Management of R&D within a Dynamic Standardization Environment

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Abstract High-technology enterprises (HTEs) need to ensure their R&D capability embraces effective management processes for dealing with the setting, upgrading and displacement of technical standards. This paper proposes a framework for R&D management for HTEs when faced with a dynamic standardization environment, with three core elements being identified as particularly critical: - R&D planning, internal R&D practices, and external co-operative R&D activities. It is further suggested that HTEs emphasize each of these three elements at differing stages of the standardization life cycle. This is an attempt to enlighten HTEs on managing their resources appropriately and adopting proactive steps in any future standardization developments. A brief case study of a Chinese HTE and its R&D capability is provided as an example, before some conclusions are drawn.
Keywords high-technology enterprises, R&D management, standardization, technical standards, China

1 Introduction

1.1 Standardization

With the rapid development of high-tech industries such as mobile communications and media technologies, the technological environment of enterprises has become substantially more complex. The demand for compatibility and inter-operability of various technologies, as required by new technical standards, is challenging various technological capabilities possessed by individual high-technology enterprises (HTEs) [1]. Simultaneously, the recognition that the dominant game rule of standards 'wars'- i.e., 'winner takes all'- and the tendency of closer combination of technical standards and patents, both lead to technical standards becoming a 'commanding height' in high-tech industries. Victories in major standards campaigns can lead to subsequent huge monopolistic profits, strong bargaining powers in international co-operation networks and thus a dominant position in international trade. In addition, the continual succession of new standards (or their complete substitution) demanded by growing markets and technological progress (and not to mention, strong promotion from international standards organizations) have together have driven numerous HTEs to be dedicated to the development and protection of standardized technologies and related core knowledge.

Standards can be formulated at various stages of technological development and therefore can be described as anticipatory, participatory, or responsive [2]. As these labels suggest, anticipatory standards are articulated before the technology has been widely adopted or even before it exists, participatory standards are developed interactively between developers and users, while responsive standards follow the emergence and adoption of a technology. Like other dynamic processes, technical standards may also pass through various phases during their 'life', a phenomenon that has been related to the 'product life cycle' concept, such that anticipatory standards relate to the emergence phase of a new product or technology, participatory standards to the improvement/development phase and the responsive phase to the maturity phase. These links have enabled Soderstrom [3] to develop a more sophisticated, general model of standards life cycle, but for the purposes of this paper, the simplified three-phase model is sufficient.

1.2 Standardization and R&D Capability

Aware of the significance of standardization to HTEs, increasing academic attention has been paid to the relationship between standardization and R&D. But as Allen and Sriram [4] indicate, the relationship between technical standards and R&D has been viewed as something of a double-edged sword. Some commentators claim that standards have promoted R&D [e.g., 5,6,7,8,9] while others claim that standards have hindered the progress of R&D [e.g.,10,11,12,13]. However, in earlier studies, R&D capability is always strongly linked with knowledge and many scholars have stated that the main

function of R&D is searching, acquiring, and drawing on existing knowledge and consequently generating new knowledge, technologies as well as products [e.g., 14,15]. Therefore R&D capability can be comprehended as primarily processing and utilizing knowledge, and has been identified as one of primary competences for distinguishing between successful and unsuccessful HTEs [e.g., 16,17,18]. So it is vital for HTEs to take a role in the formulation of new standards.

Given the critical significance of standards in today's dynamic and complex technological world, successful HTEs need to ensure their R&D capability embraces effective processes for the setting, upgrading and displacement of standards. This paper configures the core elements of R&D capability for dealing with a dynamic standardization environment into three basic categories, linked to different phases in the standardization process, as a simple device to enlighten HTEs on managing their resources appropriately and adopting proactive steps in any future standardization development. The three categories are identified as - R&D planning, internal R&D capability, and external co-operative R&D capability and each will now be outlined in turn.

1.2.1 R&D Planning

Song [19] points out that to optimize corporate investment and related R&D activities, identification of clear goals should be included into effective R&D planning. As to standardization-oriented R&D activities, key R&D planning decisions relate to the choice between compatibility and incompatibility of future technologies and the type of patenting activity.

