A Study on Commercialization of R&D Projects in Port and Logistics Industry
- Case of Non-Stop Automated Gate System -

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Abstract

The international business environment of port and logistics industry has been changed drastically in the last few decades. The increase of cargo volume due to globalization, advent of ultra-large container vessels, and improvements in cargo handling technologies created new requirements and resulted in fierce competition among the ports to become the hub port of their region. For this purpose, the ports are heavily investing in their infrastructure and operating systems to remain competitive, meanwhile a vast amount of research and development (R&D) projects and academic research are being carried on, most of which are government sponsored. On the other hand, there is a serious gap between the technology development efforts and actual commercialization of the developed systems. The real return on R&D cannot be fully realized if the systems are not commercialized. Hence this study proposes a model of commercialization of R&D outcomes which are developed in academic institutions under government sponsorship, by surveying related literature. The derived model is applied to the case of Non-stop

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Automated Gate System (NAGS), which is a typical government sponsored R&D project in port and logistics field, and the direction of commercialization was proposed. Finally the applicability of the model to other similar projects was discussed.

**Keywords**: commercialization, technology transfer, academic research and development

1. **Introduction**

Along with rapid globalization of the world economy and market opening, the importance of logistics industry is also steadily growing internally and externally, and also logistics volume is considerably increasing. To cope with increasing logistics volume, the environments of port logistics industry are also undergoing sweeping changes. Recently super container ships have emerged, and they usually call at hub ports, not visiting the other ports. In case of other small ports, small ships are carrying container cargoes. Accordingly, the hub and spoke system has been introduced to current logistics industry. Under this circumstance, major container terminals are making efforts to become a hub port, while lowering the hire of their harbors, improving their service level. At the same time, they are investing huge money in the introduction of spearhead technologies for harbor construction, loading/unloading equipments, and operating system. All these efforts focus on enhancing the efficiency and productivity of their ports.

Since sea ports are important factors of economic growth, governments are supporting port related research and development activities in order to increase terminal productivity. For example in Korea, the Ministry of Maritime Affairs and Fisheries (MOMAF) is promoting several research and development
projects on intelligent port management systems. On the other hand, none of these systems have been commercialized yet, moreover previous academic study on commercialization of port related R&D projects.

Thus this paper aims to propose a method for commercialization of port related R&D projects focusing on the case of Non-stop Automated Gate System Technology Development Project.

2. Theoretical Background

Previous studies on commercialization of R&D projects outcomes are diverse in characteristics. The study of Chung et al. (1998) derives several recommendations for government-sponsored telecommunications R&D in Korea by analyzing the case of TDX. Being a digital switching system, development of time division exchange was carried out in different cycles, and the paper proposes that the commercialization strategies must vary with development cycle. Along the paper, commercialization is divided into four categories, namely 1) technology-driven commercialization; 2) new market-driven commercialization; 3) product and process improvement-driven commercialization; and 4) end-game commercialization. Government-sponsored commercialization should fall in one of these categories.

Brown et al. (1991) classified technology transfer strategies of commercializing government-sponsored technologies into six categories: 1) contracting R&D to industrial partners; 2) working with industrial consortia; 3) licensing to industry; 4) influencing key decision makers; 5) working with broker organizations; and 6) generating end-user demand. It is also stated that contracting to industrial partners is
The most frequent strategy

The study of Span et al. (1995) derives the measures of technology transfer effectiveness. In this paper technology transfer is defined as the managed process of conveying a technology from one party to its adoption by another, and it is stated that a wide variety of descriptions and models of the transfer process has been developed but these reflect a lack of standardization and agreement about technology transfer processes, outcomes, and measures. The paper derives a framework for several measures of effectiveness according to transfer strategy (i.e. technology push vs. technology pull) and transfer models (i.e. Political Model, Out-the-Door Model, Opportunity Cost Model for push strategies and Market Impact Model and Economic Impact Model for pull strategies). The details of these models will be given in the next chapters.

