prevent firms A and B from entering into technical collaboration with each other.

According to TCE, the solution to the above problem lies in adopting governance mechanisms between the firms that is able to address the uncertainty arising from the transaction. As evident from the above discussion, the uncertainty arises from the fact that there is no penalty for opportunistic behaviour by one party against the other which means that risk is being borne by one party while rewards would be shared jointly. This risk return profile makes it less favourable for a firm to enter into collaboration with other for creating innovation similar to long-linked technology type. Thus for the collaboration to be effective it

is essential that the governance mechanism should ensure there is assurance for either party that they would not be adversely affected in case of opportunistic behaviour by the partner. This is possible when participants are made to pre-commit stakes in the transaction that they might loose of opportunistic behaviour. This is akin to bank mortgaging assets against loans to prevent wilful default of loan repayment. This would ensure that participant in the collaboration have greater commitment to the transaction while assuring the other party that chance of opportunistic behaviour is reduced.

Proposition 2: When innovation, characterised by long-linked technology type is sought to be developed through collaboration with external sources, the transaction between the collaborators when governed by reciprocal commitment would lead to increased effectiveness of the collaboration.

Intensive Technology

Intensive technology involves reciprocal interdependence between the various tasks such that performance of one task is dependent on the performance of the other tasks and vice versa. Organizations using intensive technology would need to select, combine and apply tasks based on the feedback received from the output produced (Thompson, 1967: 17). Thus the overall output of intensive technology would depend on the nature of coordination achieved between the tasks.

When the process of creating innovation is based on intensive technology logic, different technical components of the innovation would need to be combined and integrated taking into consideration their reciprocal interaction. Process of creating innovation in the information

technology industry would be similar to intensive technology type. For example the creation of software requires integration of different technological components- operating system, hardware, software language and user needs. Necessity to support certain user needs (like graphics) would require using a particular language (object oriented) that supports the functionality and which in turn might have an impact on requirement of operating system. So using any component independently without integrating the technical knowledge with the other components would not lead to improvement in the final performance of the innovation. Similarly in DRAM manufacturing, component technologies (mask, resist and alignment equipment) need to integrate for new generation commercialization. Evidence from DRAM manufacturing suggests that when the component technologies do not progress uniformly it gives rise to technological bottlenecks (Kapoor & Adner, 2007). Therefore the development of intensive technology would require focus on the coordination between the developments of various technical components involved in the overall technology development.

The coordination between the different technical tasks involved in creating the innovation is easier when the different technical tasks are carried out within the same organization as it is possible to synchronise the development in one component technology with the other. However, the problem of coordination would arise when the different technical tasks of the innovation are to be carried out by different firms say firms A, B and C who have to collaborate. Under such circumstances, it is necessary for firm A to know the nature of technical development of other collaborators (B and C) as it would then determine what efforts firm A it would make to synchronise its technical development with those of firms B and C.. However, the information flow between different technical components is not perfect due to the tasks being performed in different firms. This uncertainty would make firm A not advance its required technical development unless there is commitment from firms B and C

to develop their technical components, as firm A feels that technology development unilaterally would lead to increase in risk of asset specificity. This uncertainty regarding other collaborator's commitment makes a firm to minimise its efforts in technology development. As a consequence of this, other participants would see this act as free riding problem leading to a domino effect whereby every participant would behave likewise. This would lead to each participant in the collaboration (firms A, B and C) not contributing as required for the innovation creation thereby affecting the creation of the innovation. Unless this uncertainty is resolved, participants would be unwilling to participate in the collaboration as they might find their investments sunk. These uncertainties surrounding the transaction would prevent firms from entering into technical collaboration with each other for creating innovation of the intensive technology type.

As evident from the above, the uncertainty in this transaction arises from the fact that the tasks of firm A is going to be affected by the tasks of the firms B and C as their relationship is reciprocal but firm A has no control to influence how firm B or C would act. This prevents adequate commitment of the participant in the collaboration. This uncertainty could be reduced if the collaborator is able to influence the behaviour of other collaborators. This is possible when the participants in the collaboration get into specific terms of understanding with each other so that one can predict beforehand the behaviour of others in the collaboration and thus modify one's act accordingly.

Proposition 3 When innovation, characterised by intensive technology type is sought to be developed through collaboration with external sources, the transaction between the collaborators when governed by specific commitment would lead to increased effectiveness of collaboration.

CONCLUSION

With the expansion of technical knowledge domain it has become necessary for firms to collaborate with external sources to keep themselves abreast at the frontiers of technical development. In that regard, firms would be interested to develop long lasting and fruitful collaborative relationships with external sources. The above discussion provides organizations with possibilities of organizing their collaborative relationships with external sources according to the nature of innovation sought to be developed so that the outcome is more fruitful. The existing literature had looked at the issue of collaboration in technology as options between vertical integration or alliances based on concerns of appropriability. However, in the present context with increasing likelihood of technological obsolescence firms may be dissuaded from vertical integration (Balakrishnan & Wernerfelt, 1986), and thus the issue of technology collaboration becomes a necessity rather than a choice. In such situation the question is which type of alliance would be better to protect appropriability. The discussion in this paper provides the theoretical perspective to address this issue more effectively. The discussion of the paper may also help to explain why there are industry specific practices to protect technological appropriability e.g. use of patents widespread in pharmaceutical industry but not so in other industries, which could be explained by the way innovation is created in different industries. Being a conceptual study, the findings are in the nature of propositions that provide a basis for future researchers to direct further research to test the various hypotheses regarding governance mechanisms and the nature of technology creation process.

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