Compatible or incompatible elements within the existing dominant design depend on HTEs' resources and competences. If enterprises choose to break the technological path of the current dominant standard, one of their key tasks is to reduce the uncertainty and ambiguity of the new technology and its markets, particularly when faced with high switching costs or even possible exit from the market brought about by the failure or displacement of the old standard. This is especially relevant for later entrants or emergent actors, due to their lack of accumulation of know-how and creative knowledge as well as the gradual shortening of high technology cycles and the complexities of a new technology. The decision to develop such complex technologies needs to be based on a thorough analysis of all associated risks by applying planning tools such as R&D portfolio analysis.

On the other hand, if compatibility is preferred, HTEs must choose at the outset which standards they wish to adhere to. Cost balance, historical path dependency, installed base of respective standards, consumer expectation and the established reputation of actors behind each standard, will all affect the HTEs' final determination of choice, but the baseline is to facilitate the diffusion of the enterprises' technology and products in order to realize their full commercial value.

The capability to patent new technologies reflects HTEs' right to obtain legal recognition of their achievements in knowledge creation and technical invention. The capability of rapid patent application revolves around a HTE's motivation and superior position to obtain the first basic patent in a new technical field. Such a capability may well necessitate in-house legal expertise in order to provide rapid intelligence on patent positions (via regular searches, etc) at both national and international levels. This will aid the determination of the strategies adopted for patenting and help define the scope of the patent position. The patenting decision facing HTEs essentially boils down to three choices;-

(i) Develop basic patents to achieve monopoly power over related technology and markets.

(ii) Exploit subservient patents around others' basic patents and challenge their owners by aiming to reach an agreement to mutually license at an appropriate price.

(iii) Exploit subservient patents around one's own basic patents to construct a tight patent net to prevent others from developing related subservient patents.

However, if basic patents are the only R&D goal, enterprises need to be equipped with original creative capability to explore core technology. But subservient patent exploitation is the more likely agenda because basic patents may incur high costs and are imitable targets that are vulnerable to replacement through obsolescence.

For innovative HTEs, patenting, as part of a wider innovation strategy, can be contrasted between offensive and defensive strategies [20]. An offensive strategy refers to HTEs adopting very aggressive tactics over intellectual property rights in order to maintain technological leadership whilst defensive strategy suggests HTEs try to establish solid patent base (with a mix of basic and subservient patents) that enables them to keep up with the technological leaders. For offensive-patenting HTEs, their patenting tactics will be to ensure their basic patents are as watertight as possible to prevent competitors bypassing or leapfrogging their leading position. Subsequently offensive patentees will anticipate their patents being a major source of licensing revenue and as protection of the high pricing level of the new product in order to recoup R&D costs. In contrast, defensive strategy tactics will be aimed at ensuring

that the HTE is not excluded from the technological race with rivals by using its patents pool as a bargaining counter in attempting to weaken any monopoly and retaining as much flexibility as possible (in resources and expertise) in responding to rivals' tactics.

1.2.2 Internal R&D Capability

Despite prevailing tactics of 'out-sourcing', core competence is still actually the most competitive private asset that distinguishes one HTE from another and is embedded in their own R&D capability. The race to be first patentee and the selection and acquisition of knowledge are key elements to this internal R&D capability. Basic patents associated with new standards are the source for potential monopolistic profits. So solving basic technical challenges through R&D and linked patents becomes a competitive race between standards-driven HTEs. Thus R&D races are effective competitions between HTEs to covert their R&D output into the first basic patents. The intensity of these races will be dependent on R&D time-spans and deadlines, the quality and quantity of patents obtained, and the level of internal R&D resources devoted to that endeavor.

Corporate positions in technology 'space' and in inter-organizational networks are intensely influenced by HTEs' internal capabilities, especially for those whose specialized knowledge and know-how are unavoidable cornerstones in the process of defining a new standard. Such HTEs would be certainly welcomed as co-operative partners. Limited resources and incomplete information normally lead an HTE's R&D efforts to select a particular technological orientation. That orientation and the deployment of self-owned knowledge make the internal R&D capability of different enterprises uneven. As a result, the cultivation of internal R&D capability should emphasize the selection process of developing and acquiring knowledge.