The study of Capps and Fairley (2003) proposes a systematic approach to planning technology transfer campaigns, called PRISM. The methodology consists of five steps:

1. Pre-qualify the innovation, such as business justification.

2. Represent the composition of sub-audiences, since managers in different levels may have different characteristics for communication.

3. Investigate values and assumptions of each sub-audience with respect to the innovation, including relative advantage, complexity, compatibility, triability and observability.

4. Sensitivity analysis of innovational attributes to probe for areas of uncertainty, and finally

5. Mitigate risks by selecting an appropriate mix of engagement models, training modes, and
success models. Engagement models characterize how to communicate with the recipients about the innovation, whereas success models help to set realistic expectations and manage sponsor and stakeholder relationships.

The study of Hayes and Fitzgerald (2006) argues the importance of argumentation methods in commercialization of hybrid R&D where both academic and industrial players are involved. The paper indicates that argumentation characteristics of researchers tend to be creative and to improve ideas continuously, and not to be timed, whereas argumentation characteristics of business people tend to be action-oriented, to be timed, and to be managed to a definite conclusion. Also dissent is considered as good, constructive and value in research field, whereas it is considered as a threat to group cohesion in business field. Since commercialization activities combine the discoveries of one occupational group, such as scientists, with the commercial skills of engineers and managers, bringing innovative ideas to emerging or established markets involve interactions across occupational cultures.

The study of Walsh et al. (2002) focuses on the differentiating market strategies of disruptive and sustaining technologies, where sustainable technologies are the ones that sustain the current manufacturing practices and technological capabilities required in an industrial setting whereas disruptive technologies are the ones that disrupt the current capability set required by a given market. The paper proposes user application types “creative destroying” for technology push strategies and “replacement or substitute” for market pull strategies for disruptive technologies, and “new or major improvement” for technology push strategies and “replacement or substitute” for market pull strategies for sustaining
technologies. Moreover, it is suggested that disruptive technologies may better be commercialized by smaller firms by a commercialization strategy is to seek an entirely new set of customers to adopt the firm’s proprietary technology as a replacement or enhancement to the existing products of the dominant firms in an industry; in this way, new firms can build a customer base rather quickly.

The study of Swasdio et al. (2004) focuses on the commercialization of technologies developed in public R&D institutes. The paper introduces linear view of commercialization, consisting of the steps 1) R&D 2) Product Development and Engineering 3) Product and marketing 4) incremental R&D, and segment view of commercialization, that consists of the steps 1) Imagining 2) Incubating 3) Demonstrating 4) Promoting and 5) Sustaining. In this paper a development model for each step is proposed and the commercialization activities in an organization in Thailand are evaluated on the basis of the model.

The study of Geisler and Kassicieh (1997) focuses on the use of information technologies in technology commercialization and proposes the use of several information technologies, such as Group Decision Support Systems (GDSS’s), Electronic Meetings, Computer Networks for Technology Transfer and World Wide Web. The paper proposes that main barrier of technology transfer is the cultural differences between federal laboratories and industry, thus the stages of technology transfer, i.e. idea initiation, development, and commercialization should be a participative effort between the R&D organization and the potential user.

The study of Birchall (2007) compares the relations of large companies, small and medium
companies and spin-outs with universities. The study points out that there are several barriers for SME-university collaboration, whereas university spin-outs have the potential to overcome many of these barriers.

The study of Buckley (1996) focuses on the concept of Technology Commercialization Center. Such a center is based on the fact that successful technology commercialization depends on the quality and accessibility of markets, technology, business management, and sources of capital, thus it connects related parties each other for successful technology transfer.

Upon the previous literature above, a model for the commercialization of NAGS is developed as follows. The first step of commercialization should be re-qualifying and assessing the product whether it fits the requirements of the user (Capps and Fairley, 2003). This process must precede every step in the commercialization efforts since commercialization of any technology that is not business justified would not be reasonable. The second decision is to be made is whether the technology is to be transferred to an industrial company or directly commercialized through a spin-out. In case of spin-outs, basic concern is necessary financial and human resources. But in case of technology transfer, a more complex approach is necessary. The derived technology transfer is given in Figure 1.