1.2.3 External Co-operative R&D Capability

Modern standards usually embrace a group of technologies characterized by high complexity and integration for which co-operative R&D is an effective R&D mode in tackling key problems. Co-operative R&D capability is highly dependent on partner selection, R&D network management and internal/external co-ordination.

The purpose of selecting partners is not to identify those who are most likely to participate in the collaboration, but to find out those who are competent of integrating co-operative R&D projects with their own tasks and objectives and also those who are capable of undertaking relevant R&D and developing standards [18]. The criteria for partner selection thus has two aspects - one relates to the HTE's qualities that chiefly comprise the capability of developing relevant R&D knowledge and associated patents while the other is to do with the building of relationships with partners that involves such attributes as compatibility, complementarity, reliability and adaptability.

There is an increasing tendency for R&D networks to be integrated within co-operative standardization processes. The effectiveness of R&D network management directly intervenes with the success of co-operative standards setting. It can be analyzed in two ways: i) management over the whole network, which emphasizes the control modes and selective mechanisms; ii) management on each stakeholder's participation in networking and attempts to solve inter-firm conflicts.

R&D coordinating ability is here understood to mainly embody both the allocation of funds between internal R&D and co-operative R&D activities and also the distribution of benefits among co-operative R&D members. Firstly，the distribution of R&D fund among the internal R&D and external co-operative R&D activities will govern the target selection of R&D as well as the effort level, and exert far-reaching influence on the technological competitive edge in the future. In a similar vein, profits gained from standards–oriented co-operative R&D activities need to be fairly divided between the co-operators according to agreed proportions.

2 Correlation between Standardization and R&D Capabilities

Having described simple models of standardization lifecycle and R&D capability, it is opportune to suggest that there may be a dynamic correlation between them that may aid HTEs in determining appropriate actions and strategies at various times.

Firstly, the anticipatory phase of standardization is strongly linked to a formative and uncertain period of technological development that would suggest that R&D planning would be the most appropriate core element of a HTEs' R&D capability to be emphasized. Thus initial scoping of basic research, knowledge creation, intelligence gathering and patenting would be prominent activities at this stage.

Secondly, the participatory phase of standardization coincides with increasing development and

adoption of a new technology, so increasing focus on internal R&D investment to accelerate technological developments would seem appropriate at this stage. Production investment would be an essential activity here alongside more focused research and development, while licensing and informal network formation will also be increasingly attractive options.

Thirdly, the responsive phase of standardization relates strongly to the mature stage of technological development when increasing consolidation of embedded practices leads to routinization and eventual obsolescence. Co-operation between developers of standards, users, associated suppliers, and even regulatory bodies, probably within formal inter-organizational networks, will be dominant at this stage, so HTEs' external capabilities need to be well-honed and focused so that revision/upgrading of standards and products can occur through effective network communications.

This proposed correlation between standardization phases and core elements of R&D capability is not intended to be definitive nor exclusive but represents a sort of continuum of possible, appropriate management actions by HTEs as they compete within a dynamic standardization environment. Such actions are not necessarily confined to one particular phase but it is suggested that certain actions are more appropriate than others during a particular phase.

3 Methodology

The basic methodology of the following empirical investigation is case study-based while the source of case material is primarily from secondary documents, such as online reports, official publications, etc. The aim of the case study is to examine if the selected firm engaged in a dynamic standardization environment has adjusted the core elements of its R&D capability to meet the challenge imposed by changing external circumstances. The nest section is only a preliminary outline of the selected firm, though it is anticipated that future primary-sourced material will be added to the case as the research proceeds via interviews with relevant corporate personnel.

4 Case Study: Huawei Technologies Co. Ltd

Huawei Technologies Co. Ltd., founded in 1988, is a leading Chinese HTE, specializing in providing next generation telecommunications networks. Its aggressive strategy in international telecommunications markets has resulted in the acquisition and merger of several international telecommunication device suppliers. Huawei understands the fundamental significance of standards in this industry. According to published information on Huawei's official website [11], until now, it actively has participated in 83 international standardization organizations including ITU, 3GPP, 3GPP2, OMA, ETSI and IETF. Meanwhile, its representatives have been elected to positions in various organizations, including vice chair of ITU-T SG11, chair of 3GPP SA5, vice chair of RAN2/CT3, vice chair of 3GPP2 TSG-C WG2/WG3, and board member of IEEE CaG. In the domain of core networks, business application and wireless access, Huawei has submitted more than 1500 proposals. The underlying backing force for Huawei to tap into the globally dynamic standardization environment is its well-organized R&D capability which can be briefly outlined under the same three categories as described earlier.