Figure 1. Technology Transfer Model

Technology transfer strategies can be classified into two major groups. The first one is technology push,
where the main idea behind technology developed in the universities or research labs are not the fulfillment of user demand but the development of the most advanced system (Chung et al., 1998). But in market pull strategies the source of innovation is deemed to come from the recognition of potential customer demand (Walsh et al., 2002). After determination of the strategy, a technology transfer model must be selected. There are several transfer models that can be applied according to the characteristics of the product. Spann et al. (1995) indicates three models, namely Political Model, Out-the-door Model and Opportunity Cost Model for technology push strategies, and two models, namely Market Impact Model and Economic Impact Model for market pull strategies. Among them Out-the-door Model is the easiest one to measure since it only deals with whether the technology is transferred or not, the impact is ignored. On the other hand, Political Model concerns about the satisfaction of key stakeholders and sponsors, whereas Opportunity Cost Model deals with the effective utilization of limited financial and human resources. In the case of market pull strategies, Market Impact model concerns about the impact of the new model within the organization, either as change in behavior improvement in the competitiveness of the organization, or the whole nation as well (Capps and Fairley, 2003; Spann et al., 1995).

Another set of technology transfer models has been proposed by Ruttan and Hayami (1973) which distinguishes three phases of international technology transfer: material transfer, design transfer, and capacity transfer where licensing agreements and franchises are two practical examples of capacity transfer.

Since academicians and business experts have different debating styles (Hayes and Fitzgerald, 2006) the
model of engagement is important to convey information and knowledge related to technology transfer.

Zelkowitz (1996) offers four models, namely the People-Mover Model, the Communication Model, the Off-the-Shelf Model, and the Vendor Model. Among them, the People-Mover Model is the most effective one since the change agents deal directly with the prospective users. Others are based on publications, packaging with existing systems and indirect marketing through a vendor, respectively. In addition to these, the Rule Model given in Capps and Fairley (2003) proposes to change by fiat by compelling recipients to adopt and accept responsibility for the infused technology.

One final concept for technology transfer is the barriers to technology transfer. Johnson et al. (1997) proposes five barriers, namely social barriers, political barriers, economic barriers, personal barriers and cultural barriers to overcome for successful technology transfer.

3. Non-stop Automated Gate System (NAGS)

As a part of the Intelligent Port Logistics System Technology Development Project, Non-stop Automated Gate System Technology Development Project aims to develop an automated gate system for container terminals that can perform identification, confirmation, security and information delivery tasks without requiring the truck to stop at the gate. The project is supported by MOMAF for four years, from 2004 to 2008. In the first year, requirements for automated gate system were determined and a roadmap for technology development was composed. On the basis of this roadmap, RFID and OCR-based vehicle and container identification systems were developed. In the second year, Digital Media-based information
delivery system and ACDI-based container damage confirmation system were developed. Finally, in the fourth year, system integration and commercialization is aimed.

The system consists of RFID-based vehicle and container identification system, OCR-based vehicle and container identification system, Digital Media-based information delivery system and ACDI-based container damage inspection system. The system is also designed to support several other functionalities, such as electronic container seal check, to meet the customer demands. In this section, the basic functions of NAGS will be introduced briefly.

3.1 Identification System

Identification tasks at a container terminal gate include the identification of vehicle numbers, container numbers, chassis numbers, and drivers. Conventional gate systems utilize various techniques to accomplish identification tasks, starting from direct visual identification of the gate clerk. The later systems involve closed circuit cameras, interphone systems, and identification of drivers through ID cards, based on barcode, magnetic or RF technology. But all these techniques take long processing times and require the vehicle stop at the terminal gates, which may actually cause congestions at peak hours. On the other hand, utilization of automated recognition of vehicle and container numbers through processing digital images (OCR) is rapidly gaining ground for gate automation systems, but OCR-based systems suffer from severe misinterpretation problems.