4.1 R&D Planning

During the past 18 years, Huawei has persisted in investing a minimum of 10% of its annual sales revenue into R&D and 10% of this investment is applied to fundamental research. 48% of its employees are engaging in research work. In order to maintain a leading role in the standards campaign over 3G systems, Huawei has endeavored to conduct R&D compatible with the three dominant standards, namely WCDMA, CDMA2000 and TD-SCDMA. Until now, it has invested about 5 billion RMB (approx 0.33 billion GBP) into R&D of 3G systems.

Huawei recognizes there is a big technological gap between itself and overseas giants whose technological accumulation has been accumulated over several decades or even more than one hundred years. Therefore, most R&D projects conducted by Huawei ascribe to defensive or secondary R&D [14]. They mainly revolve around improvements in functions, features and integrating capability of western enterprises' advanced technological outcomes, and are primarily targeted to achieve technological progresses in engineering design and engineering realization, etc. Thus, on most occasions, Huawei chooses to purchase or pay royalties to gain rights in order to use core technologies, and based on original inventions, most R&D results of Huawei are applied as subservient patents and utilized as levers in crossing license with the patentees of basic patents.

Huawei's IPR department was founded in 1995, now employs more than 100 staff, and its chief

function is to learn the latest activities of rivals in terms of related technological advancement via patent searches and analysis. It conducts daily retrieval of technological intelligence, always dispatches employees to attend various international and domestic seminars and training and regularly organize intra-organizational learning. Meantime, Huawei has established favourable co-operation with some excellent patent agencies. Its own staff are not responsible for the writing of patent filing, however it assigns this task to patent agencies after communications between management departments and engineers.

Compared to leading global enterprises, Huawei is a small HTE, so it adopts a defensive IPR strategy. As a late entrant in telecommunications equipment market, Huawei's R&D tactics do not concentrate on original invention, but on product improvement and keeping up with rivals, etc., because they enable Huawei to reduce R&D investment, improve accuracy of R&D goals, shorten earning cycles of R&D and hence substantially decrease R&D risks. Huawei's IPR Department continuously invests in patents to stay at the forefront of cutting-edge technology. By the end of 2007, Huawei had filed 26,880 international patent applications (4,256 of which had been formally approved) and hold 7% (152 patents) of the world's UMTS (3GPP) essential patents, ranking it amongst the top five enterprises in the world in that technological arena.

4.2 Internal R&D

Huawei maintains ceaseless focus on research activities in new telecoms technology and associated fields. So far, it has already successfully rolled out products in areas including FMC, IMS, WiMAX and IPTV. Huawei has effectively developed an intra-firm global R&D network that incorporates multiple overseas and domestic R&D branches in Sweden, U.S.A, India and Russia as well as Shenzhen, Shanghai, Beijing, Nanjing, Xi'an, Chengdu and Wuhan in China. Most of its software development research institutes have already passed CMM level-5 certification.

4.3 Co-operative R&D

Huawei has developed many cooperation agreements with overseas enterprises forming a strong global R&D network. Examples include: i) A joint venture was established between Huawei and Siemens in 2004, its main functions being to develop TD-SCDMA directed towards Chinese markets; ii) Joint R&D Centre on UMTS (Universal Mobile Telecommunications System) between Huawei and Motorola was announced in 2006 to bring an enhanced and extensive portfolio of UMTS and HSPA infrastructure equipment to customers worldwide; iii) Several joint laboratories have been established between Huawei and leading global firms such as Texas Instruments, Motorola, IBM, Intel, Agere Systems, Sun Microsystems, Altera, Qualcomm, Infineon and Microsoft.

Huawei strongly opposes blind innovation and self-containing innovation, insisting on combing internal and external co-operative R&D together and investing in R&D projects based on related rules and relative importance. The management of various co-operative R&D is grounded on signed contracts. For instance, in the above-mentioned joint R&D project between Huawei and Motorola, these two enterprises send their own R&D staff to the R&D centre in accordance with an agreed proportion and both two firms will commonly share the IPR of any co-operative R&D results engendered in this R&D centre.