NAGS provides a combination of radio frequency identification (RFID) and optical character recognition (OCR) systems for identification tasks in container terminal gates. The system utilizes 900 MHz passive
RFID technology for vehicle identification and 433MHz active RFID for container identification. The vehicle and container numbers are also identified by OCR for cross-checking. The combination of RFID and OCR is expected to yield approximately 100% identification rates.

3.2 Information Delivery System

Information delivery tasks involve passing necessary operational information, such as location of the container in the yard, or what to do when there is a problem, to the truck driver. These tasks are very difficult to perform without information systems, since elaborate connection is needed with planning and operating system of the terminal. The early systems dealt delivery of such information by gate clerks, directly of via interphone system. The conventional systems print such information on paper. But these systems are not time efficient and require the vehicle at the terminal gates.

NAGS proposes an information delivery system through wireless communication devices, so that vehicle drivers are able to get related information on the move. The system supports various communication modules, such as SMS messages, LED display panels, and a vehicle-mounted exclusive terminal which is designed for this purpose. The equipment is called u-SLIP, and provides all necessary information through 2.45 GHz wireless communication.

3.3 Container Damage Inspection System

Container damage inspection is an essential task, since terminal gates are the points where the
responsibility of the cargo is transferred from the trucker company to the terminal management. Thus an unidentified damage at the gates may result in future customer claims. Today, most terminals perform these inspections manually. Some terminals deploy line scan cameras or high-quality cameras to take and store the picture of the container if there is a future claim. On the other hand, two-dimensional images may not be sufficient to detect the damage if the damage had occurred in the third dimension.

Thus, NAGS proposes an automated container damage inspection (ACDI) system. ACDI is based on the logic that the containers are scanned by laser detectors while they are passing through the gate. The laser scan forms the three-dimensional image of the container surface and any deviation from the original shape of the container is detected as damage.

3.4 Integrated Gate Management System

Integrated Gate Management System is the application program that links and controls the sub-modules of NAGS. It enables the monitoring of all gate operations via user friendly interface and controls the data transfer between NAGS and terminal operating system (TOS). It supports variety additional features as plug-ins to satisfy user demand.

3.5 Additional features

Besides these basic functions, NAGS is designed to support various technologies at the container terminal gates, upon the demand of the terminal operators. Since the system is developed in a modular manner, the
customers can deploy the whole integrated system or any individual system depending on the customer needs and terminal conditions. The additional techniques supported by the system cover e-Seal identification, vehicle and container weighing systems, barcode based identification systems, SLIP printers, connection with TOS and several network extremities, such as hand-held terminals.

3.6 The expected effect of the system

The most obvious characteristic of the system is using RFID and OCR in a hybrid form for both vehicle and container identification, while previous systems intent to use RFID for vehicle identification and OCR for containers, separately. By doing this, one hundred percent identification rates are expected, since the systems can cover each other in case of identification failures. In addition to this, NAGS replaces time consuming paper printers with digital information formats, such as LED display panels or SMS messages to cellular phones. NAGS even offers an exclusive terminal for this purpose. On the other hand, the customers do not require to adopt the system as a whole, the modules of the system can be adopted separately and can be integrated to other conventional systems, depending on the demands of the customers.

The developed system has various merits over the conventional gate systems. These merits cover controlling the entrance of unauthorized vehicles and drivers, reinforced cargo security, easiness of container information management, supplying the gate managers with statistical information about the gate operations, increasing the gate productivity by decreasing processing time at the gate under 10
seconds, and decreasing gate operational expenses, including labor fees and maintenance costs.

4. Developing a Commercialization Strategy for NAGS

For the privacy of the involved parties, the pseudonyms of the major stakeholders that are used in this paper and their roles are given in Table 1.