5 Conclusion

In this section the core elements of a proposed framework relating to R&D capability in a dynamic standardization environment are re-iterated, then follows a brief discussion whether the case study verifies the applicability of this framework and the correlation between capabilities and standardization phases, and finally, a few conclusions are drawn.

5.1 Justification of proposed framework

R&D capability refers to enterprises' ability to reframe present technological knowledge and produce new knowledge. Within a dynamic standardization environment, HTEs need to place much emphasis on fostering some R&D specialties aiming at standards setting, though the essential thrust of their R&D activities is still the generation of new information and development/exploitation of existing information. While high profit expectations and dominant market positions may stimulate HTEs to participate in standardization processes, such standards are never permanent and they will be inevitably upgraded or replaced after some interval, so HTEs must maintain their involvement continuously in standardization processes and simultaneously maintain appropriate levels of R&D capability.

This paper has tried to configure the core elements of R&D capability needed for responding to a dynamic standardization environment. Looking overall at the three core elements, R&D planning is a

strategic stage to decide HTEs' own positions and roles in standards setting by determining the direction of R&D efforts, while internal R&D and external co-operative R&D are more specific operational steps to achieve goals established by R&D planning. A HTE's internal R&D capability is not only the principal source of knowledge contained in their basic patents, but also provides the foundation for co-operative R&D. Therefore, though a dynamic technological environment encourages HTEs to rely more extensively on external linkages, it is not recommended that internal R&D be removed from HTEs. Enterprises are found to be more frequently engaged in R&D co-operation, when they spend more on internal R&D [15]. As to external co-operative R&D, critical factors appear to be partners' research qualities, the development of trust-based relationships and the involvement of users as well as managers of R&D networks. R&D coordinating ability is of central importance for HTEs, covering both internal R&D and external co-operative R&D. Last but by no least important is IPR management capability that enables the enterprise to finally realize the economic value of new technological developments of HTEs. Inappropriate IPR management will result in R&D outcomes never being introduced into the standardization process and consequently not being adopted and diffused.

5.2 Applicability of proposed framework and correlation

From the case study, Huawei staff are reported to be very actively involved in standardization activities, and simultaneously have developed an efficient R&D capability in order to forge a solid cornerstone of research for future exploitation. Huawei has become a leading Chinese telecom equipment vendor and an emergent participant in global standards setting during the past decade. Therefore, in the context of pressure from a dynamic standardization environment, a more detailed case study of Huawei - a less sophisticated HTE from a developing country and with less accumulation of knowledge than its foreign competitors – may be a very good test to determine if the framework proposed in this paper is applicable to HTEs.

Recognizing the deficiency of its R&D capability, Huawei has strategically developed a systematic approach to its standardization activities. From R&D planning, internal R&D, and external co-operative R&D, its practices appear to verify that these three core elements underpin its R&D capability to meet challenges imposed in a dynamic standardization environment. But because of Huawei's weaker technological capability relative to international leaders, the case of Huawei is perhaps more an indicator of the specific tactics adopted by an emergent entrant representing those enterprises without profound technology accumulation.

The evidence in this one case for a correlation between particular emphases in R&D activities and phases in standardization processes is less clear as more primary data and corporate information about research activities needs to be accumulated. Nevertheless, as a proposition for examining HTEs R&D capability, it suggests that differentiation in management tactics and strategies is desirable. Whether HTEs in developing economies might have different approaches to the development and management of R&D capability than HTEs in developed economies under the similar standardization conditions is a research issue worthy of further investigation.

5.3 Concluding Comments

This paper proposed a framework for R&D capability of HTEs within a dynamic standardization environment with three elements being identified as particularly critical: - R&D planning, internal R&D practices, external co-operative R&D activities. The paper highlights some critical activities of R&D capability in such dynamic circumstances that could assist HTEs in determining their appropriate balance of R&D activities. However, the framework needs to be further verified via more detailed empirical investigations and thereby its context can be further refined. As the present case study is only an outline based mainly on secondary sources, more detailed and comprehensive primary information is needed, through interviews and from original documents, in order to complement and more effectively test the proposed conceptual framework and correlation.

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