Table 1. Pseudonyms Used in This Paper

For successful commercialization of NAGS technology, we envisage an appropriate mixture of the models given above. First of all, direct commercialization of the system through a university spin-out is not considered as an option, since neither the sponsor nor the gatekeeper support the necessary fund for such venture. Thus, the commercialization efforts for NAGS will solely focus on technology transfer. Both direct and indirect transfer methods will be used. Direct transfers involve in licensing and cooperative researches, whereas indirect transfers are exchange of knowledge through meetings, publications and workshops (Abramson et al., 1997). For this purpose, NAGS development team has published a number of journal papers, and attended several conferences, exhibitions and workshops throughout every step of the development process.

In the case of NAGS, there are two major barriers for transfer, namely economic and political barriers. The political barriers are mainly related to the rules of MOMAF that gives transfer priority to the
companies that involve in the development project. Besides, the economic barriers are related to the big amount of transfer costs. In order to overcome the economic barriers, a market pull strategy is considered to be more appropriate in the beginning. A small number of domestic end users that demand gate system proposals would be easier to approach. After establishing a reliable reference site for the system, technology push strategies can be used to push the system to other domestic and foreign terminals.

On the basis of Opportunity Cost Model, a two-phase technology transfer process is offered, and the transfer of NAGS would be best realized through a vendor in order to make best use of limited resources and funds. Thus in such a model, a primary transfer would be from the university to the vendor and a secondary transfer would be from the vendor to the end user. (Fig. 2) According to the classification of Ruttan and Hayami, the primary transfer would be a capacity transfer, i.e. all know-how about the system will be transferred so that the vendor can produce and sell the system by itself, whereas the second one would be a material transfer which involves the transfer of the system only to be used by the end user.

Figure 2. Proposed Commercialization Model For NAGS.

The success of the technology transfer is deeply related with the efficiency of the communication channels between the involving parties. For this reason, a mixture of engagement models will be used, except for Rule Model.

• **Between the gatekeeper and the vendor:** Limited number of domestic vendors that are trying to
respond the gate system requests of the limited number of domestic terminals, is determined and
directly contacted for information exchange by the change agents. As People Mover Model, which is
proved to be the most effective, yet the most resource-consuming method for engagement, is selected
since approaching the limited number of terminals and vendors in Korea can be achieved within the
given human and financial resources.

• **Between the gatekeeper and the end-user:** As mention above, Vendor Model is quite appropriate for
the system to be transferred due to efficient utilization of limited resources. Thus the gatekeeper does
not intent to involve in direct marketing activities. On the other hand, it tries to support the vendor by
indirect transfer methods, such as conference presentations, holding seminars and workshops and
attending international fairs for transferring the NAGS related information to a wider audience, as
offered by Communication Model.

• **Between the vendor and the end-user:** Various methods can be used to facilitate technology transfer,
thus the vendor should prepare a marketing strategy by combining various models. The modular
characteristic of the system makes it suitable for Off-the-shelf Model, i.e. the more innovative parts of
the system, such as RFID, Digital Media and ACDI, can be easily commercialized by combining with
more conventional systems as a package, such as OCR, barcode identification or paper SLIP printers, in
order to increase the reliability of the system perceived by the end-user. The composition of the
package can be customized according to the requirements of the end user.

The success of the transfer can be measured through a mixture of Political Model and Market Impact
Model, in which a successful technology transfer would satisfy each of all the corresponding stakeholders and have positive behavioral and economical impacts on them. The impact of the transfer on the vendor can easily be measured through its profitability. Similarly, the impact on the end user can also be measured through increased gate productivity (behavioral impact) and decreased operational costs (economic impact). On the other hand, the impact on the sponsor is relatively difficult to measure in a short time period. The main concern of MOMAF would be increased competitiveness and market share of Korea in international port system market, which would require long term measurements for future decision making.

5. Evaluation of the Derived Model

In order to validate the derived model, an expert council consists of responsible managers of container terminals and SI companies in Korea, was set up. A meeting with council members was held in January, 2008. During the meeting, the experts were informed about the developed system and derived commercialization model. After the meeting, the members of the expert meeting were given a structured questionnaire to evaluate several aspects of the commercialization model based on 7-point-scale. The results of the questionnaire are given in Table 2.

Table 2. Evaluation results
As it is seen in the table, the responds of the experts are consistent with the offered scenario with relatively small standard deviations. Except for the seventh question, where the evaluators agreed that even the gatekeeper should also participate in the direct marketing activities like the vendor.

6. Conclusion

In this research, a model of commercialization for government supported R&D was derived from previous studies and a commercialization plan was offered for Non-stop Automated Gate System, which is a product of government supported R&D project, on the basis of the derived model. According to the results, NAGS can be best commercialized through transferring developed technology through a vendor. The vendor can make use of the demands of newly developed terminals in Korea, and then push the technology to other foreign terminals by referencing the successful cases in Korea.

The derived model indicates methods for measuring success through satisfaction of each stakeholder and it can be applied to commercialization of projects in various fields, especially in port logistics systems. It is also expected to shed light on future government supported R&D projects, starting from the projects of MOMAF that are in progress along with NAGS.

Acknowledgements

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References


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Tables:

<table>
<thead>
<tr>
<th>Pseudonym</th>
<th>Role</th>
</tr>
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<tbody>
<tr>
<td>Gatekeeper (Zelkowitz, 1996)</td>
<td>The academic institution, either university or a public research center that develops the system to be commercialized.</td>
</tr>
<tr>
<td>Change Agents</td>
<td>The researchers within the gatekeeper</td>
</tr>
<tr>
<td>Sponsor</td>
<td>The public organization that sponsors the research.</td>
</tr>
<tr>
<td>End user</td>
<td>Private enterprises that are probable to adopt and use the developed system, such as container terminals, inland depots, parking lots</td>
</tr>
<tr>
<td>Vendor</td>
<td>Private commercial companies that have direct access to market and experience in commercializing similar products</td>
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Table 1. Pseudonyms Used in This Paper
<table>
<thead>
<tr>
<th>Question</th>
<th>Mean (over 7)</th>
<th>Standard Deviation</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Commercialization considered as technology transfer instead of spin-out.</td>
<td>5.333</td>
<td>1.155</td>
</tr>
<tr>
<td>2. Transfer strategy as market pull strategy</td>
<td>5</td>
<td>1</td>
</tr>
<tr>
<td>3. Splitting the transfer into two phases</td>
<td>5.333</td>
<td>1.155</td>
</tr>
<tr>
<td>4. Selection of the vendor as the one appointed to provide gate systems for development of a domestic terminal</td>
<td>4.667</td>
<td>1.528</td>
</tr>
<tr>
<td>5. Using a vendor in order to overcome limited resources of the gatekeeper</td>
<td>5.667</td>
<td>1.155</td>
</tr>
<tr>
<td>6. Selection of domestic container terminals as end-user</td>
<td>7</td>
<td>0</td>
</tr>
<tr>
<td>7. The gatekeeper to refrain from direct marketing</td>
<td>3.667</td>
<td>2.887</td>
</tr>
<tr>
<td>8. The gatekeeper to support vendor by presentations, publications, workshops, seminars, etc.</td>
<td>5.333</td>
<td>0.577</td>
</tr>
<tr>
<td>9. Combining the newly developed systems with conventional systems as a package</td>
<td>4.333</td>
<td>1.155</td>
</tr>
<tr>
<td>10. Measuring the satisfaction of each stakeholder to evaluate the success of the transfer</td>
<td>4.667</td>
<td>2.309</td>
</tr>
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Table 2. Evaluation results
Figure 1. Basic logic of information systems in Kumport
Figure 2. Proposed Commercialization Model for NAGS.